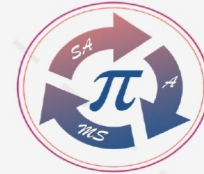




VIT
CHENNAI



INTERNATIONAL CONFERENCE ON GRAPHS AND FUZZY GRAPHS (ICGFG-2026)

26th and 27th March 2026

BOOK OF ABSTRACTS

EDITORS

Dr. Balamurugan B J
Dr. Madhumangal Pal
Dr. Sk Md Abu Nayeem

Organized jointly

by

Department of Mathematics
School of Advanced Sciences

Vellore Institute of Technology, Chennai, India
and

Research and Development Cell
Vidyasagar University, West Bengal, India

In Coordination with

Sridharacharya Academy of Mathematical Sciences (SAAMS)



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**International Conference on Graphs and Fuzzy Graphs-2026
(ICGFG - 2026)**

Email: icfg2026@gmail.com

VIT PUBLICATION

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Dr. Sk Md Abu Nayeem

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First Edition



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**International Conference on Graphs and Fuzzy Graphs-2026
(ICGFG - 2026)**

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PREFACE

The book of abstracts presents a collection of selected research contributions from the International Conference on Graphs and Fuzzy Graphs (ICGFG-2026), jointly organized by the Vellore Institute of Technology, Chennai, and Vidyasagar University, in coordination with the Sridharacharya Academy of Mathematical Sciences. The conference serves as an international platform for academicians, researchers, scientists, and industry experts to disseminate knowledge, exchange innovative ideas, and discuss recent advancements in graph theory, fuzzy graphs, and their wide-ranging applications. The abstracts compiled in this volume highlight significant theoretical developments, computational techniques, and practical applications that contribute to the advancement of mathematical sciences. The contributions reflect current research trends and emphasize the growing importance of graph-based models and fuzzy systems in addressing complex problems across interdisciplinary domains.

On behalf of the organizing committee of ICGFG-2026, we express our sincere gratitude to all authors for their valuable contributions. We also extend our appreciation to the keynote speakers, reviewers, session chairs, and participants for their efforts and support in making this conference a success. We gratefully acknowledge the support and collaboration of the organizing institutions and the coordinating organization, whose collective efforts have made the successful conduct of the conference and publication of this book of abstracts possible.

Convenors, ICGFG-2026

Dr. Balamurugan B J

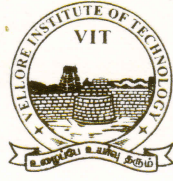
Vellore Institute of Technology, Chennai

Dr. Madhumangal Pal

Vidyasagar University, West Bengal

Dr. Sk Md Abu Nayeem

Sridharacharya Academy of Mathematical Sciences



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Dr. G. VISWANATHAN
Founder & Chancellor
Former Member of Parliament
Former Minister, Govt. of Tamil Nadu
Chief Patron, Education Promotion Society for India, New Delhi

MESSAGE

I am happy to know that the Department of Mathematics, School of Advanced Sciences, is organizing the International Conference on Graphs and Fuzzy Graphs (ICGFG-2026) on 26th and 27th March 2026. I am confident that ICGFG-2026 would emerge as a dynamic platform for discussing, developing and exploring recent advances in graph theory, fuzzy sets and fuzzy graphs and also emerging applications in fields such as artificial intelligence, communication networks and data science.

I strongly believe that the dissemination of knowledge has no limits. It is my pleasure to note that many young and renowned academicians and researchers are sharing their research findings in this conference. I am sure that delegates would immensely get benefited through the conference.

I congratulate the organizers and event coordinators on their efforts in organizing this conference successfully.

I wish the conference all success.

With best wishes,

Dr. G. Viswanathan
Founder & Chancellor

20th March 2026

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MESSAGE FROM VICE PRESIDENT



My warm greetings to all!

The **International Conference on Graphs and Fuzzy Graphs (ICGFG-2026)** on 26th and 27th March 2026 is based on the thrust areas of Graphs and Fuzzy Graphs focusing on the frontiers of Mathematical Sciences.

This conference organized jointly by the Department of Mathematics, School of Advanced Sciences, VIT Chennai and Research Development Cell, Vidyasagar University, West Bengal in coordination with Sridharacharya Academy of Mathematical Sciences (SAAMS) is a step towards achieving our vision of becoming a world-class academic and research institution to inculcate the importance of multidisciplinary research in young minds. It will provide a good opportunity to share knowledge and skills in the thematic areas of the conference.

It is a great pleasure to welcome all delegates and participants to this conference, from India and abroad. I am very certain that this occasion will provide a platform towards strengthening our relationships in knowledge sharing while at the same time provide the necessary thrust in joint research collaborations and commercialization within the research society. It is my aspiration that the conference will be a foundation for the growth of new ideas towards a better tomorrow.

I congratulate the organizers on their efforts in making the conference a grand success.

With warm regards,

A handwritten signature in black ink, appearing to be 'G.V. Selvam', written in a cursive style.

G.V. Selvam
Vice President



FOREWORD

It gives me great pleasure to know that the Department of Mathematics, School of Advanced Sciences, Vellore Institute of Technology (VIT), Chennai, in collaboration with Vidyasagar University, West Bengal, and in coordination with the Sridharacharya Academy of Mathematical Sciences, is organizing the International Conference on Graphs and Fuzzy Graphs (ICGFG-2026) on 26–27 March 2026.

Mathematics, particularly the areas of graph theory and fuzzy graph theory, continues to play a vital role in addressing complex problems arising in science, engineering, and technology. Conferences such as ICGFG-2026 provide an excellent platform for academicians, researchers, and scholars from around the world to exchange ideas, present their research findings, and foster meaningful collaborations.

I am delighted to note that this conference has attracted participation from eminent researchers and young scholars, reflecting the growing interest and advancements in this important field. The Book of Abstracts being released on this occasion is a valuable compilation of the diverse research contributions presented at the conference. I am confident that these works will stimulate further research and inspire new directions in graph theory and its applications.

I congratulate the organizers, particularly the Department of Mathematics, VIT Chennai, and all collaborating institutions for their dedicated efforts in successfully organizing this international event. I also extend my best wishes to all participants for fruitful deliberations and an enriching academic experience.

I hope that ICGFG-2026 will serve as a significant milestone in strengthening research interactions and advancing knowledge in this dynamic area of mathematics.



Dr. S. P. Thyagarajan
Distinguished Professor & Advisor to Chancellor
VIT Chennai

Professor Dipak Kumar Kar

Vice-Chancellor
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VIDYASAGAR UNIVERSITY



Date: 18.03.2026

FOREWORD

It gives me immense pleasure to present this foreword for the International Conference on Graphs and Fuzzy Graphs, scheduled to be held on 26–27 March 2026 in hybrid mode at the VIT Chennai Campus. This conference is jointly organized by VIT Chennai and Vidyasagar University, with coordination support from SAAMS.

The conference has attracted remarkable participation, with more than 200 delegates and around 170 research papers presented by scholars from across India and abroad. Such an overwhelming response reflects the growing significance and wide-ranging applications of graph theory and fuzzy graph theory in contemporary research.

A key highlight of the conference is the participation of 12 renowned professors from across the globe, who will deliver invited lectures and share their valuable insights. Their contributions will undoubtedly enrich the academic discussions and inspire future research directions.

I am confident that this conference will provide an excellent platform for researchers, academicians, and students to exchange ideas, foster collaborations, and explore recent advancements in the field.

I extend my best wishes for the grand success of the conference and congratulate the organizers for their dedicated efforts in making this event possible.

Dipak Kumar Kar
(Professor Dipak Kumar Kar)



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Date: 20.03.2026

FOREWORD

I am pleased to learn that the *International Conference on Graphs and Fuzzy Graphs (ICGFG-2026)*, scheduled to be held on 26th and 27th March 2026, is being jointly organized by the Department of Mathematics, School of Advanced Sciences, VIT Chennai, and the Research Development Cell, Vidyasagar University, West Bengal, in coordination with the Sridharacharya Academy of Mathematical Sciences (SAAMS). The conference aims to foster research discussions and promote knowledge sharing in the thrust areas of Graphs and Fuzzy Graphs.

This conference is aiming to provide an excellent platform for researchers from across India and abroad to present their findings to the scientific community, thereby contributing to the dissemination of knowledge. It is a matter of great pleasure to note that more than 200 delegates are participating to share and discuss their research in the thematic areas of the conference.

I congratulate the organizers of ICGFG-2026 for their sincere efforts in bringing together researchers across India and also from around the globe. I encourage all participants to actively engage in the sessions and trust that they will benefit from valuable opportunities to exchange ideas and gain new insights.

I extend my best wishes to the entire ICGFG-2026 team for the successful conduct of the conference.

Dr. T. THYAGARAJAN
Pro Vice-Chancellor
VIT Chennai



FOREWORD

I am very much delighted to know that Department of Mathematics, School of Advanced Sciences is organizing “International Conference on Graphs and Fuzzy Graphs (ICGFG-2026)” during March 26th and 27th 2026 in collaboration with the Department of Applied Mathematics, Vidyasagar University, Midnapore, West Bengal and in coordination with the Sridharacharya Academy of Mathematical Sciences (SAAMS) in commemoration of 50th Anniversary of Fuzzy Graph Theory.

It will really provide a platform to bring together academicians, researchers and innovators across the globe to exchange their idea, present their findings and have a fruitful discussion on the findings. It will give an opportunity to all the participants to interact among themselves to get new ideas and new collaborators. Mathematics is the queen of sciences and mother of new concepts. Whether it is artificial intelligence or communication networks or data science, mathematics is the foundation and this conference will provide a good platform for the development of ideas related to these fields.

I wish all the offline participants a memorable stay and best wishes for both online and offline participants.



Dr. K Sathiyarayanan
Director, VIT Chennai Campus



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24.03.2026



FOREWORD

It is a matter of great pride and satisfaction to introduce this volume of abstracts associated with ICGFG-2026, hosted by the Department of Mathematics, School of Advanced Sciences, VIT Chennai, along with its academic partners.

This scholarly gathering marks a significant milestone in the journey of fuzzy graph theory, celebrating five decades of sustained intellectual contributions and expanding relevance. Over the years, concepts from graph structures and fuzzy methodologies have significantly influenced diverse domains, offering robust frameworks to address uncertainty, complexity, and interconnected systems.

The present compilation reflects a wide spectrum of contemporary investigations and innovative approaches contributed by participants from various parts of the world. It stands as a testament to the continuous evolution of mathematical thought and its ability to respond to emerging scientific and technological challenges.

Such academic interactions play a crucial role in nurturing critical thinking, encouraging interdisciplinary exploration, and strengthening research networks. I am confident that the deliberations and outcomes associated with this event will open new avenues for inquiry and collaboration.

I extend my heartfelt appreciation to the Department of Mathematics, School of Advanced Sciences, the organizing team, collaborating institutions, contributors, and reviewers for their commitment and meticulous efforts in bringing out this compilation. Their dedication has ensured both the academic quality and the broader impact of this initiative.

May this endeavor contribute meaningfully to the enrichment of knowledge and inspire further advancements in the field.

G. Vinitha

Dr. Vinitha G
Dean
School of Advanced Sciences
VIT Chennai



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25.03.2026

Foreword

“Mathematics reveals its deepest truths through structures, patterns, and connections that transcend boundaries.”

It is with immense pride and academic enthusiasm that we present the Book of Abstracts of the **International Conference on Graphs and Fuzzy Graphs (ICGFG–2026)**, scheduled on **26–27 March 2026**. This conference is jointly organized by the Department of Mathematics, School of Advanced Sciences, Vellore Institute of Technology (VIT), Chennai, in association with the Research Development Cell, Vidyasagar University, West Bengal, and in coordination with the Sridharacharya Academy of Mathematical Sciences (SAAMS).

Graph Theory and Fuzzy Graphs continue to be at the forefront of mathematical research, offering powerful tools to model complexity, uncertainty, and real-world systems. Their growing relevance across disciplines such as computer science, data analytics, network science, artificial intelligence, and engineering underscores the importance of sustained research and scholarly exchange in these areas. This conference serves as a vibrant platform for eminent researchers, academicians, and emerging scholars to disseminate their findings, engage in meaningful dialogue, and explore new research directions.

We are pleased to note the overwhelming response to the conference, with participation from **more than 200 delegates across India and abroad**. The abstracts compiled in this volume reflect a rich spectrum of research contributions, highlighting both theoretical advancements and practical applications within the thematic scope of the conference. This compilation stands as a testament to the intellectual rigor and innovative spirit of the research community.

We extend our sincere appreciation to the **Conveners, organizing committee, and all members** whose dedication and meticulous efforts have ensured the successful organization of this international event. We also express our gratitude to the authors, keynote speakers, and participants for their valuable contributions and active engagement.

We are confident that **ICGFG–2026** will foster meaningful academic interactions, inspire collaborative research, and contribute significantly to the advancement of knowledge in Graph Theory and Fuzzy Graphs.

Dr. A. Manivannan

Associate Professor and Head
Department of Mathematics
School of Advanced Sciences
VIT Chennai

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25.03.2026

Foreword

It gives me great pleasure to present the *Book of Abstracts* of the **International Conference on Graphs and Fuzzy Graphs (ICGFG-2026)**, scheduled to be held on **26–27 March 2026**. The conference is jointly organized by the Department of Mathematics, School of Advanced Sciences, VIT Chennai, and the Research Development Cell, Vidyasagar University, West Bengal, in coordination with the Sridharacharya Academy of Mathematical Sciences (SAAMS).

The primary objective of this conference is to provide a vibrant platform for academicians, researchers, and scholars to exchange ideas, share research findings, and discuss recent developments in the thrust areas of **Graphs and Fuzzy Graphs**. These fields continue to play a significant role in advancing both theoretical and applied aspects of mathematics and interdisciplinary research.

I am delighted to note that **more than 200 delegates** from various institutions in India and abroad are participating in this conference. Their valuable contributions reflect the growing interest and ongoing research in these areas. The abstracts compiled in this volume represent diverse research themes and innovative approaches, and they serve as an important record of the scholarly work presented at the conference.

I sincerely hope that this Book of Abstracts will be useful to researchers, faculty members, and students, and that the discussions during the conference will lead to meaningful collaborations and future research opportunities.

I take this opportunity to thank all the authors for their contributions, the invited speakers and session chairs for their support, and the organizing committee members for their dedicated efforts in making this conference a success.

I wish the conference all success and a productive academic interaction for all participants.

B. J. Balamurugan

Dr. Balamurugan B J
Convener
ICGFG-2026
Department of Mathematics
School of Advanced Sciences
VIT Chennai





DEPARTMENT OF APPLIED MATHEMATICS

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Dr. Madhumangal Pal
Professor & Director of IQAC

Date: 06.03.2025

Foreword

It is a matter of great pleasure and honour to present this foreword for the International Conference on Graphs and Fuzzy Graphs, to be held on **March 26-27, 2026**, in hybrid mode at the VIT Chennai Campus. This conference is jointly organised by **VIT Chennai and Vidyasagar University**, and coordinated by the **Sridharacharya Academy of Mathematical Sciences, Midnapore, West Bengal**.

The conference has received an enthusiastic response from the academic community, with more than 200 participants and around 199 research papers contributed by scholars from across India and several other countries. This reflects the growing importance of graph theory and fuzzy graph theory in addressing complex problems in science, engineering, and interdisciplinary domains.

Notably, the conference will also celebrate the 50th anniversary of fuzzy graph theory, marking a significant milestone in the field's development. A special feature of the conference is the presentation of a comprehensive bibliometric study on the body of research in fuzzy graph theory. This work highlights the global development of the subject while showcasing the significant contributions of Indian fuzzy graph theorists, thereby offering valuable insights into research trends, collaborations, and emerging directions in the field.

A major highlight of the conference is the presence of distinguished speakers from around the world, including Prof. Douglas B. West (University of Illinois, USA), Dr. Srinivas Ramaswamy (USA), Prof. Ayman Badawi (American University of Sharjah, UAE), Prof. Kinkar Das (Sungkyunkwan University, South Korea), and Dr. Milica Anđelić (Kuwait University). The conference will also feature eminent Indian speakers such as Dr. S. Arumugam, Dr. Indra Rajasingh, Prof. Ankur Bharali, Prof. Shalu M. A., Dr. Sunil Mathew, and Dr. Anita Pal. In total, 12 renowned professors from across the globe will deliver invited lectures, sharing their expertise and recent research contributions.

I am confident that this conference will serve as a vibrant platform for exchanging ideas, increasing collaborations, and exploring recent advances in graphs and fuzzy graphs. It will significantly contribute to the advancement of mathematical research and its applications.

I extend my sincere appreciation to the organisers for their dedicated efforts and wish the conference a grand success.

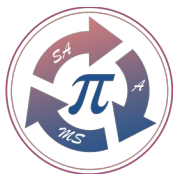
Prof. Madhumangal Pal

President, Sridharacharya Academy of Mathematical Sciences (SAAMS)

Mindapore, West Bengal

Professor of Applied Mathematics & Director of IQAC

Vidyasagar University



Sridharacharya Academy of Mathematical Sciences (SAAMS)

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Date: 20-03-2026

Foreword

It is a wonderful experience for us to coordinate the International Conference on Graphs and Fuzzy Graphs (ICGFG-2026) hosted by **VIT Chennai** and **Vidyasagar University, West Bengal** during 26 – 27 March, 2026. From a classical component of discrete mathematics, graph theory has now evolved into modern computational tool to analyze networks for system vulnerabilities and connectivity. It serves as the primary language for both the micro-scale complexities of Chemical Graph Theory and the macro-scale challenges of Network Science. By connecting Lotfi A. Zadeh's fuzzy set theory (1965) with classical graph theory, fuzzy graph theory has become a crucial interdisciplinary field that models systems with ambiguity, vagueness, and uncertainty. Rosenfeld's formal development of fuzzy relations on fuzzy sets in 1975 laid the groundwork for this field, and since then it has made significant strides in solving combinatorial issues in optimization, computer science, and social networks. This conference is organized to commemorate the 50th anniversary of the foundation of fuzzy graph theory.

In this conference, our aim is to bridge the gap between theoretical development in different areas of graph theory such as colouring, matching, domination, spectral analysis both in the classical and fuzzy graph theory setting and their applications in various fields such as molecular descriptors used in drug discovery, image processing, graph neural network (GNN) in artificial intelligence and machine learning (AI & ML).

We are indebted to our incredible invited speakers of international repute - Prof. Douglas B. West, Dr. Sridharacharya Ramaswamy, Prof. Ayman Badawi, Prof. Kinkar Chandra Das, Dr. Milica Anđelić, Prof. S. Arumugam, Dr. Indra Rajasingh, Prof. Ankur Bharali, Prof. Shalu M. A., Dr. Sunil Mathew, and Dr. Anita Pal. We sincerely thank the authorities – VC, Pro-VC, Directors, Deans, Head of the Departments of VIT Chennai and of Vidyasagar University, all advisory committee members and organizing committee members for their patronage and kind support. We also appreciate the support of our enthusiastic participants – an overwhelming 199 number of submissions are received for presentation in the conference.

We hope this conference serves as a catalyst for new dialogues, pushing the boundaries of how we map, model, and understand our interconnected world through graphs and fuzzy graphs.

All the best!

(Madhumangal Pal)

President

(Sk. Md. Abu Nayeem)

General Secretary



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**International Conference on Graphs and Fuzzy Graphs-2026
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WELCOME MESSAGE FROM THE ORGANIZERS

The organizing committee is honoured and delighted to welcome you to the International Conference on Graphs and Fuzzy Graphs (ICGFG-2026), jointly organized by the Vellore Institute of Technology (VIT), Chennai, and Vidyasagar University, West Bengal, in coordination with the Sridharacharya Academy of Mathematical Sciences (SAAMS). We believe that this conference will ensure a successful platform to share the latest achievements in various disciplines of Mathematics highlighted in the theme of the conference.

The success of this conference is a result of the collective efforts and valuable contributions of the faculty members and organizing teams from the Vellore Institute of Technology and Vidyasagar University, along with the continuous support and coordination of the Sridharacharya Academy of Mathematical Sciences. We acknowledge our gratitude to the management and officials of VIT Chennai, Vidyasagar University, West Bengal and SAAMS. Above all, we thank all the participants who have registered for this conference.

We wish you a great time during the conference.

Dr. Balamurugan B J

Convenor

VIT Chennai

Dr. Madhumangal Pal

Convenor

Vidyasagar University

Dr. Sk Md Abu Nayeem

Convenor

SAAMS



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ABOUT THE CONFERENCE

The School of Advanced Sciences (SAS) at VIT Chennai, in collaboration with the Department of Applied Mathematics at Vidyasagar University, is organizing the International Conference on Graphs and Fuzzy Graphs (ICGFG-2026) in coordination with the Sridharacharya Academy of Mathematical Sciences (SAAMS) to commemorate the 50th anniversary of Fuzzy Graph Theory (1975–2025). This conference aims to convene researchers, academicians, and practitioners to exchange ideas and discuss recent advancements in graph theory, fuzzy sets, and fuzzy graphs.

The ICGFG-2026 will serve as a dynamic platform for exploring theoretical developments and emerging applications in fields such as artificial intelligence, optimization, data science, communication networks, and decision-making systems. The conference will be hosted at the VIT Chennai Campus and will feature keynote lectures, invited talks, and technical sessions presented by leading experts from academia.

The conference focuses on, but is not limited to: Graph Theory Fuzzy Set Theory Fuzzy Graphs and Applications Algorithms and Optimization Artificial Intelligence and Data Science Network Science and Communication Systems Decision-Making Models and Soft Computing Techniques.



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ABOUT VIT CHENNAI

VIT Chennai was established in 2010 and has since become a beacon of excellence in higher education. Spearheaded by Vice President Dr. G. V. Selvam, a pioneering visionary who laid the foundation of VIT Chennai, is an insightful architect of its evergreen campus and an ingenious leader whose comprehensive vision and mission have shaped its growth. Under his guidance, VIT Chennai has rapidly evolved into a hub of innovation and academic distinction. The leadership team, including Vice Chancellor Dr. V. S. Kanchana Bhaaskaran, Pro Vice Chancellor Dr. T. Thyagarajan and Additional Registrar Dr. P. K. Manoharan, drives its mission of delivering transformative education and impactful research. Strategically located in the capital city of Tamil Nadu, VIT Chennai is a globally engaged, competitive, and research-enriched institution. It proactively addresses industrial, social, economic, and environmental challenges, fostering application-based learning that produces industry-ready professionals.

Known for its cosmopolitan atmosphere, VIT Chennai attracts students from across the globe, fostering a vibrant and multicultural community. Committed to maximizing industrial connectivity and establishing Centers of Excellence in cutting-edge research areas, VIT Chennai enriches technological and managerial human capital through a collaborative and inclusive academic environment. It serves as a platform for intellectual exchange, encouraging the convergence of diverse ideas to drive innovation and learning. Dedicated to societal and industrial advancement, VIT Chennai leverages its resources to benefit the community, supports national knowledge-building initiatives, and fosters international collaborations for mutual progress in research and education. With a clear vision and an unwavering mission, VIT Chennai continues to redefine the landscape of higher education in India and beyond.



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ABOUT SCHOOL OF ADVANCED SCIENCES

The School of Advanced Sciences at VIT Chennai encompasses the Departments of Mathematics, Physics, and Chemistry. It offers doctoral programs in physics, chemistry, mathematics, and geology, as well as Master of Science degrees in Physics, Chemistry, and Data Science. Additionally, the school provides a wide array of core and elective courses that support the B.Tech., M.Tech., MCA, Management, and Law programs.

ABOUT DEPARTMENT OF MATHEMATICS

The Department of Mathematics provides a strong mathematical foundation and the necessary computational skills to handle industrial and research problems for the students. The Mathematics Division offers Mathematics/Statistics courses to all undergraduate and postgraduate programmes of the University, and Ph.D. programme for highly motivated and deserving students interested in pursuing their research career in Mathematics/Statistics/ Computational Sciences. It comprises of highly qualified and experienced faculty who engage actively in teaching and research. We adopt novel methods to impart quality teaching to create a vibrant learning environment for the students.

Our faculty members are highly qualified, experienced and have been guiding research scholars in their area of specialization apart from teaching. Most of our faculty members contribute as invited speakers at various conferences and workshops in both India and abroad. Our faculty members contribute to funded projects from funding agencies such as Department of Science and Technology (DST), Council of Scientific and Industrial Research (CSIR) and National Board of Higher Mathematics (NBHM). Many of our faculty members serve as editors and reviewers in reputed SCOPUS indexed Journals.



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ABOUT VIDYASAGAR UNIVERSITY

Vidyasagar University, established in 1981 by the Government of West Bengal, is a prominent public institution located in Midnapore, West Bengal. Named in honor of the distinguished educationist Pandit Ishwar Chandra Vidyasagar, the University is dedicated to fostering academic excellence, promoting social inclusion, and contributing to regional development. It offers a comprehensive array of undergraduate, postgraduate, and doctoral programs across the disciplines of Arts, Science, Commerce, Management, and interdisciplinary studies, in alignment with the National Education Policy. The University boasts a robust research ecosystem, exemplified by the International Conference on Graphs and Fuzzy Graphs (ICGFG2026) scheduled for March 26-27, 2026, and supports over 750 Ph.D. scholars, having conferred more than 350 doctoral degrees in the past three years. Nationally recognized, it ranks within the 151–200 band in the NIRF Overall category and 51–100 among State Public Universities, and holds accreditation from NAAC. With its modern infrastructure, environmentally sustainable and inclusive campus, and learner-centric approach, Vidyasagar University continues to cultivate graduates who are both skilled and socially responsible.



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ABOUT SRIDHARACHARYA ACADEMY OF MATHEMATICAL SCIENCES (SAAMS)

The Sridharacharya Academy of Mathematical Sciences, established in 2024, is a registered professional organization dedicated to promoting high-quality research and innovation in mathematics. Named in honor of the esteemed Indian mathematician Sridharacharya, the SAAMS seeks to cultivate a robust research culture and promote intellectual development among mathematicians in India. The academy facilitates mathematical progress through the organization of workshops, seminars, conferences, and publications, as well as through the distribution of awards, school-level initiatives, career guidance, and international collaborations. Additionally, it advocates for the application of mathematics to address real-world challenges and to contribute to societal development, providing a platform for researchers to exchange ideas and make meaningful contributions to science and society.



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ORGANIZING COMMITTEE

CONVENORS

Dr. Balamurugan B J, Associate Professor Senior, VIT Chennai

Dr. Madhumangal Pal, Professor, Vidyasagar University, West Bengal Prof.

Sk Md Abu Nayeem, General Secretary, Sridharacharya Academy of Mathematical Sciences

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Reconstruction of graphs from smaller subgraphs: a sharp threshold for caterpillars

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Abstract

The k -deck of an n -vertex graph G is its multiset of subgraphs induced by k vertices. The famous Reconstruction Conjecture of Kelly and Ulam states that the $(n-1)$ -deck determines G when $n \geq 3$. Always the k -deck determines the $(k-1)$ -deck, so an enhanced version of the reconstruction problem is to seek the largest ℓ such that the $(n-\ell)$ -deck determines G .

An n -vertex graph is ℓ -reconstructible if it is determined by its $(n-\ell)$ -deck. Manvel conjectured that for each ℓ there is a threshold M_ℓ such that every graph with at least M_ℓ vertices is ℓ -reconstructible; the Reconstruction Conjecture is $M_1 = 3$. The first part of this talk will describe known results on the general problem.

For example, there are known thresholds on the number of vertices that suffice for ℓ -reconstructibility of various properties of a graph, such as connectedness, acyclicity, and the degree list. Also, essentially everything is known for graphs with maximum degree 2, but 3-regular graphs are only known to be 2-reconstructible, even though 1-reconstructibility of all regular graphs (with at least three vertices) is an easy exercise.

Of particular interest is the threshold on n to guarantee ℓ -reconstructibility of n -vertex trees. It is known that $n \geq 6\ell + 11$ suffices, and it is conjectured that generally $n \geq 2\ell + 1$ suffices, with small exceptions. The second part of the talk will present some of the ideas used in a recent proof that in general for caterpillars $n \geq 2\ell + 1$ suffices and is best possible (caterpillars are the trees in which deleting the leaves produces a path).

The Autonomy Paradox: Governing the Computationally Gray Areas for a Domain-Focused, Human-Centered Agentic AI

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Abstract

Today, we stand at the precipice of a new era in computational history. Soon, billions of interconnected AI agents will autonomously negotiate global supply chains, manage critical infrastructure, and drive enterprise productivity. Yet, the foundation of this future is currently built on a profound paradox: we are attempting to govern highly probabilistic, multi-dimensional AI models using the brittle, deterministic, and binary rules of legacy software.

When Agentic AI is forced into rigid binary constraints, it fails catastrophically. It confidently hallucinates, fails at the edge cases, and creates unmanageable risk profiles that terrify regulators and compliance officers alike. Historically, the AI industry has attempted to govern Large Language Models (LLMs) and Reinforcement Learning (RL) agents using rigid software structures like standard Semantic Graphs, binary kill-switches, or oversimplified symbolic surrogates. However, traditional symbolic distillation approaches, such as decision trees, partition state spaces into hyper-rectangles with constant action outputs, failing to capture the smooth, continuous dynamics required for autonomous control. This "binary despair" leads to severe value leakage, stalling enterprise AI adoption due to inadequate Trust, Risk, and Security Management.

This talk, celebrating the 50th anniversary of Fuzzy Graph Theory, explores how the mathematical language of Fuzzy Logic could solve our most urgent AI crisis. We introduce a paradigm shift via the SMARTAutonomy framework - Stable, Meta-Cognition, Assisted, and Regulated for revoked Autonomy. This framework transitions AI governance from deterministic structures into a fluid architecture, establishing geometric boundaries for authorized agent behaviors. For example, we can leverage a Hierarchical Takagi-Sugeno-Kang (TSK) Fuzzy Classifier System to distill opaque neural policies into human-readable IF-THEN rules. By utilizing K-Means clustering for state partitioning and Ridge Regression for local action inference, the framework can enable smooth interpolation across continuous action spaces, fundamentally overcoming the discretization issues of legacy symbolic methods. Furthermore, employing triangular membership functions yields highly focused, sparse rule activations, making internal logic transparent and semantically meaningful to human auditors. Under such a framework, AI safety is no longer a qualitative guessing game. It can operationalize enterprise trust by novel, quantifiable explainability metrics such as: Fuzzy Rule Activation Density (FRAD) to measure explanation focus, Fuzzy Set Coverage (FSC) to validate vocabulary completeness, and Action Space Granularity (ASG) to assess control mode diversity. Empirical evaluations reveal a 'less is more' phenomenon, demonstrating that

complex neural policies can be distilled into as few as four dominant fuzzy rules for each of these states, while achieving over 97% behavioral fidelity.

This mathematical rigor transforms compliance into a formally guaranteed reality, providing the exact quantifiable metrics required by global regulations like the NIST AI RMF and the EU AI Act. By cohesively integrating these principles, we transition from the rigid mechanics of pure probability to the fluid intelligence of multi-phased plausibility. This evolution grants AI agents the mathematical degrees of freedom necessary to bypass binary despair and act with safe, domain-focused, governed intuition.

Keywords: Agentic AI Governance, SMARtAutonomy Framework, Explainable AI, Trust, Risk, and Security Management

Book:

1. **Srini Ramaswamy**, “AgenticAI Beyond Patterns: Human-Centered, Domain-Driven Governance of Critical Infrastructures”, ISBN-13 979-8241494665, 2025

On the m -graph of a finite abelian group

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Abstract

Let H be a finite abelian (commutative) group of order $n \geq 2$ and $m > 1$ be an integer. We define the m -graph of H , denoted by $m-G(H)$, as a simple undirected graph with vertex set H , and two distinct vertices, $a, b \in H$, are connected by an edge if and only if $a^m = b$ or $b^m = a$. Several results regarding the properties of the $m-G(H)$ have been established.

Keywords: graphs from rings, graphs from groups, trees, diameter, power graph.

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On the Sum of the k Largest Eigenvalues of Adjacency and Laplacian Matrices of Graphs with Applications to Brouwer's Conjecture

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(joint work with Shaowei Sun and Yaping Min)

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Abstract

In this talk, we present some upper bounds on the sum of the k largest eigenvalues of both the adjacency matrix and the Laplacian matrix of graphs. Furthermore, these results are extended to the broader setting of symmetric matrices. When applied to the adjacency matrix of a graph, our bounds improve upon the related results of Mohar [On the sum of k largest eigenvalues of graphs and symmetric matrices, *J. Combin. Theory Ser. B* 99 (2009) 306–313]. In addition, for the Laplacian matrix, we establish that Brouwer's well-known conjecture holds for small values of k for almost all graphs, thereby providing a meaningful step toward its complete resolution.

Keywords: Graph, Symmetric matrix, Eigenvalue sum, Adjacency matrix, Laplacian matrix.

Ferrers Diagrams in the Spectral Analysis of Threshold Graphs

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Abstract

We explore the relationship between the Ferrers diagram associated with the degree sequence of a threshold graph and the spectra of its Laplacian and signless Laplacian matrices. In particular, we examine how structural features encoded in the Ferrers diagram correspond to key spectral properties of the graph. We further extend this framework to weighted threshold graphs, demonstrating that analogous spectral patterns and relationships persist in the weighted setting.

The Hamiltonian Index of a Graph

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Abstract

The line graph $L(G)$ of a graph $G = (V, E)$ is a graph whose vertices are the edges of G , with two of these vertices being adjacent if the corresponding edges are adjacent in G . The iterated line graph $L^k(G)$ is defined by $L^1(G) = L(G)$ and $L^{k+1}(G) = L(L^k(G))$. The hamiltonian index $h(G)$ of G where G is not a path, is the least positive integer r such that $L^r(G)$ is hamiltonian. In this talk we present a survey of results on $h(G)$ and a characterization of trees with hamiltonian index 2.

Applications of Graph Theory in Modelling of Ecosystem

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Abstract

This presentation explores the application of graph theory in modelling ecological systems, with particular emphasis on food webs. Ecosystems consist of complex interactions among species that can be effectively represented as directed, weighted graphs, where vertices denote species and edges represent predator–prey relationships. The study demonstrates the use of food web construction, including weighted and fuzzy graph models, to capture variability and uncertainty in ecological interactions. A pond ecosystem and a marine ecosystem are used to illustrate these concepts. The notion of competition graphs is introduced to analyse inter-species competition based on shared resources. Furthermore, the adjacency matrix representation of food webs is used to compute the graph's energy, providing insight into the ecosystem's structural properties. The work highlights how graph-theoretic tools offer a systematic framework for analysing ecological balance, species dependency, and the impact of species removal. Finally, future research directions include fuzzy modelling of uncertain species populations and energy transfer mechanisms in ecological networks.

Keywords: Food web, Fuzzy graph, Competition graph, Graph energy

Wirelength of Embeddings in Networks

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Abstract

Graph or Network embedding is widely used to model how one network structure can be efficiently simulated within another. In practical terms, embedding provides a systematic way to map a guest graph (representing a problem or application) into a host graph (representing a physical network or architecture), while preserving connectivity and minimizing communication cost.

Formally, the embedding of a graph G into another graph H is defined as a pair (f, P_f) , where f is a one-to-one mapping from the vertex set of G to the vertex set of H , and P_f maps each edge of G to a path in H connecting the corresponding mapped vertices. This ensures that adjacency relationships in the guest graph are maintained through paths in the host graph.

The quality of an embedding is evaluated using three important parameters: dilation, congestion, and wirelength. Dilation measures the maximum length of the paths assigned to edges of the guest graph, reflecting communication delay. Congestion represents the maximum number of guest edges routed through a single edge of the host graph, indicating load or traffic bottlenecks. Wirelength is the total length of all such paths and serves as a global measure of communication cost.

Graph embedding has significant applications in computer science, particularly in the simulation of parallel algorithms and interconnection networks. Many complex architectures such as hypercubes, grids, cylinders, and tori can be analyzed through embedding techniques. By embedding a complex network into a simpler structure, it becomes easier to study routing, communication efficiency, and scalability.

Recent research focuses on computing optimal wirelength for embedding graphs into various network topologies such as paths, cycles, wheels, hypertrees, and circulant graphs. Theoretical results such as the Congestion Lemma and Partition Lemma provide efficient ways to determine optimal embeddings. These methods reduce computational complexity and make embedding analysis feasible even for large-scale networks. Overall, graph embedding is a powerful tool for understanding and optimizing communication in networks.

On Hermitian Randić Matrix of Second Kind

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Abstract

In this communication, we define the Hermitian Randić matrix of second kind of a mixed graph, and study some properties of its eigenvalues and energy. This new matrix involves the sixth root of unity, ω . This matrix is defined using the sixth root of unity, ω , which arises naturally in combinatorial contexts due to the relations $\omega \cdot \bar{\omega} = 1$ and $\omega + \bar{\omega} = 1$. The product of “weights” of edges is natural with the counting of closed walks and similarly the sum is needed when dealing with multiple arcs or with weighted edges.

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Different Types Of Incidence Structures In Fuzzy Graph Theory

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Abstract

Zadeh [4] introduced fuzzy logic in 1965 as a paradigm shift from classical two valued Aristotelian logic. Kaufmann [2] introduced fuzzy graphs in 1973 and Rosenfeld [3] successfully introduced the basic concepts in 1975. Several related structures like fuzzy digraphs, bipolar fuzzy graphs, intuitionistic fuzzy graphs, etc. were also introduced and studied in recent times. Dinesh [1] introduced the concept of fuzzy incidence graphs recently. This presentations aims to introduce the basic concepts in fuzzy incidence graphs and fuzzy influence graphs. Incidence structures are relevant when we have illegal flows in networks, like illegal trafficking paths. Basic concepts like illegal pairs, illegal and legal flows, flow enhancing and reducing nodes, etc. will be discussed. Directed fuzzy incidence graphs are also characterized. Legal fuzzy incidence blocks will be analyzed and famous max flow min cut theorem will be generalized for directed fuzzy incidence graphs.

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Total Domination and Algorithms

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Abstract

A total dominating set is a subset of vertices where every vertex in the graph has at least one neighbor within that set. The presentation details the Heuristic Total Domination (HTD) algorithm by A Henning and Anders Yeo, and provides a formal proof for its upper bound.

On the eccentricity energy of various graph products

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Abstract

The eccentricity matrix $E(G)$ of a graph G is constructed from the distance matrix $D(G)$ by only retaining the leading values in each row and each column and setting the rest of the elements in the corresponding row and column to zero. The paper aims to study the concepts of energy and the inertia of the eccentricity matrices of graphs obtained by means of various graph products, like the strong product and the Cartesian product and well-established relations are derived in terms of their base graphs. Furthermore, we construct infinitely many pairs of non-isomorphic graphs having the same set of eigenvalues with respect to the eccentricity matrix.

Keywords: Cartesian product, strong product, inertia, eigenvalues.

Stress Centrality of Some Graph Operations

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Abstract

Centrality measures are the tools used in most network analysis to rank the vertices of the network. Depending on different perspectives, many important centrality measures are defined and used for network analysis. Stress is one such important centrality measure of graphs applicable to the study of social and biological networks. Stress centrality evaluates the importance of a node by counting how many shortest paths pass through it. A node with higher stress centrality tends to be the one that plays a critical role in connecting different parts of the network, as it lies on a large number of shortest paths between other nodes. In this article, we obtain the stress centrality of vertices in the product graphs with reference to the unary operations, namely the splitting graph and the shadow graph. Further, we have given the expressions for the total stress of a few standard classes of graphs with respect to these operations.

Keywords: Shortest path; splitting graph; shadow graph.

Subclasses of Bipartite Graphs Preserving Word-Representability Under Complement Operation

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Abstract

A graph $G(V, E)$ is *word-representable* if there exists a word over the alphabet V such that two distinct letters *alternate* in the word if and only if they are adjacent in G . In the book *Words and Graphs*, the authors show that word-representability is not closed under *complementation*. For example, bipartite graphs are word-representable, but their complements, called *co-bipartite graphs*, are not necessarily word-representable. This motivates the problem of identifying graph classes whose complements remain word-representable. Such classes are important because the maximum independent set problem can be solved in polynomial time, since the maximum clique problem is known to be polynomial-time solvable for word-representable graphs. In this paper, we provide an affirmative answer for certain subclasses of bipartite graphs. We prove that complements of *path graphs*, *even cycle graphs*, and *generalised crown graphs* are word-representable. Furthermore, we obtain word-representations for *well-partitioned chordal co-bipartite graphs*.

Keywords: Word-representable graph, Co-bipartite graph, Generalized crown graph, Well-partitioned chordal graph.

Adjacency eigenvalues of tennis racket graphs: computation, analysis, and applications

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Abstract

Spectral graph theory and algebraic combinatorics are some areas where the spectral properties of graphs play a crucial role in understanding the structural and combinatorial properties of graphs. In this paper, we define a new class of graph, known as the tennis racket graph. The adjacency spectrum of the tennis racket graph is determined, and the spectral radius is analyzed separately. Combinatorial methods and the concept of expected eigenvectors are used to determine the entire adjacency spectrum of this new class of graphs. This paper not only determines the eigenvalues but also provides explicit constructions for the eigenvectors, thereby providing a complete characterization of the spectra. The graph energy is calculated based on the spectrum, and its behavior with respect to varying graph parameters is analyzed. Additionally, a statistical analysis of graph energy is conducted to determine the trends and sensitivity of graph energy to structural variations. These spectral results also provide insights into potential applications of the graph in network connectivity analysis, communication systems, and chemical graph theory.

Keywords: Graph spectrum, Tennis racket graph, adjacency matrix, eigenvalues, graph energy.

General Degree Product Energy of Graph Operations

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Abstract

Let G be a simple connected graph with n vertices and m edges. In this paper, we introduce the general degree product matrix and define the corresponding general degree product energy of a graph G . We compute the general degree product energy for several new families of graphs derived from a given base graph, including duplication graphs and R -graphs. Furthermore, we introduce new corona-type graph operations based on the middle graph and determine the general degree product energy for these newly defined graph constructions.

Keywords: Degree product matrix, duplication graph, R -graph, middle graph.

Total Rainbow Antimagic Coloring of Comb-Related Graphs

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Abstract

A vertex and edge of a graph are defined through a bijective function $f: V(G) \cup E(G) \rightarrow \{1, 2, 3, \dots, |V(G) + E(G)|\}$ and the total rainbow path occurs with respect to the arbitrary pair of vertices, which is defined as the edge weight and internal vertex weights having a distinct color and the edge weight being obtained as $w_f(e) = f(e) + f(p) + f(q)$, where p and q are vertices incident with e is known as Total Rainbow Antimagic Coloring. The vertex weight is obtained as $w_f(p) = f(p) + \sum_{e \in E(G)} f(e)$, where $e \in E(G)$ is the set of edges incident with p. The Total Rainbow connection number, denoted as $\text{trac}(G)$ is the smallest color required to achieve coloring. This work derives the Total Rainbow Antimagic Coloring for a path, comb graph and double comb graph and also derives Total Rainbow Coloring for comb and double comb graphs.

Keywords: Total Rainbow Antimagic Coloring, Comb Graph, Path, Total Rainbow Coloring.

Fuzzy Domination Number of Honeycomb Networks

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Abstract

Honeycomb networks $HC(n)$ are graphs formed by hexagonal tessellations and are widely used to model communication systems, chemical structures, and biological networks due to their regular and symmetric architecture. In this paper, we derive an explicit formula for the domination number of $HC(n)$ by analysing its combinatorial structure and neighbourhood properties. The domination number represents the minimum number of vertices required to control the entire network. To incorporate uncertainty, we extend this study using fuzzy set theory. In the fuzzy model, vertices and edges are assigned membership values in the interval $[0, 1]$, representing varying node activity and connection reliability. Based on strong edge concepts, we define fuzzy dominating sets, effective dominating sets, strong dominating sets, and α -strong dominating sets. A method is developed to compute the fuzzy domination number by minimizing the total membership value required for energy-efficient network design. This approach supports lower power consumption in next-generation wireless and sensor networks and ensures reliable network performance under uncertainty.

Keywords: Honeycomb graphs, Dominating set, Fuzzy domination number, α -strong dominating set.

Burning Number of Flower snarks and Benzenoid Structures

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Abstract

Graph Burning is a discrete deterministic time model for the propagation of social contagion on a graph. A graph with vertices representing individuals and edges representing relationships may be used to simulate a social network. The result of sharing videos, memes with friends on social media platforms like Facebook and Instagram, a node is quickly impacted by its neighbors. At first a node is affected by a single friend. But as the propagation process progresses, several nodes are affected by numerous user friends. The network structure which is at play determines the rate of spread. Graph Burning is a technical approach that calculates the number of steps the shared data has taken to traverse the network. In chemistry a molecule's edges represent its chemical bonds, while its vertices represent its atoms. The graph obtained is known as chemical graph. In this paper we have found the burning number of flower snarks and benzenoid structures like linear chain benzenoid, triangular benzenoid.

Keywords: Burning, benzenoids, contagion, flower snarks, network.

Dynamic and Fault-Tolerant k-Tuple Locating-Domination in Transportation Networks

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Abstract

This paper introduces a framework for k-Tuple Locating-Domination in transportation networks to address the limitations of classical domination model. A k-Tuple Locating-Domination set ensures that each vertex is uniquely identified and covered by at least 'k' vertices, providing redundancy and structural resilience. We establish theoretical bounds on the minimum size of k-tuple locating-dominating sets, applicable to network designs, and also propose an algorithmic method for dynamic transportation networks. The applications include strategic placement of emergency services, design of resilient traffic sensor networks, and adaptive smart mobility systems. This study aims to deepen our understanding of fault-tolerance in directed networks and provide practical and resilient solutions to maintain the functionality and observability of crucial transportation systems.

Keywords: k-Tuple Locating-Domination, Dynamic Transportation Networks, Fault-Tolerant Systems

Properties of Finite Dimensional Complex-valued Fuzzy Normed Linear Spaces

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Abstract

In this paper, we investigate some basic properties of finite dimensional complex-valued fuzzy normed linear spaces. The notion of complex-valued fuzzy normed linear space is an extension of the idea of fuzzy normed linear space by making use of the concept of complex-valued t-norm and complex-valued fuzzy set. One fundamental lemma in complex-valued fuzzy normed linear spaces is established which is analogous to the lemma used to study different results in finite dimensional normed linear spaces. We prove that every finite dimensional complex-valued fuzzy normed linear space is complete with the help of this lemma. Finally it is shown that a closed and bounded set is compact in a finite dimensional complex-valued fuzzy normed linear space.

Keywords: Complex-valued fuzzy normed linear space, Complex-valued t-norm, Compact set, Finite dimensional lemma.

A Study of Unary Graph Operations on the Clutch Graph $Cl_{3n}(G)$

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Abstract

This paper explores unary graph operations on clutch graphs. Fundamental graph transformation operations, including vertex deletion, edge deletion, contraction, and subdivision, are systematically examined. In addition, derived graph constructions such as the complement, graph powers, line graph, and total graph are investigated. For each operation, the resulting vertex and edge sets are explicitly characterized and the corresponding changes in key structural properties, such as connectivity, planarity, girth, Hamiltonicity, and degree distribution are analyzed. Representative examples are provided to illustrate the structural variations induced by these transformations.

Keywords: Clutch graph, vertex deletion, edge deletion, contraction, subdivision

Analysis of an M/M/1 Retrial Queue with Two-Way Communication and Hybrid Vacation Policy

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Abstract

This study considers a single-server retrial queue with two-way communication and a hybrid vacation policy. An arriving incoming call that finds the server busy joins the orbit and retries after a random time. If the server is free, service begins immediately, and the service time follows an exponential distribution. After completion of a service, the server checks whether the orbit is empty. If the orbit is empty, the server takes a working vacation with probability p and a complete vacation with probability q . If the orbit is not empty, the server becomes idle. During the idle period, the server may initiate outgoing calls, whose service times follow an exponential distribution. The condition for stability is established, and the system state distribution is computed. Several performance measures influencing system efficiency are derived and illustrated graphically and numerically.

Keywords: Single server, Retrial queue, Two way communication and Hybrid vacation policy.

R-S Correspondence of Edge Colored Partition Algebras

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Abstract

We study the G -edge colored diagram algebra $\overrightarrow{P}_k(x, G)$, which is the centralizer algebra of the group $G \wr S_n$ on the tensor space W . In this paper, we provide the *Robinson–Schensted correspondence* of $\overrightarrow{P}_k(x, G)$, which gives a bijection among the edge-colored diagrams and the pair of multi-vacillating tableaux of the shape. In addition, we derive the Knuth relations for the G -edge colored diagram algebras.

Keywords: Partition algebra, R-S correspondence, Wreath product, Young tableaux.

Quantifying Miner Node Fragility: A Multi-Phase Stochastic Model of Blockchain Reliability under Volatility-Driven Arrivals

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Abstract

This research presents a novel reliability-aware MAP/PH/1 framework designed to quantify the operational fragility of blockchain miner nodes. Recognizing that idealizing miners as "always-online" entities leads to significant latency underestimation, we propose a three-phase service process integrated with a Volatility-Driven Markovian Arrival Process (MAP). The model explicitly characterizes the stochastic transitions between computational hashing (P_1), logical verification (P_2), and network propagation (P_3). Unlike traditional models, this framework incorporates a disruptive failure and repair cycle in the hashing phase and a dual-exit logic for propagation. Specifically, we introduce a Byzantine Retry Mechanism governed by a Retry Analyzer to simulate network resilience, alongside a Complete Failure path that triggers a global system restart. By mapping market-induced transaction surges (CVI-driven) to internal hardware and network vulnerabilities, this study provides a granular view of "wasted computational effort." Numerical results demonstrate that the interplay between Byzantine re-stimulation and logical satisfaction thresholds is critical for maintaining mempool stability in decentralized environments.

Keywords: Volatility-Driven MAP, Byzantine Retry Mechanism, Operational Fragility, PH-Type Service Process, Wasted Computational Effort, Mempool Stability Analysis

Topology-Aware Nodal Classification for Intelligent Optimization of Smart Warehouse Logistics Systems

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Abstract

Modern logistic networks operate in a turbulent logistics ecosystem where traditional deterministic models often struggle to capture the vagueness. The smart warehouse logistics network is analyzed by an advanced fuzzy graph-based framework to address the limitations. This proposed framework integrates fuzzy topological indices of fuzzy graphs with intelligent nodal classification. The vertices of the fuzzy graph are defined by warehouses, distribution centers, and transfer hubs, and the edges are based on transportation and material handling connections. The systemic uncertainties are captured by these edges. The proposed methodology incorporates three structural measures to address the local connectivity, global transportation efficiency, and cascading operational effects across interconnected logistics units. The nodes are classified into distinct functional categories by using a fuzzy inference system, and the complex relationships among networks are preserved by this approach effectively. This model provides a scalable and explainable decision-support tool for smart logistics optimization.

Keywords: Fuzzy Wiener index, Logistics networks, Nodal classification, Fuzzy inference system, Decision support

Detecting Subtle Query Tampering in Cloud-Based Healthcare Systems Using Hybrid Quantum Learning

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Abstract

It is crucial to identify slight query tampering in cloud-based healthcare systems because even little, unauthorized changes to the answers to medical queries might have a negative impact on clinical decision-making in real time. Cloud platforms make it possible to access healthcare data efficiently, but the absence of direct control over servers that are outsourced raises severe questions about data integrity and trust. While traditional machine learning models frequently miss low-magnitude semantic perturbations, current cryptographic authentication methods have a substantial computational burden and are not appropriate for real-time applications. This research suggests a hybrid authentication approach based on quantum learning to identify modest query manipulation in cloud-based healthcare systems, therefore addressing these constraints. Feature representations with high dimensions are produced by converting healthcare query attributes into compact digital signatures and encoding them into parameterized quantum circuits. After that, a traditional deep learning classifier separates tampered and genuine inquiries. Compared to traditional methods, experimental results show better authentication performance.

Keywords: Cloud-Based Healthcare Systems, Query Authentication, Subtle Tampering Detection, Hybrid Quantum Learning, Real-Time Data Integrity

Super Edge-Magic Total Labeling of Triangular Ladder Graphs

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Abstract

A super edge-magic total labeling of a graph $G = (V, E)$ with $p = |V|$ and $q = |E|$ is a bijection $f: V(G) \cup E(G) \rightarrow \{1, 2, 3, \dots, p + q\}$ such that $f(V) = \{1, 2, 3, \dots, p\}$ and for every edge $xy \in E(G)$ $f(x) + f(xy) + f(y) = k$ (a constant). In this paper we prove that the triangular ladder graph TL_{2n} admits a super edge-magic labeling for all $n \geq 2$. A constructive labeling is provided together with explicit examples and verification. This extends known results on triangle based ladder families and contributes a new class of super edge-magic graphs.

Keywords: Graph labeling, Magic constant, Edge-magic total labeling.

Centrality Measures in Streaming Graphs: A Survey

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Abstract

Centrality measures play a fundamental role in analyzing the structural importance of vertices and edges in complex networks. They identify influential nodes, critical connections and key components across domains such as social, communication, biological and transportation networks by capturing how information or resources flow. Measures such as degree, betweenness, closeness, and eigenvector centrality reveal hubs, highly reachable nodes and influential connections. Although centrality has been extensively investigated in static networks, many real-world systems are inherently dynamic and are better modeled as streaming graphs, where structural changes can occur and require adaptive analytical techniques. Recent studies have proposed algorithms to address these challenges; however, comprehensive surveys and comparisons remain limited. This work presents a survey of centrality measures in streaming graph models and provides a comparative analysis based on time complexity, space requirements, update mechanisms and performance, highlighting challenges and future research directions.

Keywords: Centrality measures, Streaming graphs, Vertex stream, Edge stream, Complexity

A Fuzzy Graph-Theoretic Framework for Detecting Distributed Financial Evasion Structures

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Abstract

Financial evasion strategies, like smurfing and laundering, utilize fragmented transactions to bypass traditional detection. Binary graph representations often fail to capture the indirect coordination and behavioural similarities inherent in these flows. This paper proposes a fuzzy graph-theoretic framework for modelling transaction networks, where edge membership values in the interval $[0, 1]$ represent relational strength based on temporal proximity, magnitude similarity, and structural patterns.

We define a fuzzy transaction graph $G_f = (V, A_f)$ and introduce adapted invariants, including fuzzy clustering coefficients, weighted degree distributions, and Laplacian-based spectral characteristics. Our results demonstrate that evasion patterns induce unique signatures within the fuzzy graph's spectrum and centrality distributions. By offering a mathematically rigorous alternative to binary modelling, this framework enables the detection of distributed evasion structures without heavy reliance on statistical learning. This work advances fuzzy graph theory as applied to uncertainty-aware relational systems in real-world financial networks.

Keywords: Fuzzy Graphs, Spectral Graph Theory, Financial Evasion Detection, Network Analysis, Graph Invariants.

Planarity-Based Stability Analysis of Urban Flood Drainage Networks Using Planar Linguistic Z-Graphs

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Abstract

Urban flood management in rapidly growing metropolitan cities requires models capable of handling uncertainty, spatial complexity, and intersection-based vulnerability. In this paper, the theory of planar linguistic Z-graphs (PLZGs) is applied to analyze the stability of an urban drainage network in Kolkata. Drainage junctions are represented as vertices, while canals and pipelines are modeled as edges embedded in a planar structure. Linguistic Z-numbers are assigned to edges to incorporate uncertainty in blockage intensity and reliability of assessment. An edge-strength measure is introduced to classify drainage segments into α -strong, β -strong, and weak categories. To capture hydraulic stress at junctions, an intersection value is defined as the average strength of intersecting edges. Based on the cumulative intersection strength, a global planarity index is proposed to evaluate the structural stability of the drainage network. The framework helps identify critical overflow points and weak drainage segments, supporting infrastructure planning under uncertainty and improving urban flood resilience.

Keywords: Fuzzy graphs; Z-number; Fuzzy planar graphs; Dual of planar graphs; Linguistic Z-graphs.

Weighted Arithmetic and Geometric Aggregation Operators for Interval-Valued Bipolar Picture (S,T)-Fuzzy Graphs

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Abstract

Uncertainty and intricate interactions between decision entities are common components of decision-making challenges. Such relational uncertainty may not be well captured by traditional aggregation-based methods created under fuzzy set frameworks, which often presuppose independence among possibilities. In order to solve this problem, a new aggregation framework based on Interval-Valued Bipolar Picture (S,T)-Fuzzy Graphs is proposed in this paper. This framework allows uncertainty and interdependence to be modeled together. In this structure, interval-valued bipolar picture fuzzy information is combined with graph topology using two graph-based aggregation operators called the Weighted Arithmetic and Weighted Geometric operators. The operators reflect optimistic and cautious aggregation tendencies by using suitable S-norms and T-norms. To ensure mathematical validity, a number of theoretical qualities are developed, such as closure, idempotency, boundedness, monotonicity, and consistency with fuzzy graph constraints. The viability and efficiency of the suggested aggregation architecture are illustrated numerically.

Keywords: Interval-Valued Bipolar Picture Fuzzy Graphs, Weighted Arithmetic Operator, Weighted Geometric Operator, S-norm and T-norm, Graph-Based Aggregation.

A Novel Group Decision-Making m -Polar Neutrosophic ELECTRE I Approach with Dombi Power Aggregation Operators

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Abstract

This article introduces a novel multi-attribute group decision-making (MAGDM) approach by integrating m -polar neutrosophic Dombi power aggregation operators with the well-known Elimination and Choice Translating Reality (ELECTRE) I method. Existing ELECTRE I approaches are effective for precise, fuzzy, or multi-polar data but have limitations in handling incomplete, indeterminate, and inconsistent information characterized by truth, indeterminacy, and falsity values. Moreover, many existing operators for m -polar fuzzy sets lack flexibility and may produce biased results. To address these issues, this study proposes new m -polar neutrosophic Dombi power aggregation operators, including averaging and geometric forms, and analyzes their fundamental properties. A MAGDM framework based on these operators is developed to select the best global e-learning website. Comparative analysis demonstrates that the proposed model improves flexibility, reliability, and decision accuracy over existing methods.

Keywords: m -polar fuzzy neutrosophic set, Dombi power aggregation operator, Group decision-making, ELECTRE I approach, E-learning website.

Decision Graphs: Compact Graph Models for Decision-Making

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Abstract

Decision Graphs are proposed as a compact graph-theoretic alternative to decision trees for decision sciences where choices, uncertainty, and outcomes repeat across contexts. A Decision Graph is a directed, labeled graph with decision, chance, and value nodes; identical sub-decisions can be merged instead of copied. We introduce a “bunch graph” technique that groups frequently reused subgraphs into identifiable bunches (modules) and replaces them with macro-nodes, enabling fast editing, clearer communication, and scalable computation. Evaluation is performed by propagating expected value through acyclic parts and solving loops by strongly connected component decomposition and fixed-point updates, so iterative “act–observe–revise” processes remain well-defined. For optimization, we exploit graph cuts and bunch-level sensitivity scores to locate the few modules that drive utility, risk, or cost. Illustrations in exception handling and adaptive resource allocation show large reductions in model size while preserving decision quality and interpretability. This framework supports multi-criteria robustness under scenario stress tests.

Keywords: Decision graph, Decision making, Bunch graph, Compact graph.

Evaluating Fuzzy Similarity Measures for Quantum State Deviation Detection in Noisy Quantum Environments

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Abstract

Quantum computing systems operating on real hardware are inherently affected by noise, making accurate assessment of quantum state deviation a critical challenge. This study evaluates five normalized fuzzy similarity measures — Hamming, Euclidean, Cosine, Hausdorff, and Minkowski — for detecting deviations between ideal and noise-affected quantum states. Grover's search algorithm and the Bernstein-Vazirani algorithm were implemented using Qiskit and executed on IBM quantum hardware (ibm_kyiv, ibm_brisbane) as well as QASM simulators. State vector outputs were extracted and compared using each measure to quantify the impact of hardware noise. Results indicate that the Normalized Hamming similarity measure (M1) demonstrates superior robustness and consistency across both algorithms and noise conditions. This work establishes a fuzzy-theoretic framework for noise characterisation in quantum systems, with implications for quantum error mitigation and the benchmarking of near-term quantum devices..

Keywords: Quantum Computing, Quantum States, Quantum Fuzzy Set, Fuzzy Similarity Measure

A Study on Linguistic Z-threshold Graphs

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Abstract

The threshold graph is a well-established concept in graph theory, known for its structural simplicity and wide applicability. In this study, we introduce the notion of a Linguistic Z-threshold graph (LZTG) by incorporating the concept of linguistic Z-numbers. By using Score function we convert both uncertainty and reliability of Linguistic Z-number into a single numerical value. We define key graph-theoretic elements under this framework, such as L-stable sets, L-cliques, L-isolated vertices, L-dominating vertices, and L-alternating 4-cycles. Furthermore, we discuss L-threshold dimension and L-split graphs. Like classical threshold graphs, we investigate structural properties and derive significant results for LZTGs. One key finding is that an LZTG can be constructed from a single vertex by iteratively adding either an L-isolated vertex or an L-dominating vertex. Consequently, every LZTG is an L-split graph. This study lays the foundation for extending classical graph theoretical ideas to a linguistic and uncertain environment, enhancing their applicability in real-world scenarios involving vague or imprecise information.

Keywords: Threshold Graph, Linguistic Z-number, LZTG, L-stable Set, L-clique, L-isolated Vertex, L-dominating Vertex.

A note on Sombor index of unicyclic graphs with fixed domination number

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Abstract

The Sombor index, introduced by Gutman in 2021, is a new vertex- degree-based topological index defined as

$$SO(G) = \sum_{uv \in E(G)} \sqrt{d_u^2 + d_v^2}$$

where d_u and d_v denote the degrees of the vertices u and v in a simple connected graph G . Determining sharp bounds of the Sombor index for specific graph classes has become an active research area due to its structural and chemical significance. In this work, we address one of the open problems posed by Alidadi *et al.* concerning the extremal behaviour of the Sombor index in unicyclic graphs with fixed domination number. We derive a sharp upper bound for the Sombor index of unicyclic graphs with fixed domination number and characterize the class of graphs attaining this bound.

Keywords: Sombor index, Domination number, Unicyclic graph.

Matrix-Analytic Analysis of a MAP/PH/1 Queuing–Inventory System with Opportunistic Replenishment and Server Vacation

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Abstract

This study extends opportunistic queuing inventory models by incorporating server vacation into a MAP/PH/1 framework. Customer arrival follows a Markovian Arrival Process (MAP), allowing correlated inter-arrival times, while service times are follows phase-type (PH) distributions. Customer demands occur in batches and deplete inventory upon allocation. Replenishment opportunities arise according to a Poisson process. The joint dynamics of queue length, inventory level, arrival phase, service phase, and vacation state are formulated as a structured quasi-birth-and-death (QBD) process. Matrix-analytic methods are employed to derive stability conditions and obtain the steady-state distribution in matrix-geometric form. Performance measures including mean system size, loss probability, mean inventory level, server utilization, and vacation frequency are evaluated. Numerical illustrations demonstrate how server deterioration significantly influences congestion and stock-out behavior under opportunistic replenishment policies.

Keywords: Queuing–inventory system; MAP arrivals; PH service; Opportunistic replenishment; Server vacation; QBD process; Matrix-geometric solution; Performance measures.

Fuzzy Graph Theory: A Bibliometric Review on The Golden Anniversary

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Abstract

In 2025, fuzzy graph theory celebrates the 50th anniversary. Motivated by this event, this article describes a detailed development of fuzzy graphs by critical analysis with various modifications over fifty years. Fuzzy graph is a branch of mathematics that started with a famous work by Azriel Rosenfeld in 1975. The database from the Web of Science Core Collection for several indicators related to bibliometric analysis like keyword occurrence, country productivity, institutional productivity, and bibliographic coupling to represent this article with an evolving and dynamic academic landscape in fuzzy graph theory. The intention is to identify “Fuzzy Graph Theory”’s prevailing trends in authors, highly cited documents, countries, journals, keywords, topics, and universities. This article also provides a graphical mapping using the VOSviewer software for several bibliometric materials. Asia, Europe, North America played an efficient role in a wide growth in the past years.

Keywords: Bibliometrics; Web of Science; Graph Theory; Fuzzy Graph Theory; VOSviewer.

On the spectral analysis of superpower graph of the direct product of dihedral groups

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Abstract

The superpower graph S_Γ of a finite group Γ is defined as a simple undirected graph whose vertex set consists of the elements of Γ , where two distinct vertices $a, b \in \Gamma$ are adjacent if and only if the order of one divides the order of the other, that is, $o(a)|o(b)$ or $o(b)|o(a)$. In this paper, we examine the A_α -adjacency spectral properties of the superpower graphs corresponding to the groups $D_p \times D_p$, D_{p^k} , D_{pqr} , and D_{p^2q} , where p, q , and r are prime numbers. We explicitly determine the adjacency, Laplacian, and signless Laplacian spectra of these graphs. Consequently, we prove that the superpower graphs of $D_p \times D_p$ and D_{p^k} are Laplacian integral.

Keywords: A_α -adjacency matrix; Laplacian Matrix; Eigenvalues; Power Graph; Dihedral group.

Enhancing Multi-Criteria Decision Making with Interval-Valued Plithogenic Fuzzy Forest Hypersoft Sets with Plithogenic Fuzzy Contradiction

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Abstract

Plithogenic based decision making approaches offer greater flexibility and adaptability when it comes to handling various attributes. This paper introduces the concept of the Interval Valued Plithogenic Fuzzy Forest Hypersoft Set (IVPFFHS) and proposes a decision-making model that revolves around IVPFFHS representations. By incorporating the Plithogenic framework which emphasizes decision making through contradictions into the newly introduced IVPFFHS structure, a powerful and scalable method is developed for managing complex attributes and their corresponding sub-attributes. The proposed integrated method is demonstrated through a case study focused on selecting suitable traits for new product launching. Key decision criteria are identified, and corresponding IVPFFHS representations are built using the relevant sub-attributes. In this model, each primary trait is represented as a Plithogenic tree within the hypersoft set, consisting of multiple sub-attribute values. Alternatives are evaluated against each criterion to determine their specific rankings, and aggregate scores are calculated to provide an overall ranking. Furthermore, the IVPFFHS framework has potential for integration with other decision making techniques, paving the way for the development of innovative hybrid models.

Keywords: Neutrosophic Sets, Hypersoft Sets, Plithogenic Sets, Interval Valued fuzzy sets, Fuzzy forest hypersoft sets.

Energy and Laplacian Energy of Neutrosophic Graphs

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Abstract

Neutrosophic graphs provide a powerful framework for modeling complex networks. In this paper, we study neutrosophic graphs whose edge weights are represented by neutrosophic numbers. Extending the classical concept of graph energy, which is defined as the sum of the absolute values of the eigenvalues of the adjacency matrix, we introduce and analyze the energy of neutrosophic graphs. Unlike classical graphs, where the number of eigenvalues equals the number of vertices, the adjacency matrix of a neutrosophic graph yields a spectrum whose cardinality is the square of the number of vertices. This distinctive spectral property necessitates a redefinition and careful examination of energy-related measures. Furthermore, we investigate the Laplacian energy of neutrosophic graphs by employing the corresponding neutrosophic Laplacian matrix. Theoretical properties of both energy and Laplacian energy are discussed, highlighting their differences from classical graph invariants. The results presented in this paper contribute to the spectral theory of neutrosophic graphs and provide new tools for analyzing uncertain and indeterminate network structures.

Keywords: Neutrosophic graph; Graph energy; Laplacian energy; Spectral theory

A comprehensive study on balanced m-polar picture fuzzy graphs with application in tourism

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Abstract

This article studies the concept of balanced m-polar picture fuzzy graphs (mPPFGs) and investigates their properties and applications. The paper defines and explores various types of mPPFGs, such as self-complementary mPPFGs, intense mPPFGs, feeble mPPFGs, mild balanced mPPFGs, equally balanced mPPFGs, strictly balanced mPPFGs, and balanced mPPFGs. Furthermore, the paper introduces the concepts of density, arithmetic average density, and geometric average density of mPPFGs. The properties of order and density for balanced mPPFGs are examined in detail, and necessary and sufficient conditions for an mPPFG to be strictly balanced or balanced are provided. An algorithm is designed to determine whether an mPPFG is balanced or not. The article also presents a proof of correctness of the proposed algorithm and analyzes its time complexity. Finally, the paper illustrates an application of balanced mPPFGs regarding selection of hotels in a city according to the requirements of the tourism agencies. This is the first work on mPPFGs for different aspect of the parameters.

Keywords: Picture fuzzy graph, mPPFG, density of mPPFG, balanced mPPFG, mild balanced mPPFG

Design and Performance Evaluation of a Flight Control System for Quadrotor UAVs

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Abstract

Unmanned Aerial Vehicles (UAVs) require reliable and accurate flight control systems to achieve stable and autonomous operation. A flight control system is responsible for maintaining the attitude, stability, and trajectory of the aircraft by processing real-time sensor data and generating appropriate control signals for actuators. This work presents the design and implementation of a flight control system for a quadrotor UAV using inertial sensors and a feedback control algorithm. Sensor data from an Inertial Measurement Unit (IMU) are fused to estimate the roll, pitch, and yaw angles of the UAV. A Proportional–Integral–Derivative (PID) controller is employed to regulate the attitude and ensure stable flight under disturbances. The developed system is implemented on an embedded microcontroller platform and validated through experimental testing. Results demonstrate improved stability, fast response, and reliable performance, making the proposed flight control system suitable for low-cost UAV applications.

Keywords: Unmanned Aerial Vehicle (UAV), Flight Control System, PID Controller, Inertial Measurement Unit (IMU), Sensor Fusion.

Cycle-Valid Matchings and Enumeration of Feasible Exchanges in Kidney Exchange Programs

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Abstract

Kidney transplantation has been widely recognized as an extremely efficient treatment for end-stage renal disease. However, immunological incompatibility between patients and their intended donors sometimes restricts its effectiveness. Kidney exchange programs address this by facilitating mutually advantageous transplants between patients and incompatible donor pairs, which helps to increase transplant opportunities and save lives. Most prior research in this field mainly concentrates on maximizing the overall number of transplants. In contrast, this study investigates kidney exchange through a matching-theoretic perspective, aiming to identify all possible exchanges rather than merely focusing on increasing the number of transplants. This is accomplished by introducing a concept, cycle-valid matching, which finds matchings that form cycles and ensure the participation of patient–donor pairs within valid exchange structures. Additionally, we present a computational approach for determining it using a matching enumeration algorithm.

Keywords: Matching, Cycle-Valid Matching, Directed Graphs, Kidney Exchange, Matching Enumeration.

Developments in the Study of Intuitionistic Fuzzy Outerplanar Framework and their Application in Medical Diagnosis

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Abstract

This work introduces the novel concept of Intuitionistic Fuzzy Outerplanar Graphs (IFOGs) within the framework of intuitionistic fuzzy set theory and establishes fundamental relationships between their associated dual structures. Classical outerplanar graphs are extended to the intuitionistic fuzzy setting, and their structural properties are systematically examined under this generalized perspective. We define and investigate vertex-deleted (VD) and edge-deleted (ED) intuitionistic fuzzy outerplanar subgraphs, along with the notions of maximum and maximal intuitionistic fuzzy outerplanar subgraphs obtained through vertex and edge deletions. Furthermore, the structural interaction between these subgraphs and their corresponding intuitionistic fuzzy dual graphs is analyzed to understand how outerplanar properties are preserved or transformed under intuitionistic fuzzification. All theoretical developments are substantiated through precise definitions, illustrative examples, and rigorously formulated and proven theorems. These contributions collectively establish a comprehensive and robust foundation for future research in the domain of intuitionistic fuzzy graph theory. Finally, Application of Intuitionistic Fuzzy Outerplanar Graphs in Medical Diagnosis

Keywords: Intuitionistic Fuzzy Graphs, Intuitionistic Fuzzy Outerplanar Graphs, VD and ED Intuitionistic Fuzzy Outerplanar Subgraphs, Maximum and Maximal Intuitionistic Fuzzy Outerplanar Subgraphs, Intuitionistic Fuzzy Dual Graphs. Medical Diagnosis

Sigma Coloring of Circulant and Windmill Graphs

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Abstract

Let $G(V, E)$ be a non-trivial, simple, connected graph with vertex set $V(G)$ and edge set $E(G)$. Let $c: V(G) \rightarrow \mathbb{N}$ be a vertex coloring function of G where adjacent vertices may be colored with the same color. For a vertex $v \in V(G)$, the color sum $\sigma(v)$, is defined as the sum of colors of the vertices adjacent to v . The vertex coloring c is called sigma coloring of G if $\sigma(u) \neq \sigma(v)$ for every pair of adjacent vertices u and v in G . The minimum number of colors required for such a coloring is called the sigma chromatic number of G , denoted by $\sigma(G)$. In this article, the sigma chromatic numbers of the circulant graphs $C_n(1,2,3)$ and $C_n\left(1,2,\dots,\frac{n}{2}-1\right)$ are determined. Furthermore, a lower bound for sigma chromatic number of $C_n\left(1,2,\dots,\frac{n}{2}-i\right)$ for some $i \geq 1$ is established. In addition, the sigma chromatic numbers of windmill graph and three types of generalized windmill graphs are obtained.

Keywords: Sigma coloring, sigma chromatic number, color sum, circulant graph, windmill graph.

Roman Domination in Neighborhood Corona Graphs and their Variants

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Abstract

Let $G = (V(G), E(G))$ be a simple connected graph, where $V(G)$ and $E(G)$ denote the non-empty set of vertices and edges, respectively. A Roman dominating function (RDF) on the graph G is a function $f: V \rightarrow \{0,1,2\}$ defined such that for every vertex $u \in V$ with $f(u) = 0$ is adjacent to at least one vertex $v \in V$ with $f(v) = 2$. The weight of f is $f(V) = \sum_{u \in V} f(u)$ and the minimum weight among all such functions is the Roman domination number of G , denoted $\gamma_R(G)$. In this paper, the Roman domination numbers of the neighborhood corona $G \star H$, subdivision-vertex neighborhood corona $G \square H$, and subdivision-edge neighborhood corona $G \boxminus H$ are determined, where H is any simple connected graph, and G is a path P_n , cycle C_n , star graph S_n , complete graph K_n , or complete multipartite graph K_{m_1, m_2, \dots, m_n} .

Keywords: Roman domination number; neighborhood corona; subdivision-vertex neighborhood corona; subdivision-edge neighborhood corona.

Hosoya Polynomial And Wiener Index Of Lattice Graph

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Abstract

The Wiener index is defined as the sum of distances between all unordered pairs of vertices in a graph. Hosoya polynomial is defined as $H(G, x) = \sum_{v \in V(G)} x^{d(u,v)}$, where $d(u, v)$ is the shortest distance between the vertices $\{u, v\}$. In this paper, I have obtained Hosoya polynomial and Wiener Index of Lattice Graph. Wiener Index is one of the topological index to find the characterization of the molecular graph. Wiener index is used to predict the boiling point of the molecules.

Keywords: Wiener Index, Hosoya Polynomial, Molecular graph, Lattice graph

Metric Dimension and its Variants in the Divisor Function Graph $G_{D(n)}$

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Abstract

Let $G(V, E)$ be a graph with vertex set V and edge set E . A subset $W \subseteq V$ is called a resolving set if for every two distinct vertices $u, v \in V$, there exists $w \in W$ such that $d(u, w) \neq d(v, w)$. The minimum cardinality of such a set is called the metric dimension of G , denoted by $dim(G)$. The set W is a dominating metric set if every vertex in $V \setminus W$ is adjacent to at least one vertex in W . The minimum cardinality of W is the dominant metric dimension, $Ddim(G)$. For a vertex $v \in V$ and an edge $e = uv \in E$, the distance between e and v is defined as $d(e, v) = \min\{d(u, v), d(w, v)\}$. A set $S \subseteq V$ that distinguishes every pair of distinct edges is called an edge metric generator. The minimum cardinality of S is the edge metric dimension, $edim(G)$. The divisor function graph $G_{D(n)}$ is a graph whose vertex set consists of all positive divisors of n and two distinct vertices of $G_{D(n)}$ are adjacent if one divides the other. In this article, the aforementioned variants of metric dimensions are investigated for the graph $G_{D(n)}$ with applications in work progress report of supply chains and organizational structures.

Keywords: Divisor function graph, metric dimension, dominant metric dimension, edge metric dimension, work progress report.

Raindrop-Based Metaheuristic for Scalable Wireless Charger Deployment in Energy-Constrained Wireless Sensor Networks

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Abstract

A wireless sensor network is a collection of interconnected nodes that can sense the environment and communicate with each other. These nodes can sense the environment, collaborate, and share the sensed data. Thus, wireless sensor networks can be an effective, flexible, and reliable solution for data collection. However, one of the major challenges of wireless sensor networks is their high energy consumption. The sensor nodes use batteries as a power source. When the battery level is low, it may cause network problems, resulting in data collection problems in certain areas. To overcome this, instead of replacing the batteries, wireless chargers can be used. The placement of wireless chargers for effective sensor coverage with a certain number of chargers is an optimization problem. For solving the optimization problem, an Artificial Raindrop Algorithm, a Bio-inspired evolutionary algorithm, is proposed. The performance of the Artificial Raindrop Algorithm is compared with other algorithms for wireless chargers. The proposed ARA outperforms existing metaheuristics such as Random, wavelet-driven heuristics such as Bior55, Sym8, db2, Haar, etc., as it achieves a statistically significant improvement in terms of coverage ($p < 0.05$) as well as convergence rate. In addition, existing algorithms such as Random, Bior55, Sym8, db2, Haar, etc., have shown partial coverage due to a limited number of chargers, whereas ARA achieves full QoC (100 %) as well as minimizes mean recharge latency by 15–22 % in large-scale WRSNs. This addresses the performance gap identified in earlier studies as ARA achieves global optimality with reduced resource redundancy due to the integration of the evaporation mechanism.

Keywords: Minimum Charger Deployment Problem, Maximum Sensor Coverage Problem, Artificial Raindrop Algorithm, Optimized Charging Strategy.

Minimum Connected Extended Dominating Set in Interval Graphs: An Application in Energy-Efficient Monitoring of Railway Track Networks Using Wireless Sensors

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Abstract

Let $G = (V, E)$ be a connected graph and let k be a positive integer. A subset $S \subseteq V$ is called a k -extended dominating set of G if every vertex $v \in V$ satisfies at least one of the following conditions: either there exists a vertex u such that the distance between u and v is at most one, or there are at least k distinct vertices in S whose distance from v is exactly two. The minimum cardinality of such a set is called the k -extended domination number of G . When $k = 2$, the set is called an extended dominating set and the corresponding minimum size is the extended domination number. A subset $S \subseteq V$ is an extended connected dominating set if it is an extended dominating set and the induced subgraph is connected. In this paper, we investigate structural properties of extended connected dominating sets in interval graphs and propose a linear-time algorithm to compute a minimum such set. We prove its correctness, analyze its time and space complexity, and demonstrate its application in railway track monitoring using wireless sensor networks modeled as interval graphs

Keywords: Domination; Extended domination; Extended connected domination; Interval graph

Learning Who to Trust: Graph-Based Reinforcement Routing for Secure Wireless Sensor Networks

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Abstract

The wireless sensor networks are used in the monitoring of the environment, smart infrastructure and industrial automation where the distributed and resource-limited nature leaves it susceptible to malicious nodes that disrupt the communication process by either dropping or tampering packets. WSN applications work in real-life scenarios in which the network topology is dynamically operated by failures of nodes, movement, or the physical environment. The paper is based on a trust-conscious reinforcement learning framework which formulates the network interactions into a dynamically evolving state of the network as a trust graph and perpetually learns which nodes can be relied upon to relay packets. This changing trust structure is then used by a reinforcement learning agent to make routing decisions, and at the same time, detect suspected nodes using graph-based anomaly ranking. The framework has a routing system that is energy conscious with the priority to nodes that have a higher amount of energy left in them to allow equal utilisation of resources and also the network has a longer lifetime under the conditions found in a real world deployment. The approach sacrifices malicious nodes early on so that the network can maintain stable delivery of packets in the conditions of dynamically changing networks. By combining reinforcement learning and trust-based routing, secure communication in wireless sensor networks can be improved, as those nodes that are not trustworthy can be spotted.

Keywords: Trust-Based Routing, Dynamic Trust Graph, Malicious Node Detection, Secure Network Routing.

Arrhythmia Recognition Based on Support Vector Machine Using ECG Morphological and Segmental Features

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Abstract

Effective defibrillation therapy in automated external defibrillators (AEDs) and continuous patient monitoring forms basis on the accurate prediction and identification of cardiac arrhythmias based on wave patterns observed on variations in tachycardia, Bradycardia, heart Rate Variability (HRV). Infinite detection methodologies have been proposed, on the class of temporal, spectral, and time–frequency domain parameters obtained from surface ECG signals through individual feature analysis. In this approach, a novelty is introduced that integrates 14 ECG parameters across multiple domains using support vector and MATLAB algorithms to enhance arrhythmia detection performance. To identify the parameters that most significantly influence detection accuracy, a new Feature Selection (FS) algorithm based on the Support Vector Machine (SVM) classifier is incorporated. The proposed method has been evaluated under two distinct binary detection scenarios, demonstrating its potential for real-time ECG-QRS detection applications.

Keywords: Arrhythmia Recognition, ECG Morphology, Segment Feature Extraction, Support Vector Machine, Signal Processing, Machine Learning, Automated Diagnosis

Spatio-temporal deep learning for detecting informal urban settlement expansion using satellite imagery

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Abstract

Rapid urbanization in developing cities has led to the expansion of informal settlements, posing challenges for sustainable urban planning and resource allocation. This study presents a spatio-temporal deep learning framework for detecting and analyzing informal settlement patterns using multi-temporal satellite imagery. Multi-year imagery from the Sentinel-2 mission was processed to extract key spectral bands along with vegetation and built-up indices, namely NDVI and NDBI. A ConvLSTM-based segmentation model was developed to capture both spatial patterns and temporal changes in urban morphology. The model generates pixel-level settlement probability maps and enables the assessment of settlement expansion over time. Model performance was evaluated using built-up density information from the Global Human Settlement Layer dataset, achieving an IoU of 0.55 and an F1-score of 0.71. The results indicate noticeable growth of dense settlement clusters between 2018 and 2023 and highlight potential future expansion zones. The proposed approach demonstrates the capability of satellite-driven analysis for large-scale monitoring of informal settlement dynamics.

Keywords: Informal Settlements, Spatio-Temporal Deep Learning, ConvLSTM, Sentinel-2, Urban Expansion

On Extended Adjacency Matrices Associated with Eccentricity Based- Topological Indices

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Abstract

Several investigations of the extended adjacency matrices associated with various degree-based topological indices have been undertaken in recent years, leading to sharper theorems and conclusions. Motivated by this, we explore eccentricity-based topological indices and the extended adjacency matrices associated with them. Suppose F is a symmetric function associated with an eccentricity-based topological index, then a generalised extended adjacency matrix $A_F^e(G)$ has $(i, j)^{th}$ – entry as the value of F at the eccentricities of the corresponding vertices v_i, v_j if they are adjacent, else it is 0. The expressions and bounds for parameters like the trace, determinant, and eigenvalues associated with this matrix are derived in this article. The expression for the determinant indicates that it depends on the number of elementary spanning subgraphs present in the graph.

Keywords: Eccentricity, Determinant, Trace, Extended Adjacency Matrix.

Beyond Binary Edges: Fuzzy Graph Neural Networks for Legal Contract Risk Identification

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Abstract

The identification of legal contract risk involves ensuring clauses that have compliance, operation or financial liability and doing so manually is an intensive endeavour and automation using keywords has a recall of only 32.1% and fails to identify most or all real risks. Current graph-based methods represent the relationship between clauses as binary edges, eliminating the continuous signal of semantic similarity and making an arbitrary cut-off point. This paper presents a proposal of a Fuzzy Graph Neural Network (FGNN) that represents legal contracts as fuzzy graphs, with the membership values of the edges representing the degree of relatedness between clauses by semantics or structure and being graded. Fuzzy risk membership scores at the node level also represent risk as an uncharacterized range, as opposed to a hard characterized one, which characterizes the vagueness of legal risk measurement. A Graph Attention Network (GAT) based on the resulting fuzzy graph (242) real-world commercial contracts under 14,992 clauses with severe imbalance in classes (98.2 in low-risk) is tested. The proposed Fuzzy-GAT improves the F1-score by 21.8% and precision by 27.5% over a binary-edge GAT baseline, decreasing false positives which have an undesirable impact on legal practitioners by meriting a re-review. On a Keyword-based technique, Fuzzy-GAT provides a 114.2% relative recall enhancement, and an 88.7% F1 score. These findings show that maintaining graded semantic similarity in the form of fuzzy edge weights, instead of reduced to binary presence or absence, can give the GAT a deeper relational information that can significantly enhance risk discrimination. This study defines fuzzy graph theory as a principled and empirically validated framework of lawful contract analysis, and it provides perspectives on heterogeneous fuzzy GNN structures that differentiate structural, semantic and referential connections between clauses in future research.

Keywords: Fuzzy Graph Theory; Graph Neural Networks; Graph Attention Networks; Legal Contract Analysis; Risk Classification

Hinge Domination in Graphs

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Abstract

A dominating set in a finite graph $G(V, E)$ is a subset of vertices $D \subseteq V$ where every vertex not in D is adjacent to at least one member of D . The minimum size of such a set is the domination number of G which is denoted by $\gamma(G)$. Since then, several mathematicians had studied and introduced new domination parameters in graphs. One such domination is a hinge domination in graph. A set S_h of nodes in a graph G is said to be a hinge dominating set if every node $x \in V \setminus S_h$ is adjacent to some node $y \in S_h$ and a node $z \in V \setminus S_h$ such that (y, z) is not a line in $E(G)$. The hinge domination number $\gamma_h(G)$ is the minimum size of a hinge dominating set. In this paper, certain advanced results on hinge domination number of graphs are obtained.

Keywords: Graph, Domination in graph, Domination number, Hinge domination, Hinge domination number

Real-Time Pothole Detection and Depth Detection using Computer vision

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Abstract

Potholes are leading cause of accidents of the road, damages to vehicles, and traffic jam particularly in developing economies such as India. The traditional practices of trying to detect and repair potholes are based on manual inspection which is time consuming, labour intensive and ineffective. Although more sophisticated detection systems are built with LiDAR and other state-of-the-art sensors to provide accurate data usage, they are not cost-effective to implement in large scale. In order to overcome these issues, this project suggests a low-cost, vision based system that can identify potholes in real time with the help of a typical RGB camera. The system uses object detection algorithms that are based on deep learning, including YOLO (You Only Look Once), to identify potholes on live video feeds. Image processing methods are used to calculate the size of the pothole and the depth as well as determine the severity of the road defect once a pothole has been detected. The resulting processed information can be utilized to send alerts to drivers or to update central databases of road maintenance. Preprocessing methods like contrast enhancement, noise reduction and adaptive thresholding are applied to ensure that the performance of the system will remain reliable in different lighting and weather conditions. The system is real-time based reducing the amount of time that passes between detection and notification, something that is critical in providing awareness and response in time. In addition to driver assistance, the framework can facilitate the smart road monitoring by relaying the pothole positions detected to a cloud-based database through the IoT integration to enable the authorities to more effectively organize the repairs. On the whole, this project has shown that AI-enhanced vision systems could be offered as a cost-effective, scalable, and efficient solution to detect potholes. The system enhances transportation safety, minimizes the amount of damage to vehicles, and assists in the creation of smarter transportation infrastructure by automating the process of detecting and estimating the depth of the object.

Square Difference Geometric Mean 3-Equitable Labeling of Uniform Theta graph and Mongolian Tent graph

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Abstract

A Square Difference Geometric Mean (SDGM) 3-Equitable labeling of a graph $G = (V, E)$ is a mapping $f: V(G) \rightarrow \{0, 1, 2\}$ such that the induced mapping $g: E(G) \rightarrow \{0, 1, 2\}$ is defined by $\lceil \sqrt{|(f(u))^2 - (f(v))^2}| \rceil, \forall uv \in E(G)$ with the condition $|v_f(i) - v_f(j)| \leq 1$ and $|e_g(i) - e_g(j)| \leq 1$ for all $0 \leq i, j \leq 2$. Also, if $|(v_f + e_g)(i) - (v_f + e_g)(j)| \leq 1$ for all $0 \leq i, j \leq 2$ then the labeling is called Perfect Square Difference Geometric Mean 3-Equitable labeling. A graph is called a Square Difference Geometric Mean (SDGM) 3-Equitable graph if there exists a SDGM 3-Equitable labeling and Perfect Square Difference Geometric Mean 3-Equitable graph if there exists a Perfect SDGM 3-Equitable labeling. In this paper we investigate the SDGM 3-Equitable labeling or Perfect SDGM 3-Equitable labeling of Uniform Theta graph and Mongolian Tent graph.

Keywords: Square Difference Geometric Mean 3-Equitable labeling, Mongolian Tent graph, Uniform Theta graph.

Vertex Prime and Edge Ternion Sum Labeling of certain Bouquet graphs

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Abstract

A graph $G(V, E)$ is observed to admit Vertex Prime and Edge Ternion Sum Labeling when the vertices of the graph are labeled with unique integral values from $[1, |V|]$ in a way that for each edge uv , the end vertices u and v are designated labels that share no common positive factors except 1 and the edges of the graph are assigned labels with distinct integral values from $[1, |V| + |E|]$ such that the ternion sum of the designated labels of the vertices u, v and the edge uv constitutes uniform ternion sum or 1-edge varied ternion sum or k -edge varied ternion sum. In this research article we investigate that the bouquet related graphs such as lily bouquet graph, lotus bouquet graph, Cherry blossom bouquet graph and Clematis Rosalie bouquet graph admit Vertex Prime and Edge Ternion Sum Labeling.

Keywords: lily bouquet graph, lotus bouquet graph, Cherry blossom bouquet graph, Clematis Rosalie bouquet graph, Vertex Prime and Edge Ternion Sum Labeling.

Grundy Chromatic Number of Closed Helm Graphs and Their Derived Structures

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Abstract

The Grundy chromatic number of a graph, also called the First-Fit chromatic number, measures the maximum number of colors that can be enforced by a greedy coloring under some vertex ordering. This parameter has been investigated for many structured families of graphs because it highlights the gap between greedy and optimal colorings. In this work we study the Grundy chromatic number of the closed helm graph and extend the analysis to its line graph and middle graph. We establish tight results for each family by constructing adversarial color orderings and applying degree-based bounds. The results demonstrate that the Grundy number of closed helm graphs is bounded by a small constant, while their line and middle graph counterparts grow linearly with the cycle length. The closed helm graph serves as an application model for hub-and-spoke communication systems, connecting terminals to a central hub and linking them in a ring along the outer layer.

Keywords: Grundy chromatic number, Closed Helm Graph, Line Graph, Middle graph, Hub and spoke communication.

Ensuring Reliable Sensor Coverage Using Dual Distance Domination for Charger Deployment in Wireless Sensor Networks

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Abstract

Wireless sensor networks (WSNs) consist of numerous battery-powered sensor nodes that require efficient energy replenishment mechanisms to sustain long-term operation. The placement of wireless chargers plays a crucial role in ensuring effective sensor coverage and network reliability. Most existing approaches focus on single coverage, where each sensor is served by only one charger, which may lead to reduced reliability if a charger fails or becomes unavailable. To address this limitation, this paper proposes a Dual Distance Domination (DDD) based charger deployment model, which ensures that every sensor node is covered by at least two chargers within a specified charging range. The proposed method determines both the minimum number of chargers required and their optimal placement to guarantee redundant sensor coverage. A mathematical formulation is developed to model the dual coverage constraint and evaluate the coverage efficiency of charger placement. The performance of the proposed approach is evaluated through extensive simulations and compared with well-known metaheuristic algorithms, including Bird Swarm Optimization (BSO), Black Hole Algorithm (BH), and Dragonfly Algorithm (DA). Experimental results demonstrate that the proposed DDD-based approach achieves reliable dual coverage while maintaining efficient charger deployment, thereby improving the robustness and sustainability of wireless sensor networks.

Keywords: Wireless Sensor Network, Dual Distance Domination, Optimal Position of Chargers, Evolutionary Algorithm.

Laplacian and Signless Laplacian Energy of a Digraph with Self-Loops

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Abstract

Let $D = (V, A)$ be a directed graph of order n with a arcs. For a subset $S \subseteq V$ with $|S| = \sigma$, we construct a directed graph D_S by attaching a self-loop to each vertex of S . Motivated by recent developments in graph energies for structures with self-loops, we extend the notions of Laplacian and signless Laplacian energies to directed graphs with self-loops. The Laplacian matrix $L(D_S)$ and the signless Laplacian matrix $Q(D_S)$ are defined in terms of the out-degree sequence incorporating the contribution of self-loops. We introduce the Laplacian energy and the signless Laplacian energy of D_S as the sums of the absolute deviations of their eigenvalues from the average value $\frac{a+\sigma}{n}$. These definitions extend the classical concepts to directed graphs and naturally include the effect of self-loops. We also obtain upper and lower bounds for these energies and establish bounds for the spectral radius of the corresponding matrices.

Keywords: Digraph; Laplacian matrix; Signless Laplacian matrix; Self-loops.

E-Waste Safety: Hierarchical CNN with Adaptive Fuzzy Temporal Supervisory Risk Model for Pre-Shred Ignition Control

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Abstract

Pre-shredder lithium-ion battery fires represent a critical and under addressed hazard in electronic waste recycling, with incidents rising sharply across global facilities. Existing systems optimize for classification accuracy rather than ignition risk, leaving no predictive safety control between detection and shredder operation. This paper proposes an adaptive fuzzy temporal supervisory framework integrating a two-stage hierarchical CNN coarse e-waste categorization followed by specialized battery detection with real-time multi-sensor risk escalation. A Mamdani fuzzy inference engine uses membership boundaries calibrated from lithium-ion thermal runaway physics, replacing arbitrary parameterization. Risk is propagated via an adaptive exponentially weighted update where $\beta(t)$ dynamically responds to sensor change rate, balancing escalation speed against noise rejection. A four-state supervisory graph governs shredder control with hysteresis-band de-escalation and mandatory operator confirmation for emergency recovery, following IEC 62061 principles. Evaluation on a hybrid dataset assesses False Negative Rate, Time-to-Emergency-Stop, and Catastrophic False Negative Cost, demonstrating reduced missed ignition risk over vision-only and static-threshold baselines.

Keywords: E-waste safety; fuzzy temporal inference; CNN battery detection; supervisory risk control; lithium-ion thermal runaway

A spectral study of the maximum reverse vertex eccentricity matrix of graphs

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Abstract

Let G be a graph with vertex set $V(G)$ and edge set $E(G)$. The reverse eccentricity of vertex v_i in a simple connected graph G is defined as $D + 1 - e(v_i)$, where $e(v_i)$ denotes the eccentricity of the vertex v_i and D is the diameter of G . In this study, we introduced a new matrix associated with the graph G , called the maximum reverse vertex eccentricity matrix, denoted by $M'_R(G)$. For any two vertices, the corresponding entry of $M'_R(G)$ is the maximum of their reverse eccentricities if they are adjacent, and zero otherwise. First, we establish some basic properties of the maximum reverse vertex eccentricity matrix. We also derive bounds for the spectral parameters, such as the trace, determinant, spectral radius, and energy of this matrix. Furthermore, the energy of the maximum reverse vertex eccentricity matrix was derived for several graph classes, including the crown graph, triangular book graph, and wheel graph.

Keywords: Diameter, Eccentricity, Radius, Reverse eccentricity.

Degree-Based Fuzzy Topological Indices of Some Linear Chain Networks

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Abstract

Fuzzy topological indices are important due to their applications in real-world systems, including communication networks, technological systems, molecular structure analysis, bioinformatics, and physical modelling. A fuzzy graph is a useful mathematical tool that describes uncertain relationships between objects more effectively than classical crisp models. The flexibility of fuzziness helps in better modelling and problem solving in complex environments. Topological indices are numerical descriptors that capture structural properties of graphs using graph theory principles and are widely applied not only in chemistry but also in computer science and networking. In this paper, we compute several degree-based fuzzy topological indices namely, the fuzzy first Zagreb index, fuzzy second Zagreb index, fuzzy forgotten index, fuzzy harmonic index, fuzzy inverse degree index, fuzzy geometric arithmetic index and fuzzy Sombor index for linear chain networks such as the silicate chain network (SCN_n), linear crossed phenylenes (LCP_n) and pentagonal double chain network ($PDC_{5,n}^2$).

Keywords: Fuzzy topological indices, fuzzy graph, degree-based indices, linear chain networks.

Integrated AI-Digital Twin-Virtual Reality Ecosystems for Education: A Systematic Literature Review

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Abstract

The integration of Artificial Intelligence (AI), Digital Twin (DT), and Virtual Reality (VR) technologies is expected to make a significant shift in pedagogical approaches, scaling from the traditional methods into immersive, adaptive, and personalized ecosystems for learning. This review deals with the combined impact of the mentioned technologies across diverse educational tiers (K-12, higher education, and professional training) and disciplines, including healthcare, engineering, and STEM. A novel taxonomy of educational systems is established based on their degree of integration, ranging from VR-only environments to fully integrated AI-DT-VR systems. Key findings support that while VR-only systems perform well in spatial and procedural learning, the addition of AI enhances real-time adaptivity and personalized coaching, and the integration of Digital Twins open venue for safe, high-fidelity experimentation with real-world complex systems. The study assesses technical architectures, pedagogical design frameworks, and the development of process-oriented assessment methodologies. The review addresses critical implementation roadblocks and ethical considerations regarding data privacy and algorithmic fairness. This review furnishes a framework for future research into blended pedagogical systems that reduces the gap between theoretical knowledge and integrated practice.

Keywords: Artificial Intelligence, Digital Twins, Virtual Reality, Immersive Learning, Educational Technology

Singular Homology Groups of Lattice Valued Neutrosophic Topological Spaces

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Abstract

Homology groups play a fundamental role in topological data analysis. They used to identify the shape and structure of data. They help to detect topological features such as connected components, holes and higher dimensional holes in data set.

Neutrosophic topology is a generalization of classical topology. It helps to study topological structures derived from neutrosophic sets. The concept of neutrosophic set was introduced to deal with indeterminacy and inconsistency in data. Lattice valued neutrosophic topology is a generalization of single valued neutrosophic topology.

In this paper, we introduce singular homology group of lattice valued neutrosophic topological space. By extending classical homology, we define chain groups in lattice valued neutrosophic topological space and construct appropriate boundary operators between successive chain groups. Several basic properties of these groups are discussed, illustrating how the concepts of classical homological groups can be generalized to the neutrosophic setting. This work establishes a foundation for further development in neutrosophic algebraic topology and its applications in areas dealing with uncertain or incomplete information.

Keywords: L - neutrosophic unit interval, L - neutrosophic basic cube, L - neutrosophic singular n cube, L - neutrosophic singular homology group

Non-neighbor Zagreb indices and some graph operations

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Abstract

A topological index of a graph is a numerical parameter that describes its molecular topology and is often a graph invariant. It may forecast some physico-chemical characteristics of chemical substances, including their boiling point, entropy, acentric factor, etc. A Non-neighbor Zagreb indices are topological indices defined and are based on non-neighbor degree of a vertex of a graph. In this work, Non-neighbor Zagreb indices are studied for certain graph operations.

Keywords: Topological indices, Non-neighbor Zagreb indices, Graph operations

Color and Texture based Graph Matching for Image Segmentation

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Abstract

Image segmentation can be elegantly framed as a graph problem, where pixels or regions are represented as nodes and edges encode similarity. Traditional graph-based segmentation methods often suffer from over-segmentation, sensitivity to parameter tuning, and limited integration of multiple visual cues, which restrict their ability to produce coherent partitions. In this study, an image is first converted into a weighted graph and partitioned into superpixels using the Felzenszwalb–Huttenlocher algorithm. These superpixels form the nodes of a region adjacency graph, with edges defined by spatial neighborhood relations. A graph-based region matching strategy is then employed in which neighboring regions are evaluated using multi-cue similarity measures derived from color and texture descriptors. Regions exhibiting strong feature similarity are progressively merged through edge contraction, resulting in more coherent and meaningful segmented regions. Experimental observations illustrate how the proposed graph-based matching strategy guides region merging and produces coherent segmented regions.

Keywords: Graph partitioning; Region adjacency graphs; Superpixels; Similarity matching; Edge contraction.

Adaptive rank selection for DCT-SVD based image compression

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Abstract

Image compression is important for reducing the storage space and transmission bandwidth of digital images. Transform-based techniques such as the Discrete Cosine Transform (DCT) and Singular Value Decomposition (SVD) are widely used because they can efficiently represent image information while removing redundancy. However, traditional DCT–SVD compression methods usually use a fixed number of singular values (rank) during compression. This fixed selection may not work well for all types of images, which can either reduce important image details or lead to less efficient compression.

In this work, an adaptive rank selection method is proposed for DCT–SVD image compression. The proposed approach automatically selects the optimal number of singular values based on an energy threshold, so that the important image information is preserved while reducing storage size. The performance of the method is evaluated using standard image quality metrics such as Peak Signal-to-Noise Ratio (PSNR), Structural Similarity Index Measure (SSIM), and Compression Ratio (CR). Experimental results show that the proposed adaptive method provides better compression efficiency while maintaining good image quality compared to the traditional fixed-rank DCT–SVD method.

Keywords: Image Compression, DCT, SVD, Adaptive Rank Selection, Fixed Rank Selection.

k-Disconnected Captive Dominating Set in Graphs

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Abstract

Domination concepts in graph theory are widely used to represent control, coverage, and influence within networks. In this paper, we introduce a new variation called the k -disconnected captive dominating set. A subset S contained in $V(G)$ is said to be a k -disconnected captive dominating set if S is a captive dominating set of the graph G and the induced subgraph $G[S]$ consists of at least k connected disconnected components. The smallest cardinality of such a set is defined as the k -disconnected captive domination number of G . In this work, we examine the basic properties of this parameter and establish several results related to its behavior. We also study its values for certain standard classes of graphs and present examples to illustrate the concept clearly. The proposed idea extends the study of captive domination by incorporating structural disconnection within the dominating set.

Adjacency eigenvalues of the Involutory Cayley graph of the ring \mathbb{Z}_n

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Abstract

Let R be a ring with unity. The Involutory Cayley graph of R , denoted by $\mathcal{G}(R)$, is the graph whose vertices are the elements of R , and two distinct vertices x and y are adjacent if and only if $(x - y)^2 = 1$. In this paper, we investigate the adjacency eigenvalues of the Involutory Cayley graph of $\mathcal{G}(\mathbb{Z}_n)$.

Keywords: Cayley graph, involution, Adjacency eigenvalues, Kronecker product

QSPR Modeling of Some Molecules in Drugs Used in the COVID-19 Treatment Using Degree-Based Topological Indices.

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Abstract

COVID-19 caused by the SARS-COV-2 virus, which has been spreading rapidly all over the world. Although no specific drug was initially available for its treatment, several existing antiviral drugs have been investigated. Topological indices are numerical descriptors based on the molecular graph of the molecular structure. Topological indices are used in modeling to predict the physicochemical properties and biology activities of molecules in the quantitative structure - property relationship (QSPR) models. In this study, antiviral drugs such as Remdesivir, Chloroquine, HydroxyChloroquine, Lopinavir, Ritonavir, Arbidol, Thalidomide and Theaflavin used for COVID-19 treatment are analyzed. Degree-based topological indices are employed to develop QSPR models for predicting various physicochemical properties of these molecules. The relationship between the calculated indices and the physicochemical properties is examined using regression analysis.

Keywords: COVID-19; Drugs; Antiviral; QSPR; Topological index

Automatic Modulation Classification Using Deep Learning

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Abstract

In wireless communication systems, different types of signals are used to send information. Automatic modulation classification is important in modern wireless communication systems. When a receiver receives a signal, it often does not know which modulation schema is used. In defence communication systems, this is important because signals can come from different transmitters. Traditional methods require human experts to analyse signals manually, which is difficult and unreliable in a noisy environment. In this work, deep learning-based techniques are used for automatic modulation classification, handling IQ (In-Phase and Quadrature) signal representations. A dataset consists of multiple digital modulations captured at different SNRs (signal-to-noise-ratio) and used for model training and evaluation. Many deep learning model architectures were used to learn signal patterns directly from IQ data and classify the modulation type automatically. The results show that deep learning can recognise modulation patterns and achieve classification accuracy. In real communication systems, unknown or new signal types may appear. Open set classification can detect signals that do not belong to trained classes. The results demonstrate that deep learning models can provide efficient automatic modulation classification for wireless systems

Keywords: Automatic Modulation Classification, IQ Signal Representation, Deep Learning, Open-Set Classification, Modulation Patterns

Hybrid Grey Relational Decision Modelling Using Interval Picture Fuzzy Information under Uncertainty

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Abstract

Complex decision-making problems often involve uncertain, imprecise, and hesitant information, making the evaluation of relationships among multiple criteria challenging. To address this issue, this study proposes a novel decision-support framework based on Interval-Valued Picture Fuzzy Grey Relational Analysis (IVPF-GRA). The proposed approach integrates interval-valued picture fuzzy sets with Grey Relational Analysis to effectively represent uncertainty through interval-based membership, neutral, and non-membership degrees. A systematic IVPF-GRA procedure is developed to measure relational closeness and evaluate the influence of different decision indicators within a multi-criteria environment. The framework enables the identification of dominant factors and provides a structured mechanism to analyse their relative significance under uncertain conditions. To demonstrate the applicability of the proposed model, an empirical case study on sustainable supply chain performance evaluation is conducted. The results illustrate that the proposed framework effectively captures complex relationships among decision criteria and supports reliable evaluation when expert judgments are uncertain or hesitant. Furthermore, comparative analysis with existing fuzzy and grey relational approaches indicates that the IVPF-GRA framework provides improved robustness, interpretability, and sensitivity. The proposed approach can serve as a useful decision-support tool for various real-world applications involving uncertain multi-criteria evaluation.

Keywords: Interval-Valued Picture Fuzzy Sets; Grey Relational Analysis; Uncertainty Modelling; Multi-Criteria Decision Making; Sustainable Systems.

Vertex Neighbourhood Based Multiset Cover Deployment Method for Q-Coverage in Wireless Sensor Network

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Abstract

Achieving target Q-coverage in a Wireless Sensor Network (WSN) is a challenging problem due to ineffective sensor placement. Several optimization algorithms are introduced to address this issue. However, finding the minimum number of sensors required to achieve 100% Q-target coverage remains a challenging task. In this work, a novel deployment technique based on graph theory called Vertex-Neighbourhood-Based Multiset Cover (VN-MC) algorithm is introduced. In the proposed method, each target forms a set with its neighbouring targets based on the sensing range of sensor. The objective is to select the minimum number of sets that satisfy the Q-coverage requirement. The selection of sets that satisfies the Q-coverage requirement is a combinatorial optimization problem and is proven to be NP-hard. To address this optimization problem, the Integer Linear Programming (intlinprog) function in MATLAB is used to determine the optimal set selection. The number of sensors required, determined using the VN-MC algorithm is utilized for sensor deployment in metaheuristic algorithms such as the Grey Wolf Optimizer (GWO), Firefly Algorithm (FA), and Whale Optimization Algorithm (WOA).

Keywords: Q-coverage, Multiset cover problem, Linear programming, Grey Wolf Optimizer, Firefly Algorithm, Whale Optimization Algorithm

Extremal Edge Bounds for Supergraphs of Wheel Graphs

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Abstract

Suppose $G(V, E)$ be a graph, where V and E are vertex set and edge set respectively. Cardinality of V and E are denoted by $v(G)$ and $e(G)$ respectively. Let us consider a graph H , now a graph G is called H – free if it does not contains H as a subgraph. Let $\mathcal{M}(n, H) = \{G: G \text{ is } H\text{ – free graph on } n \text{ vertices}\}$. Turan number of a graph H , on n vertices graphs is denoted by $ex(n, H)$ and is defined by $ex(n, H) := \max_{G \in \mathcal{M}(n, H)} e(G)$

For example, consider H is triangle graph (See Figure 1), then G_1 is not H – free graph, but G_2 is H – free graph and G_2 is the extremal graph for this Turan problem, so the Turan number $ex(5, H) = e(G_2) = 6$.

In this article, we consider a supergraph of wheel W_5 and denoted by H illustrated in Figure 2. Clearly, H is supergraph of W_5 . Then which graphs are W_5 – free they must be H – free. Tomasz and Andrzej, solved Turan Problem for W_5 . In this article, we show Turan number $ex(n, H) = ex(n, W_5)$ for $n > 6$. Explicitly, we show that $ex(6, H) = 12$ and for $n \geq 7$,

$$ex(n, H) = ex(n, W_5) = \begin{cases} \frac{n^2}{4} + \frac{n}{2} + 1 & \text{if } n \equiv 2 \pmod{4} \\ \left\lfloor \frac{n^2}{4} \right\rfloor + \left\lfloor \frac{n}{2} \right\rfloor & \text{otherwise} \end{cases}$$

Moreover, we establish that the W_5 – free extremal graphs are also the H – free extremal graphs.

Keywords: Tur'an Problem, Tur'an Number, Wheel Graph

AI-Driven Educational Visualization: Integrating NLP and Diffusion Models for Diagram Generation

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Abstract

Concepts on education are usually based on diagrams to make better comprehension, yet, to produce good quality of instructional visuals needs time and skills. The current text-to-image models produce realistic images but with no pedagogical clarity and structure diagram representation. The given work suggests a multi-modal AI architecture of automated educational diagram generation based on Natural Language Processing (NLP) and diffusion models. The input of the user that can be in the form of text or speech is first processed with the help of keyword extraction and prompt engineering to produce structured prompts that have a diagrammatic representation. The educational visuals are created with the help of a Stable Diffusion-based model, and then the post-processing methods are employed to increase the clarity and structure. The system also creates supporting studying aids like flashcards. The framework is based on modern web technologies and implemented on Flask and it enhances the accessibility and usability of the framework by the learners. Image quality measures and user feedback assessment show that experimental evaluation is better than baseline strategies in terms of clarity and educational relevance, which further proves that they can be scaled to obtain an educational visualization based on AI.

Keywords: Text-to-Image, Stable Diffusion, Prompt Engineering, Educational AI, Image Quality Metrics, Supabase, Flask.

Radio Contraharmonic Mean Numbers of Degree-Splitting Graphs of Various Graph Classes

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Abstract

Radio contraharmonic mean labeling of a connected graph G , with vertex set $V(G)$ is a one to one map τ from the vertex set to the set of natural numbers such that for any two distinct vertices u, v of G , $d(u, v) + \left\lceil \frac{\tau(u)^2 + \tau(v)^2}{\tau(u) + \tau(v)} \right\rceil \geq 1 + \text{diam}(G)$. The radio contraharmonic mean number of τ , or $r_{chmn}(\tau)$ is the largest integer that can be assigned to any $v \in V(G)$ under this mapping τ . Furthermore, the least value of $r_{chmn}(\tau)$ across all radio mean labeling τ of G is $r_{chmn}(G)$, the radio contraharmonic mean number of G . If $r_{chmn}(\tau) = |V(G)|$, then G is known as radio contraharmonic mean graceful. This work investigates how radio labeling combined with degree splitting can enhance channel assignment efficiency in communication networks. Specifically, we examine the labeling of certain degree-splitting graphs using radio contraharmonic mean techniques.

Keywords: Contraharmonic Mean, Degree splitting graph, Communication Network

A Graph-Theoretic Approach for Efficient Target Coverage in Wireless Sensor Networks with Adjustable Sensing Ranges

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Abstract

Deploying excessive sensors in Wireless Sensor Networks (WSN) with fixed sensing ranges to monitor targets may increase energy consumption and result in redundant coverage. Hence, this paper addresses the target coverage problem using a deterministic deployment approach with adjustable sensing ranges. In this work, a domination-based optimal sensor placement algorithm is proposed to determine the minimum number of sensors required for coverage with their positions. The adjacency graph is constructed by considering the targets as vertices, and edges exist between them if the Euclidean distance is less than the maximum sensing range of the sensors. The cardinality of the minimum independent dominating set for the graph gives the required number of sensors for the network, and each dominating target acts as a potential sensor location. A series of simulations is carried out to validate the performance of the proposed algorithm under varying network parameters. To further assess its effectiveness, meta-heuristic algorithms such as the Firefly algorithm, Grey Wolf Optimization algorithm, and Harris Hawks Optimization algorithm are integrated with the proposed graph-theoretical approach to determine the optimal sensor placement.

Keywords: Target Coverage Problem, Sensor Requirement, Minimum Independent Dominating Set, Optimal Sensor Placement

A Bipartite Domination Strategy for Sensor Scheduling in Wireless Sensor Networks

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Abstract

Wireless Sensor Networks are widely used for monitoring applications in military surveillance, environmental and wildlife monitoring. In such target-oriented scenarios, sensors are deployed densely to ensure reliable coverage, which often leads to redundancy and excessive energy consumption. This inefficient energy utilization reduces the operational lifetime of networks. One effective strategy to prolong the network lifetime is sensor scheduling, where sensors are partitioned into disjoint cover sets. Each cover set needs to monitor all targets and activating one another extends the network lifetime. However, constructing maximum number of cover sets while minimizing redundant sensors remains a challenging problem. To address this issue, a Bipartite Domination based strategy is presented in this paper. The proposed approach constructs cover sets each of which ensures maximum target coverage while minimizing unnecessary sensor participation. By reducing redundancy and improving sensor utilization, the proposed method enhances overall network lifetime. To evaluate the performance, simulations were conducted under various deployment scenarios with randomly distributed sensors and targets. The results validate the efficiency of the proposed approach in creating the maximal number of coverage feasible cover sets.

Keywords: Target Coverage, Sensor Scheduling, Bipartite Graph, Dominating Set, Cover Set

Dream2Video: Fully Automated Film Generation from Text Prompt

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Abstract

The growing trend of animations and short-form content stands in stark contrast to the challenges associated with traditional animation creation. This is due to the fact that traditional animation creation is a costly affair that requires skilled professionals, expensive equipment, and considerable time. To overcome this problem, this paper proposes a completely automated system that can convert a given script or dialogue into a fully completed animated video through the use of a series of progressive, open-source generative AI models. This system can greatly simplify each step involved in creating a traditional animation video, including generating characters and scenes through Stable Diffusion, text-to-speech tools, background music creation, etc. This system can be developed through a powerful backend system along with a simple frontend system that can be operated by non-technical individuals without any issues. This system can also overcome the problem of cloud privacy issues, making it a cost-effective solution for a wide range of users.

Keywords: AI-driven animation, GAI, text-to-video, Stable Diffusion, automated video generation, open-source animation.

Odd and Even Sequential Harmonious Labeling in Duplicate graphs of Path Related Graphs

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Abstract

The concept of graph labeling was introduced by Rosa(1967). A graph labeling is an assignment of integers to the vertices or edges or both subject to certain condition(s). If the domain of the mapping is the set of vertices (or edges), then the labeling is called a vertex labeling(or an edge labeling). In the intervening years various labeling of graphs have been investigated in over 2500 papers. E. Sampath kumar introduced the concept of duplicate graph and proved many results. Harmonious labeling was introduced by R.L. Graham and N.J. Sloane and investigated the existence of the same on some standard graphs. Z. Liang and Z. Bai introduced odd harmonious labeling. Even harmonious labeling was introduced by B. Gayathri and D. Muthukrishanan . Even sequential harmonious labeling was introduced by P.B. Sarasija and R. Binthiya and they investigated the same on some standard graphs. P. Vijayakumar, P.P. Ulaganathan and K. Thirusangu has proved that the duplicate graph of the ladder graph, the extended duplicate graph of star graph, the extended duplicate graph of bistar graph and the extended duplicate graph of double star graph are harmonious, odd harmonious, even harmonious and even sequential harmonious. In this paper, we prove that the extended duplicate graph of path graph $EDG(P_m)$, $m \geq 2$, the extended duplicate graph of comb graph $EDG(CB_m)$, $m \geq 2$ and the extended duplicate graph of twig graph $EDG(T_m)$, $m \geq 2$ admit odd sequential harmonious labeling and even sequential harmonious labeling.

Keywords: Graph labeling, duplicate graph, harmonious labeling, Odd Sequential Harmonious Labeling, Even Sequential Harmonious Labeling.

An Enhanced Artificial Protozoa Optimization Framework for Coverage Optimization in Wireless Sensor Network

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Abstract

Coverage Optimization is a critical design challenge in WSN, where the objective is to maximize the coverage area while minimizing the coverage gaps within the region of interest and it is is firmly influenced by the spatial distribution of sensor nodes. Efficient sensor deployment significantly influences coverage of the network and sensing accuracy. This study proposes an Artificial Protozoa Optimizer (APO), a bio-inspired metaheuristic, to address the coverage optimization problem by strategic sensor deployment and it further enhanced using opposition-based learning strategies. In this paper, three algorithms are proposed to optimize the coverage rate as the basic APO, Opposition-Based Learning APO (OBL-APO), where opposite candidate solutions are generated during population initialization and iteration phases to enlarge the search space, and Chaotic Opposition-Based Learning APO (COBL-APO), where it further integrates chaotic maps with opposition learning to improve population diversity and prevent premature convergence. The performance of proposed algorithms is analyzed by various simulation tests and it demonstrate that COBL-APO provide better coverage rate and faster convergence by effectively balancing exploration and exploitation during the optimization process.

Keywords: Chaotic Maps, Coverage Optimization, Meta-Heuristic, Opposition-based Learning, Wireless Sensor Network,

Role-Aware Map Matching for Transportation Networks

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Abstract

Map matching is the process of aligning sequences of GPS latitude–longitude observations to a road network in order to infer the most probable path travelled by a moving object. Existing map-matching approaches, including probabilistic models such as Hidden Markov Model (HMM), primarily rely on geometric proximity and network topology when associating observations with road segments. However, these approaches typically ignore the functional roles of road segments within a trajectory, such as stops, intersections, arterials, and corridor segments, which can provide valuable behavioural context for trajectory inference.

In this work, we propose a **role-aware map-matching framework** that incorporates functional roles of road segments into the probabilistic framework. The proposed approach extends the traditional HMM formulation by integrating role information into both emission and transition probabilities, enabling the model to jointly infer road segments and their functional roles along a trajectory. By incorporating role-based constraints and contextual information, the proposed framework demonstrates how integrating functional semantics into map matching can enhance trajectory inference and provide richer representations of mobility patterns in transportation systems.

Keywords: Map Matching, Hidden Markov Models, Transportation Networks, Functional Road Roles, Trajectory Analysis

A Generalized Inertial Iterative Scheme for Equilibrium and Fixed Point Problems in Banach Spaces with Application to Image Restoration

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Abstract

In this work, we propose a generalized inertial iterative scheme for approximating a common solution of equilibrium problems and fixed point problems in a real 2-uniformly convex and uniformly smooth Banach space. The feasible set is assumed to be a nonempty closed convex subset of the Banach space, and the solution set is nonempty. The equilibrium bifunction is assumed to be pseudomonotone and to satisfy a Lipschitz-type condition, while the associated mapping in the fixed point problem is quasi- Φ -nonexpansive and satisfies the demiclosedness condition. By introducing an additional control parameter into the iterative framework, we construct a generalized algorithm that extends several existing inertial and extragradient methods. In particular, previously known algorithms can be obtained as special cases of the proposed scheme for suitable choices of parameters. Under appropriate control conditions on the parameter sequences, we establish a strong convergence theorem for the sequence generated by the algorithm, proving that it converges strongly to a common solution of the equilibrium problem and the fixed point problem. Numerical experiments are conducted in MATLAB, and the performance is evaluated using peak signal-to-noise ratio (PSNR) and structural similarity index measure (SSIM).

Keywords: Equilibrium problem; Fixed point problem; Strong Convergence; Banach spaces.

Strong Convergence of a Improved Inertial Framework for Pseudomonotone Equilibrium and Fixed Point Problems

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Abstract

Equilibria in the context of fixed point problems play a central role in nonlinear analysis with applications in optimization, game theory, economics, and variational inequalities. The equilibrium problem provides a unified framework to determine a point satisfying a suitable bifunction inequality over a feasible set, while fixed point problems involve finding an invariant point under a given mapping.

In this work, we consider the problem of finding a common solution to equilibria through fixed point in real 2-uniformly smooth Banach spaces with uniform convexity. Motivated by recent developments in inertial iterative techniques, we propose a modified inertial framework incorporating a control parameter of the form $\frac{1}{4N}$ for $N \geq 1$ to regulate the step size and improve convergence.

Under suitable assumptions such as pseudomonotonicity and Lipschitz-type continuity conditions of the bifunction. We prove strong convergence of the proposed method. Numerical illustrations further support the efficiency and applicability of the proposed approach.

Keywords: Equilibrium problem, Fixed point problem, Inertial methods, Banach space, Strong convergence

Maximal tangent Sombor index of Unicyclic, Bicyclic and Tricyclic Graphs

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Abstract

Recently, a topological index of graphs, called tangent Sombor index, inspired by geometric behavior of trigonometric functions, has been proposed to find correlations with some physicochemical properties of chemical compounds. The tangent Sombor index of graph G is denoted by $\tan(G) = \sum_{v_i v_j \in E(G)} \frac{|d^2(v_i) - d^2(v_j)|}{2d(v_i)d(v_j)}$, where $d(v_i)$ is the degree of a vertex v_i and $E(G)$ be the edge set of G . In this work, we establish sharp upper bounds for various classes of graphs, including unicyclic, bicyclic and tricyclic graphs. We show that if G is n (≥ 3) vertex-connected unicyclic graph, then $\tan(G) \leq \frac{(n-1)(n-2)}{2} - \frac{(n+1)}{2(n-1)}$. And if G is n (≥ 4) vertex-connected bicyclic graph, then $\tan(G) \leq \frac{(n-1)(3n-8)}{6} - \frac{(n+3)}{2(n-1)} + \frac{5}{6}$. Also, if G is n vertex-connected tricyclic graph, then $\tan(G) \leq \frac{6n^2 - 26n + 47}{12} - \frac{(n+5)}{2(n-1)}$ for ($4 \leq n \leq 14$) and $\tan(G) \leq \frac{n^2 - 4n + 3}{2} - \frac{(n+5)}{2(n-1)}$ for ($n \geq 15$). Finally characterize the corresponding extremal graphs that attain these bounds.

Keywords: tangent Sombor index, Unicyclic graphs, Bicyclic graphs, Tricyclic graphs, Extremal values.

Koopman-Based Hybrid Machine Learning for Food Addiction Detection Using Multimodal EEG and Behavioral Data

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Abstract

Food addiction, a pressing behavioral-neurological disorder, drives compulsive intake of palatable foods through dysregulated reward circuits. Unravelling its neurophysiology is key to early diagnosis and tailored therapies. Electroencephalography (EEG) non-invasively probes craving, reward, and decision dynamics, but conventional machine learning struggles with EEG's nonlinear, spectral intricacies. We present three innovative hybrid models for EEG-based food addiction detection, integrating behavioral data: Koopman–XGBoost Fusion (KX-FAP), Attention–Graph Neural Network Ensemble (AGNE), and Fourier State-Space XGBoost (FSSX). Focus is on differential Koopman operator, transforming nonlinear signals into linear, interpretable latent modes for addiction-specific neural dissection. Tested on 227 subjects' data (138 features: EEG bands, behaviours, nutrition), mutual information pruned to 40 predictors. Stratified splits (181 train/46 test, balanced classes) yielded KX-FAP's top marks: 86.96% accuracy, 0.8696 F1-score, 0.9395 AUC-ROC eclipsing AGNE and FSSX. Koopman modes spotlighted unstable eigenmodes ($\lambda_{\max}=100.16$) fuelling addiction variance, illuminating compulsive preference circuits. Our dynamical-ML fusion advances precise, explainable EEG diagnostics, paving the way for neurobehavioral forecasting, and precision nutrition interventions.

Keywords: Food Addiction Detection; Electroencephalography (EEG); Hybrid Machine Learning; Koopman Operator; Multimodal Data Analysis

Improving air and sea surface temperature prediction: machine learning models combined with cubic spline interpolation

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Abstract

Accurate prediction of air temperature and sea surface temperature is crucial for better understanding of air–sea interactions. This study presents a comparative analysis of six machine learning models namely, Extreme Learning Machine, Bagged Extreme Learning Machine, Random Forest, Support Vector Machine, LSBoost, and Artificial Neural Network for temperature prediction using buoy observations recorded during **2024** at buoy station **46060** (60°34'16" N, 146°47'42" W). Extensive hyperparameter optimization and detailed lead–lag sensitivity analysis are conducted to determine optimal configurations. Lead times of **1–6 hours** and lag times of **1–12 hours** were analysed. Model performance is evaluated using error metrics such as RMSE, MAE, MAPE, and R². Comprehensive data analysis reveals a substantial portion of missing observations, which were reconstructed using cubic spline interpolation framework. A sensitivity analysis confirms that the spline interpolation closely matches the observed data and preserves the underlying temporal structure. Results show that incorporating spline interpolation reduces forecasting error by 4–7%. Statistical tests further confirm significance of this improvement, highlighting the effectiveness of spline interpolation as a reliable data pre-processing technique for temperature prediction.

Keywords: Air temperature, Sea surface temperature, Machine learning, Cubic spline interpolation, Buoy data.

A study on wave characteristics off Cuddalore using SWAN wave model

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Abstract

Assessment of wave parameters such as significant wave height (H_s) and mean wave period (T_p) plays a crucial role in weather prediction. In this study, a third-generation wave model-SWAN was simulated along the coast off Cuddalore for the periods, 2015–2017. The model was investigated in two cases- with and without nonlinear source terms (quadruplet and triad term) and examined their influence at the location. Annual and seasonal variation of the wave parameters were analysed and validated using buoy measurements and reanalysis data. The simulated range of H_s for the two years was 0.4–2.3m and 0.5–2.38m, respectively. Similarly, the range of T_p varied from 3.8–9.09s and 3.65–9s, respectively, that are agreeing well with buoy observations. Sensitivity analysis was carried out based on the boundary setup to evaluate the model performance for both cases. A positive correlation of $r = 0.65$ and $r = 0.86$ was obtained comparing the model output including source terms with buoy measurements and the ERA5 data, respectively. Statistical error measures were estimated that added confirmation to the model stability at the concerned location.

Keywords: Wind waves, Observational data (Buoy data), ERA5- reanalysis data, SWAN wave model, Wave parameters.

Entropy-Guided Landmark Selection for Metric-Dimension-Based Graph Compression

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Abstract

Large graph-structured datasets are pervasive in social network analysis, biological modelling, and communication systems. Representing structural relationships in such graphs requires storing all-pairs shortest-path distances, yielding high-dimensional, computationally expensive representations. This paper presents a graph-theoretic dimensionality reduction approach based on metric dimension and minimum resolving sets. A minimum resolving set, known as the metric basis, enables each node to be uniquely represented by a vector of shortest-path distances to a small set of landmark nodes, providing a lossless structural embedding. Since computing an exact metric basis is NP-hard, we propose the Information Content Heuristic (ICH), an entropy-guided landmark selection strategy, to approximate resolving sets in $O(V^2)$ time by maximizing the entropy of node distance-vector representations. Experiments on synthetic and real-world graphs (Karate Club and Les Misérables) compare entropy-guided, collision-based, and random selection across compression ratio and runtime. Results show entropy-based selection improves compression over random baselines, whereas the collision heuristic yields similar performance with faster runtime in structured graphs. The proposed entropy-guided framework thus offers an effective, scalable approach to structural graph compression and dimensionality reduction.

Keywords: Metric Dimension, Graph Compression, Resolving Set, Information Entropy

Some properties of the idempotent Cayley graph of the ring \mathbb{Z}_n

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Abstract

Let R be a finite commutative ring with identity and $Id(R)$ be the set of idempotent elements in the ring R . The idempotent Cayley graph of R , denoted by $\Gamma(R)$, is the graph whose vertices are the elements of R , and two distinct vertices x and y are adjacent if and only if $x - y \in I$ where $I^* = Id(R) - \{0\}$ and $I = I^* \cup (I^*)^{-1}$. In this paper, we investigate the properties of $\Gamma(\mathbb{Z}_n)$. Specifically, we determine its girth, chromatic number, diameter, clique number, and independence number. Furthermore, we investigate some results on adjacency eigenvalues of $\Gamma(\mathbb{Z}_n)$.

Keywords: Cayley graph, Idempotent element, Idempotent graph, Adjacency eigenvalues,

Fire Station Location Optimization for Enhanced Emergency Response using Graph Theory Centrality Measures

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Abstract

Efficient fire station placement is essential for minimizing emergency response times and enhancing urban safety. Traditional planning methods often rely on Euclidean distance, which fails to capture real-world road network constraints, resulting in suboptimal facility locations. This study proposes a graph theory-based framework for optimizing fire station placement by modeling the urban road network as a weighted directed graph, where nodes represent intersections or demand points and edges represent road segments with travel-time weights.

The framework utilizes multiple centrality measures to identify optimal locations. Closeness centrality minimizes average response time by selecting highly accessible nodes, while betweenness centrality identifies critical transit points that ensure network connectivity. Degree centrality captures local accessibility, and eigenvector centrality prioritizes nodes near high-risk or high-demand areas.

To combine these metrics, a multi-criteria decision-making approach is applied using the Entropy Weight Method and TOPSIS for ranking candidate locations. Results demonstrate that the hybrid centrality approach improves coverage efficiency, reduces response time, and enhances network resilience compared to single-metric methods.

Keywords: Graph Theory, Fire Station Optimization, Centrality Measures, TOPSIS, Urban Networks

On the Design and Analysis of Graph Products in Fuzzy Soft Graph

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Abstract

Fuzzy soft graphs have become an important mathematical tool for modeling complex systems involving uncertainty, vagueness, and incomplete information. This study introduces and investigates six types of product operations on fuzzy soft graphs, including the normal, modular, boxdot, tensor, homomorphic, and Cartesian products. Each product operation is rigorously defined, and its key structural properties are investigated for both complete and strong fuzzy soft graphs. The theoretical developments are supported with illustrative examples that clarify the construction and behaviour of the proposed products. The results not only extend existing concepts in fuzzy soft graph theory but also provide a unified framework for studying interactions between fuzzy soft graph structures. The proposed operations expand the theoretical scope of fuzzy soft graphs and offer effective tools for modeling and solving complex problems in decision-making, artificial intelligence, social networks, and operations research.

Keywords: Fuzzy Soft Graph, Modular Product, Boxdot Product, Tensor Product, Harmonic Product

A Game of Cops and Robber on Planar Graph

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Abstract

The Cops and Robbers game is a pursuit–evasion game played on a finite connected graph, where cops attempt to capture a robber moving along the edges. A central parameter is the cop number, the minimum number of cops required to guarantee capture. This thesis studies structural and algorithmic aspects of cop-win graphs, where one cop can always win. A key characterization is given using dismantlability: vertices can be successively removed through domination (pitfalls) until a single vertex remains. This provides both theoretical insight and an algorithmic method to recognize cop-win graphs. We also show that the class of cop-win graphs forms a variety, closed under operations such as retractions and Cartesian products. The study further examines graphs requiring multiple cops and shows that graphs with arbitrarily large cop numbers exist under suitable minimum degree and girth conditions. Finally, planar graphs are investigated: outerplanar graphs require at most two cops and planar graphs at most three cops, with discussion of the Dodecahedron graph conjecture.

Keywords: cops and robber, cop number, cop-win graph, dismantlability, planar graph.

Digital Humanities and Knowledge Graphs for Developing Integrated Indian Knowledge System Repository with Modern Engineering

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Abstract

The enthusiasm for study on Indian Knowledge System (IKS) has led to a need for systematic preservation, organization and digital availability of traditional knowledge resources related to diverse fields. A study proposes a Digital Humanities and Knowledge Graph-based framework for developing an Indian Knowledge Systems repository. The study proposes an Indian Knowledge System repository enabling semantic search and interdisciplinary analysis using ontology, linked data approaches and knowledge graph databases. The proposed framework would enable various capabilities, including concept mapping, contextual linking of texts, visualization of knowledge systems, etc., through machine-readable data that could be utilized for computational analysis of traditional knowledge resources related to Indian Knowledge Systems. Furthermore, the study proposes a conceptual architecture for developing this kind of repository which creates new opportunities for interdisciplinary research, digital learning, and data-driven cultural analysis by preserving the intellectual heritage embedded in these classical sources of information.

Keywords: Digital Humanities; Indian Knowledge Systems (IKS); Knowledge Graphs; Semantic Web; Digital Repository.

Coalition-Based Distance Hierarchy for Fault-Tolerant Network Routing

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Abstract

Modern communication networks depend on efficient routing to ensure reliable data delivery. While shortest path algorithms perform well under stable conditions, router failures can disrupt communication and require costly route recomputation, especially in large and dynamic networks.

This work proposes a coalition-based distance hierarchy approach to improve routing resilience. Routers are organized into cooperative groups, or coalitions, where nodes share routing information and maintain hierarchical distance structures. These structures store both primary and alternative paths, enabling faster recovery when failures occur. Instead of recomputing routes globally, the system identifies alternative paths within the coalition, reducing delay and overhead.

The proposed model enhances fault tolerance, scalability, and routing efficiency by combining hierarchical routing with cooperative node behavior. Its performance can be evaluated based on recovery time, routing overhead, and network stability under failure conditions.

Keywords: Network Routing, Fault Tolerance, Distance Hierarchy, Coalition-Based Routing, Communication Networks

Graph Eccentricity as a Polypharmacology Predictor: A Weighted Bipartite Network Framework for Multi-Target Drug Discovery

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Abstract

Identifying polypharmacological agents remains central to drug repositioning and rational design. Existing molecular fingerprint or docking approaches neglect the global topology of drug–target interaction networks. We introduce the Weighted Network Eccentricity Profile (NEP_w), a vector descriptor encoding each drug’s Dijkstra-weighted eccentricity across target-specific subgraphs of a bipartite drug–target network, with edge weights as reciprocal binding affinity ($w = 1/pIC_{50}$). The Eccentricity Transition Score (ETS)—the population variance of NEP_w—quantifies selectivity switching across targets. Applied to eight anti-inflammatory drugs against COX-1, COX-2, 5-LOX, and PGE2S (ChEMBL release 33), weighted COX-2 eccentricity achieves Pearson $r = -0.865$ ($R^2 = 0.748$, $p = 0.006$), outperforming all single-molecule topological indices tested. Ward clustering on NEP_w cosine distance recovers three pharmacologically validated clusters—broad-spectrum, non-selective, and COX-2-selective—without activity labels, establishing NEP_w as a computationally efficient ($O(|T| \cdot n^2)$) and interpretable polypharmacology descriptor.

Keywords: Weighted bipartite drug–target interaction network; Network eccentricity profile; Polypharmacology; Affinity-weighted graph centrality; Drug repositioning.

Hybrid Forecasting of Gold Prices Using Neutrosophic Logic-Driven Sentiment Features and LSTM Networks

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Abstract

Forecasting gold prices is challenging due to the influence of market sentiment and the uncertainty inherent in financial data. Traditional Natural Language Processing (NLP)-based sentiment analysis methods often fail to effectively capture ambiguity and indeterminacy in textual information from social media and financial news. To address this issue, this study proposes a hybrid Neutrosophic Logic–Long Short-Term Memory (LSTM) model for gold price prediction. The proposed approach utilizes neutrosophic logic to represent sentiment through three components truth, indeterminacy, and falsehood providing a more comprehensive and uncertainty aware feature representation.

The methodology integrates neutrosophic sentiment features with historical gold price data and employs an LSTM network to capture temporal dependencies and nonlinear patterns. The model is evaluated using real-world datasets and standard performance metrics such as accuracy, RMSE, MAPE, and F1-score.

Experimental results demonstrate that the proposed model outperforms conventional approaches by improving prediction accuracy and reducing forecasting errors. The findings highlight the effectiveness of incorporating uncertainty-aware sentiment modeling for robust financial forecasting.

Keywords: Gold Price Prediction, Sentiment Analysis, Neutrosophic Logic, Long Short-Term Memory (LSTM), Uncertainty Modelling, Natural Language Processing (NLP), Time Series Analysis.

A Study on the Application of Large Language Models for Defect Detection in Additive Manufacturing

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Abstract

In industrial defect detection and quality control, artificial intelligence has progressed from traditional Machine Learning (ML) to Deep Learning (DL) and more recently, Large Language Models (LLMs). Traditional ML techniques are interpretable and computationally efficient. But they rely on manually created features and find it difficult to handle complex multimodal data in dynamic manufacturing environments. DL methods improved fault detection by automatically extracting features from image and sensor data. However, they often lack interpretability and require large labelled datasets. Additionally, their inability to integrate contextual process knowledge limits their efficacy in real-time quality monitoring systems. These problems can be solved by the LLMs reasoning, understanding and multisource information processing capabilities. These are helpful in improving defect detection, prediction and intelligent process optimization even in data-scarce situations. LLMs can use both structured data and unstructured data to make better decisions in current manufacturing systems such as additive manufacturing technologies. This study examines the development, benefits and drawbacks of ML, DL and LLM approaches, with a focus on LLMs as a possible avenue for future intelligent industrial quality control systems.

Keywords: Defect Detection, Machine Learning, Deep Learning, Large Language Models, Additive Manufacturing.

Harnessing Machine Learning to revolutionize Additive Manufacturing: A Review

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Abstract

The integration of Machine Learning (ML) with Additive Manufacturing (AM) has made tremendous breakthroughs across industries in various aspects of 3- D printing in the past few years testifying its firm stand to revolutionise printing technology. The role of Machine learning in AM is resolute, due to its ability to capture intricate relationships between diverse parameters in different AM techniques. For various informed decision-making in AM process, ML models are ideal for extracting curated information from the given datasets enhancing reliability. Moreover, the alliance of two vast fields provides critical insights into challenges and opportunities emerging at their intersection. Additive manufacturing combined with Machine Learning enables predictive modelling, process optimisation, and quality control that accelerates the process. This review brings out the perspectives of ML used in AM research focusing on process monitoring, defect detection, and material property prediction. Techniques like Neural Networks and disputes like data scarcity are discussed to envision the capabilities of ML to enhance 3-D printing across AM related research fields.

Keywords: Machine Learning, Additive Manufacturing, Informed decision- making, Neural Networks, Data scarcity

Assessment of Tank Water Quality Using Fuzzy Inference System

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Abstract

Water quality is significant to human health and environmental protection. Tank water is commonly utilized in various applications, such as domestic and agricultural uses. However water quality is significantly affected by human activities and environmental conditions. Hence, it is significant to develop an efficient tool to assess water quality properly. In this paper, a Mamdani-type Fuzzy Inference System (FIS) is utilized to assess water quality in terms of seasonal variation in tank water. Two tanks in West Bengal, namely Digha Tank and Medinipur Tank, are considered in this paper. Four significant water quality parameters, namely DO, BOD, pH, and Turbidity, are utilized as input parameters. Fuzzy linguistic values are generated using membership functions and then assessed using fuzzy IF-THEN rules. Based on this FIS tool, it is observed that water quality is relatively higher in winter and decreases gradually up to summer, with the lowest water quality in April.

Keywords: Tank Water Quality, Fuzzy Inference System, Mamdani FIS, Water Quality Assessment.

Supply Chain Management with Variable Production System and Substitutable Products

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Abstract

Now a days, every industry using many strategies to give better service to customers. Industry mainly tries to solve the three problems economical problem, environmental problems, social problems. This research mainly focus on sustainable supply chain model, in this model industry tries to improve customer satisfaction by avoiding stockout situations, delivering products faster. The model introduce here in which two manufactures using sustainable product through online and offline channel and both the company using renewable energy. This model helps manufactures to take decision about stock of inventory in offline and online, calculate revenue, production cost, holding cost, rework cost and carbon emission cost and analyse when production rate should be kept high, and when the production should be stopped. we used Hessian matrix and Karush-Kuhn Tucker method for optimization.

Keywords: Supply Chain, Hessian matrix, Karush-kuhn tucker, Dual Channel

Soft β^* -Open Set Based Model for Academic Intervention Decision Making

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Abstract

In this paper, the concept of soft β^* -open sets is applied to a decision-making model for identifying students who are academically at risk. A dataset consisting of a list of students and six academic performance parameters is constructed and analyzed. In this context, academically at risk refers to students who exhibit multiple indicators of weak academic performance, such as low attendance, poor examination scores, incomplete assignments, weak quiz performance, limited classroom participation, or low final examination results. These factors often indicate a higher likelihood of academic difficulty or potential course failure if timely support is not provided. Using the concepts of soft β^* -closure and soft β^* -interior, the proposed framework classifies students into strongly under performing and borderline categories. The model enables the identification of students who require early academic intervention, mentoring, or remedial support. The study demonstrates that soft β^* -open sets provide a flexible mathematical framework for handling uncertainty in educational decision-making and student performance analytics.

Keywords: soft set, soft topological space, soft β^* -open set, academic risk analysis, decision-making problem.

Computation of the Weighted Wiener Index for Simple Hydrocarbon Molecular Graphs

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Abstract

Topological indices play an essential role in chemical graph theory for modelling molecular structures and predicting physicochemical properties. Among them, the weighted Wiener index (WWI) extends the classical Wiener index by incorporating vertex degrees along with shortest path distances between vertex pairs. In this study, the WWI is computed for simple hydrocarbon molecular graphs such as methane (CH_4), ethane (C_2H_6), and propane (C_3H_8). The contributions of all unordered vertex pairs are evaluated using their respective degrees and distances in the molecular graphs. Based on these calculations, explicit WWI values are obtained for each structure. Furthermore, a general expression for the WWI of this class of hydrocarbons is proposed. Four new theoretical results are established to support the analysis. The findings demonstrate the influence of molecular connectivity on distance-based descriptors and provide insights for future studies in quantitative structure–property relationship (QSPR) modelling.

Keywords: Chemical Graph Theory; Weighted Wiener Index; Molecular Graph; Distance-Based Topological Indices; Hydrocarbon Graphs

Imperfect and Minimally Imperfect Fuzzy Graphs

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Abstract

Perfect graphs have marked its advent in the literature of graph theory since the middle of nineteenth century and became very popular due to their structural specifications and wide range of applications. Perfect fuzzy graph came into existence very recently in the year 2022 which then opened a new area of research for fuzzy graph theorists to explore. While perfect fuzzy graph has stood out owing to its special features and independent existence, this paper focuses on imperfect or minimally imperfect fuzzy graph. The goal of this research is to explore the condition when a fuzzy graph fails to be perfect and when exactly can it be called minimally imperfect. The study has been approached from two directions -- structurally, that is, by giving importance to structural configuration of a fuzzy graph and functionally- that is by giving importance to the properties of perfectness in a fuzzy graph. Lastly, we give an algorithm to detect whether a fuzzy graph is perfect or imperfect in which case minimally imperfect or not.

Keywords: Perfect fuzzy graph; partial fuzzy clique; imperfect fuzzy graph; minimally imperfect; fuzzy transversal; algorithm

A Simple Graph-Theoretic Model for Energy-Aware Communication in Wireless Sensor Networks with Regulatory Considerations

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Abstract

Wireless Sensor Networks (WSNs) are widely used in applications such as environmental monitoring, smart agriculture, industrial automation, and Internet of Things (IoT) systems. However, the limited energy capacity of sensor nodes significantly impacts network lifetime and communication reliability. This paper presents a simple graph-theoretic model for energy-aware communication in WSNs. The network is modeled as a graph, where sensor nodes are represented as vertices and communication links as edges, enabling analysis of connectivity and routing efficiency. The model highlights how optimal path selection and efficient network structure can reduce transmission distance and minimize redundant data forwarding, thereby conserving energy. The discussed framework provides an intuitive approach to understanding energy-efficient communication design and supports improved network organization. It also acknowledges practical considerations related to data handling and system-level constraints in IoT-enabled environments.

Keywords: WSN; Graph-Theoretic Modelling; Energy-Aware Communication; Network Connectivity; IoT

Extremal Unicyclic Graphs with Respect to the Nirmala Index: Sharp Bounds and Structural Characterization

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Abstract

The Nirmala index is a recently introduced degree-based topological descriptor defined as:

$$N(G) = \sum_{uv \in E(G)} \sqrt{d(u) + d(v)},$$

where $d(u)$ denotes the degree of the vertex u in a graph G . This index captures structural information of molecular graphs and has potential applications in quantitative structure–property relationship (QSPR) analysis. In such studies, determining bounds of topological indices is important as they provide insight into extremal molecular structures that may influence physicochemical and biological properties of compounds. In this paper, the authors investigate the extremal behaviour of the Nirmala index for unicyclic graphs with a fixed number of vertices. Using graph transformation techniques and degree concentration arguments, sharp lower and upper bounds for the Nirmala index were derived within this class of graphs. The study proves that the cycle graph C_n uniquely minimizes the Nirmala index, whereas the graph obtained by adding an edge between two pendant vertices of the star graph S_n , denoted by $S_n + e$, uniquely maximizes it. Explicit expressions for these extremal values are obtained, and the corresponding extremal graph structures are characterized.

Keywords: Nirmala index, unicyclic graphs, extremal graphs, topological indices, graph transformations.

$m \times n$ Grid Graphs Under Mean Edge Cordial Labeling for Portrait Pixel Connectivity

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Abstract

Graph labeling is a method of assigning numerical values to the vertices and edges of a graph $G = (V, E)$ according to specified rules. Among the various labeling techniques, mean edge cordial labeling is a binary edge-labeling scheme in which vertex labels are induced through the average of incident edge labels while maintaining balanced counts of labels across both vertices and edges. In this paper we establish mean edge cordial labeling constructions for rectangular grid graphs and their super subdivision graphs, represented through the Cartesian product $P_m \times P_n$. Suitable labeling patterns are developed and shown to satisfy the required cordiality conditions for all admissible parameters. As an application, the obtained results provide a graph theoretic framework for studying portrait pixel connectivity. The proposed constructions illustrate the applicability of mean edge cordial labeling in representing balanced structural patterns within grid-based image models.

Keywords: Graph Labeling, Cordial Labeling, Mean Edge Cordial Labeling, Grid Graphs, Portrait Pixel Connectivity.

Mathematical and Computational Framework of Relationship Transition Dynamics Analysis

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Abstract

Dynamics of relationships within marriage is a significant study field in social and mathematical sciences. In this paper, a mathematical model is formed to investigate marriage, separation and divorce in a framework of a system of differential equations describing transition over time. Computational learning techniques are introduced in order to study patterns and trends of the generated data, which allows predicting the behavior of systems and nonlinear interactions. Standard statistical metrics and validation methods are used to obtain model performance to make sure that it is reliable and consistent. The findings represent evidence that the combination of mathematical modelling and evidence-based analytical strategies offers a powerful conceptualization of the investigation of marital dynamics. Such a complex methodology provides a more in-depth insight into relationship transitions and brings the complex socio-dynamic systems to comprehension.

Keywords: Mathematical Modeling, Differential Equations, Computational Analysis.

Comparison of M and NM Polynomial Topological Indices Famciclovir vs Ganciclovir

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Abstract

In this paper presents a comparative of the antiviral drugs Famciclovir and Ganciclovir using M-polynomial and NM-polynomial methods from chemical graph theory. The molecular graphs of both drugs are constructed, and several degree-based topological indices are derived from the corresponding polynomials. The results show that Famciclovir possesses higher polynomial coefficients and index values, indicating greater structural complexity and branching compared to Ganciclovir. This study demonstrated the effectiveness of polynomial-based topological indices in analyzing and comparing antiviral drug structure.

Keywords: Degree based topological index, M-polynomial, NM-polynomial, Chemical graph theory, Antiviral drugs.

Narumi-Katayama and Multiple Zagreb indices in fuzzy graph operations and applications

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Abstract:

Topological indices are numerical graph invariants that represent network structural features. They are commonly utilized in chemical graph theory and complex network research. Classical indices like the Wiener, Zagreb, Randic, and Gutman indices are usually defined on graphs with explicit vertex-edge relationships. However, many real-world systems have uncertainty that cannot be accurately modelled using traditional graph architectures. Fuzzy graphs are an extension of standard graphs that assign membership values to vertices and edges, allowing imprecise interactions to be represented.

In this study, the Narumi-Katayama (NK) index and the Multiplicative Zagreb indices are studied using fuzzy graphs. To capture the multiplicative connectivity properties of fuzzy networks, we offer a new formulation of the Fuzzy Narumi-Katayama (FNK) index that includes vertex membership values. Furthermore, fuzzy extensions of the First and Second Multiplicative Zagreb indices (MZ_1 and MZ_2) are constructed to analyze structural properties under uncertainty. The behavior of these indices is investigated using fuzzy graph operations such as union, join, and Cartesian products. Applications to chemical network analysis and multi-attribute decision-making show that the proposed indices are effective in modelling complicated uncertain systems.

Keywords: Fuzzy Narumi-Katayama index, Fuzzy Multiplicative Zagreb index, Multi Attribute Decision Making.

A Fuzzy Soft Set Topological Framework for Child Psychological Assessment

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Abstract

Psychological assessment of children typically depends on observations from parents, teachers, and self-reports. Because children behave differently across environments, these assessments often involve uncertainty and subjectivity. Mathematical frameworks can help model such vagueness and improve interpretation.

In this work, we propose a decision-support framework for child psychological assessment based on fuzzy soft sets and topological parameters. Questionnaire responses are converted into crisp scores and normalized to construct an object-parameter fuzzy information structure, where psychological parameters such as attention, impulsivity, and social interaction are represented through fuzzy membership values. By applying α -cut thresholds to this representation, subsets of parameters satisfying a chosen confidence level are obtained, which induce a topology on the parameter space.

Mathematical properties of the proposed structure are investigated. An illustrative example involving parent, teacher, and self-report assessments demonstrates how questionnaire data can be transformed into a fuzzy soft representation and analysed through the resulting topology, providing an interpretable framework for integrating multi-source psychological information and supporting decision-making in child psychology.

Keywords: Fuzzy soft sets; α -cut topology; Fuzzy soft topology; Multi-source psychological assessment;

Product Root Sum Mean Labeling Scheme on Various Subdivision Snake Graphs

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Abstract

Let $G = (V, E)$ be a simple graph with p vertices and q edges an injective function $f: V \rightarrow \{1, 2, 3, \dots, q + 1\}$ is said to be a Product Root Sum Mean Labeling if the induced function f^* defined on edges by $f^*(uv) = \frac{f(u)f(v) + \sqrt{f(u)+f(v)}}{2}$ yields different values. In this paper we prove the Product Root Sum Mean Labeling on Subdivision Graphs such as Subdivision graph of Alternate Triangular Snake graph, Subdivision graph of Alternate Quadrilateral Snake graph, Subdivision graph of Double Quadrilateral Snake graph, Subdivision graph of Double Alternate Quadrilateral Snake Graph, Subdivision graph of Double Triangular Snake Graph, Subdivision graph of Double Alternate Triangular Graph and Sub Division Graph of Irregular Triangular Snake Graph.

Keywords: Subdivision Graphs, Snake Graphs, Product Root Sum Mean Labeling.

Energy of Graphs and Posets: Concepts and Recent Advances

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Abstract

The concept of graph energy, introduced by Ivan Gutman in connection with the Hückel molecular orbital theory in chemistry, has become an important topic in spectral graph theory. A graph's energy, which has been extensively studied because of its close connection to combinatorics, linear algebra. Many conclusions about bounds, extremal qualities, and other generalizations of graph energy have been established over the past few decades.

The theory of energy related to graphs and posets is reviewed in detail in this paper. We provide an overview of the basic concepts, significant findings, various extensions, including minimum covering energy and other energy-like invariants, are also discussed. Furthermore, the concept of covering energy of posets is examined, along with the construction of covering matrices, spectral properties, and computed energies for several well-known classes of posets.

This survey aims to present a comprehensive view of the evolution of energy notions in discrete mathematics and compile current work. The analysis also identifies new directions for the study of spectral invariants of graphs and posets and outlines recent research trends.

Keywords: Graph energy, Spectral graph theory, Posets, Adjacency matrix, Covering matrix.

Accurate Hub Domination: A Structural Extension of Domination in Graphs

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Abstract

The concept of accurate hub domination in graphs is introduced to incorporate both strong internal connectivity and exclusiveness within domination frameworks, thereby addressing certain limitations present in existing domination parameters. This notion combines the structural requirements of hub-based connectivity with the restrictive nature of accurate domination, leading to a more refined domination model. Fundamental bounds and structural properties of accurate hub domination are established, and its relationships with several existing domination parameters are examined. In addition, the study further offers a comprehensive structural analysis of related domination frameworks, emphasizing how additional constraints influence their formation and behavior. The analysis highlights the progressive refinement of domination models, moving from basic coverage conditions toward more restrictive and structurally organized configurations. Through this unified perspective, the work clarifies the theoretical development of domination parameters and the role of structural constraints in strengthening domination concepts. The results contribute to a deeper understanding of the hierarchical evolution of domination structures within graph theory and provide a foundation for further investigations in this area.

Keywords: Domination, hub domination, accurate domination, accurate hub domination

A Hybrid Graph Grammar and Graph Neural Network Framework for Molecular Graph Generation

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Abstract

Molecular graph generation using Graph Neural Networks (GNNs) has gained significant attention due to their ability to learn structural patterns from data. However, purely GNN-based generative models construct molecular graphs through probabilistic node and edge predictions, often resulting in structurally invalid or chemically inconsistent graphs due to the lack of explicit constraints. In this paper, we propose a hybrid framework that integrates graph grammar rules with GNN-based molecular generation. The baseline model generates molecular graphs using a standard GNN approach, while the proposed method incorporates graph grammar production rules to guide graph transformations and enforce structural validity at each step of generation. This ensures that intermediate and final graphs adhere to predefined constraints. A comparative analysis between unconstrained GNN generation and grammar-guided generation is presented. Results indicate that while GNNs provide flexibility and diversity, the integration of graph grammar rules significantly improves the validity and consistency of generated molecular structures.

Keywords: Graph Grammars, Graph Neural Networks, Molecular Graph Generation, Graph Rewriting Systems.

Fuzzy Flat Splicing P Systems

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Abstract

Splicing systems are well known bio-inspired formal models used for string generation in automata and language theory. Flat splicing P systems extend this idea by introducing a membrane structure that supports parallel application of splicing rules. In this paper, we introduce a new variant called fuzzy flat splicing P systems, in which fuzzy membership values are associated with axioms and splicing rules to represent uncertainty in the splicing process. The working mechanism of fuzzy splicing operations in the flat membrane environment is formally defined and the corresponding fuzzy language generation process is studied. We establish fundamental properties of the proposed model and investigate its generative power under different fuzzy operations. In particular, we show that the fuzzification of flat splicing P systems can influence the class of languages generated and may increase the expressive capability of the system under suitable conditions. The study provides a natural extension of existing splicing models and contributes to the theoretical understanding of fuzzy mechanisms in membrane computing frameworks.

Keywords: Fuzzy flat splicing P systems; Formal languages; Membrane computing; Fuzzy computation; Parallel string processing.

Crystal Growth Pattern Formation using Fuzzy Cellular Automata on Finite Triangular Lattice

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Abstract

Pattern formation in discrete dynamical systems provides valuable insights into natural growth processes. In this work, a fuzzy cellular automata model on a finite triangular lattice is proposed to study the emergence of crystal growth patterns. The triangular lattice enables multi-directional interactions among cells, supporting the development of highly symmetric spatial structures. By incorporating fuzzy transition rules, the model captures gradual variations in cell states and the influence of neighboring interactions. Through iterative evolution, the system produces complex crystal-like growth patterns characterized by radial symmetry and branching structures. Numerical experiments illustrate how variations in fuzzy rule parameters influence the morphology and evolution of the generated patterns. The proposed approach demonstrates the potential of fuzzy cellular automata on triangular lattices as an effective framework for investigating crystal growth phenomena and pattern formation in discrete dynamical systems.

Keywords: Fuzzy cellular automata, Crystal growth, Triangular lattice

Text to Video generation for continuous story telling and content creation

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Abstract

This project presents a text-to-video generation system that uses artificial intelligence to convert written descriptions into short videos. The system is built using the CogVideoX AI model, which is capable of producing video frames based on natural language input. To ensure the program works efficiently even on computers with limited GPU memory, the code includes memory optimization techniques and lightweight configurations.

In this system, the user provides a text prompt that describes a particular scene, action, or environment. The AI model processes the input using deep learning techniques and interprets the meaning of the text. Based on this understanding, the model generates a sequence of visual frames that represent the scene described in the prompt. Each frame is created carefully to maintain visual continuity and relevance to the original description.

After the frames are generated, they are arranged in order and combined to produce a smooth video. The final output is saved as a video file that can be played, downloaded, or shared.

This project demonstrates how artificial intelligence can transform simple text ideas into visual content automatically. Such technology can be useful in areas like digital content creation, storytelling, education, advertising, and media production. It highlights the growing potential of AI in supporting creative processes and making visual content generation faster and more accessible.

Keywords: CogvideoX ;.Generative AI ;Video Frame

On a Class of Generalized Janowski-Type Starlike Functions using Salagean Q-Differential Operator

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Abstract

In this paper, we apply the idea of subordination, to introduce a new class $S_q^*(n, \lambda, \alpha, A, B)$ of analytic functions in Janowski domain, related to generalized Salagean q-differential operator. The class $S_q^*(n, \lambda, \alpha, A, B)$ contains many subclasses of starlike functions when its associated parameters are altered. Further, we study the geometric properties of new class such as coefficient inequality, growth, distortion and covering properties. Also, we solve radii problems and derive the subordinating factor sequence property for the class. As mathematical applications, we study Bernadi integral operator for the new class.

Keywords: Analytic function, Janowski type q-starlike functions, Salagean q-differential operator, Subordination, Benadi operator

More Results on Independent Domination and Hinge Domination Number of Graphs

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Abstract

Domination in graphs is one of the most interesting and important topics in graph theory as it has wide applications in different domains. A dominating set of a finite, simple, connected, and undirected graph $G(V, E)$, or simply G with a non-empty node set $V(G)$ and line set $E(G)$, is a set $S_D \subseteq V(G)$ such that every node, $\alpha \notin S_D$ is adjacent to a node, $\beta \in S_D$. The domination number of G , represented by $\gamma(G)$, is the cardinality of a minimum dominating set. Similarly, set $S_I \subseteq V(G)$ of nodes is called an independent set if no two nodes in S_I are adjacent to each other. An independent dominating set of G is a set S_i that is both dominating and independent in G . The independent domination number of G , represented by $i(G)$, is the cardinality of a minimum independent dominating set. On the other hand, a set D of nodes in G is said to be a hinge dominating set if every node v is adjacent to some node $x \in D$ and a node $y \in D$ such that (x, y) is not a line in E . The hinge domination number of G , denoted by $\gamma_h(G)$ is the minimum size of a hinge dominating set. In this paper, the independent domination number and hinge domination number of various classes of graphs are obtained.

Keywords: Graph, Domination in graph, Domination number, Independent Domination number, Hinge Domination number

Labeling Schemes on Vertex-Switched Jewel Graphs: Algorithmic Framework And Application To Electricity Distribution Models

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Abstract

This paper deals with graph theory, a key area of discrete mathematics that focuses on the study of structures formed by vertices and edges to describe relationships among discrete entities. It provides systematic techniques to investigate properties such as connectivity, adjacency, and overall structure, and is widely used to address problems involving routing, matching, covering, partitioning, and optimization. Graph theory also plays a vital role in practical domains like communication networks, electrical systems, and algorithm design. A major topic within this field is graph labeling, which assigns integers to the vertices or edges of a graph under defined conditions. Several labeling schemes, including graceful, odd graceful, even graceful, harmonious, and magic labelings, have been extensively studied. Graceful labeling was introduced by Alexander Rosa, followed by odd graceful labeling by R. Gnanajothi in 1991, and even graceful labeling by Ahmed A. Elsonbaty and Salama Nagy Daoud in 2017. In this study, we focus on vertex-switched jewel graphs and establish the existence of graceful, odd graceful, and even graceful labelings through constructive methods. The proposed algorithms further support these results and encourage future exploration of advanced labeling techniques.

Keywords: Graceful labeling, Odd graceful labeling, Even graceful labeling, Jewel graph, Vertex- Switched Jewel graph.

Farey Cordial Labelling of Graphs

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Abstract

The Farey sequence F_n of order n is the ordered list of all reduced fractions between 0 and 1 whose denominators do not exceed n . Many interesting works have been carried out on Farey sequence. Our work is defining a graph cordial labelling using Farey sequence. An injective function $f:V \rightarrow F_n$ where $F_n = \{\frac{p}{q} : 0 \leq p \leq q \leq n, \gcd(p, q) = 1\}$ that assigns reduced fractions $p/q \in F_n$ to vertices is said to be Farey Cordial Labelling if the induced edge function $f^*:E \rightarrow \{0,1\}$ defined by

$$f^*(uv) = |f(u) - f(v)| = \begin{cases} 1 & \text{if } ad - bc = 1 \\ 0 & \text{otherwise} \end{cases} \quad \text{for some } f(u) = \frac{a}{b} \text{ and } f(v) = \frac{c}{d}$$

Farey cordial graphs are graphs that admit Farey Cordial labelling. In this article, the existence of Farey Cordial labelling has been studied to certain family of graphs.

Keywords: Graphs, Farey Cordial labelling, Farey Cordial graphs

Sum and Product Cordial Labelling of Certain Graphs

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Abstract

Numerous problems in graph theory consist in finding vertex labeling or an edge labeling for a graph with numbers satisfying certain properties. Weaker version of sum and product cordial labeling was introduced by B.J.Murali et.al. and studied the existence for certain classes of graphs. In this paper we are going to study about the stronger version of the same labeling known as strong sum and product cordial labeling of graphs. A graph $G(V, E)$ is said be strong sum and product cordial labeling if there exists an injective function f from the vertex set $V(G)$ to the set of positive real numbers so that the induced edge function f^* from the edge set $E(G)$ defined by $f^*(uv) = f(u) + f(v) = f(u) \times f(v)$ takes the value 1 if it satisfies or 0 otherwise . Also satisfies the cordiality condition that $|e_{f^*}(0) - e_{f^*}(1)| \leq 1$. We are going to investigate this labeling for certain classes of graphs such as corona graph $C_n \odot K_1$, comb graph, spider graph and tadpole graph .

Keywords: Graph, sum and product cordial labeling, strong sum and product cordial labeling , strong sum and product cordial graphs.

A Study on the Connected Power Domination of Graphs

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Abstract

Ensuring full network observability in power grids via optimal PMU placement led to the study of power domination (PD). Connectivity enforcement among units minimises processing stations and infrastructural cost, motivating the concept of connected power domination (CPD). In a graph G , the connected power domination number $\gamma_{p,c}(G)$, corresponds to the cardinality of the minimum power dominating set, which is connected. In this paper, we study the comparative behaviour of $\gamma(G)$ and $\gamma_{p,c}(G)$ in trees, highlighting the structural characterisation that governs their relationship. We further investigate the relationship between PD and CPD in trees. In addition, we propose an algorithm to construct a minimum CPD set.

Keywords: Domination, Power Domination, Connected Power Domination, Trees.

Multi criteria Decision Making with Risk Attitudes in Fuzzy PERT Networks using Trapezoidal Intuitionistic Fuzzy Numbers

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Abstract

Making decision in real world situation is more complex due to uncertainty and impreciseness. Hence fuzzy MCDM is very helpful for the decision maker to choose the best alternative with the conflicting multi criteria. In this paper, criteria values are considered as Trapezoidal Intuitionistic fuzzy numbers in fuzzy PERT networks. This approach enhances the accuracy and reliability of decisions making it highly applicable in practical scenarios such as travel selection, resource allocation etc. The best alternative is chosen for different risk attitudes using linguistic expressions.

Keywords: Multi criteria decision making; Trapezoidal intuitionistic fuzzy number, linguistic variables.

Characteristics of Difference Mean Edges in Complements of Fuzzy Graphs

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Abstract

This study investigates the behavior of difference mean edges in the complements of fuzzy graphs. This includes identifying the conditions under which edges in a graph's complement preserve the difference mean property. Investigating scenarios including effective difference mean edges, which not only meet mean-based criteria but also reflect the complement's strongest membership relations. The specific conditions in which edges in complements also turn into difference-mean edges in accordance with definitions of complement membership are determined.

Keywords: Fuzzy graph, Difference mean edge, Difference Mean fuzzy graph, Effective Difference mean edge, Effective fuzzy graph, Complement.

Machine Learning-based Predictive Analysis of Prostate Cancer Drugs through Distance-Based Topological Indices

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Abstract

Cancer is one of the most deadly diseases that can affect both humans and other living organisms. Prostate cancer is the second most common cancer among men and the leading cause of cancer-related deaths in this group. As people age, their risk of developing prostate cancer increases, although experts remain uncertain about the exact reasons for this trend. Regression models are essential in quantitative structure-property relationship (QSPR) analysis, particularly when working with topological indices. These models help quantify the relationship between chemical structure and properties, which is crucial for drug development. This study investigates the correlation between distance-based descriptors and the physico-chemical properties of drugs used to treat prostate cancer. We computed ten distance-based topological indices for nineteen different drugs using computational techniques. Subsequently, we developed curve-fitting and regularized regression models using these distance-based indices to estimate seven physico-chemical properties of the prostate cancer drugs. Additionally, the most effective predictive models have been evaluated using the leave-one-out cross-validation technique to quantify the goodness of fit.

Keywords: Topological indices, Distance-based indices, Zagreb connection indices, QSPR analysis.

Graph Driven Link Prediction for Ayurvedic Drug Development

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Abstract

Ayurveda research explores plant-based therapies that are considered safer alternatives to modern synthetic drugs, which may cause adverse effects. However, validating these herbal compounds through laboratory studies demands significant time, infrastructure, and cost. To address this, we constructed a knowledge graph that integrates key Ayurvedic herbs and their phytochemicals—extracted inspired by recent research via NLP-assisted literature mining and mapped them to protein targets using curated resources such as IMPPAT and STRING. Standard identifiers like KEGG and UniProt were used to unify biological entities. We leveraged Graph Neural Networks (GCN, GraphSAGE, and GAT) and centrality based heuristics to capture topological patterns and predict missing herb–protein associations using both global link prediction and localized one-hop subgraph classification. The best model demonstrated strong predictive capability (accuracy: 0.976, precision: 0.954, recall: 0.976, ROC AUC: 0.99), illustrating the potential of graph-based AI for accelerating Ayurveda focused drug discovery.

Keywords: Graph Neural Networks, Bipartite graphs, Node2vec, Centrality measures,

Analysing Power Domination on Q -graphs and Q -vertex (or edge) Join Graphs

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Abstract

To achieve complete monitoring of electrical networks and power systems, it is often facilitated by the strategic placement of the Phasor Measurement Units (PMUs). This motivated to research on the power domination (PD) problem which efficiently selects the minimum required locations for these sensors to be placed. In this article, we investigate the domination number $\gamma(G)$ and power domination number (PD-number) $\gamma_p(G)$ of Q -graphs and determine their general bounds in terms of order, $\gamma(G)$ and $\gamma_p(G)$. Furthermore, we study on the PD-number of various graphs obtained by performing join operations on Q -graphs.

Keywords: Domination, Power domination, Q -graphs, Q -vertex join graphs.

Secure Domination in Generalized Petersen Graphs

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Abstract

This paper examines the rapidly evolving concept of Secure domination in Graph Domination study. In this paper, the Secure domination number of Generalized Petersen Graphs has been discussed, and bounds for the Secure domination number $\gamma_s(G)$ have been established for all families of graphs $P(n, m)$, where $m \geq 1$ and $n \geq 2m + 1$. The study shows that secure domination provides effective coverage with less redundancy and safeguards against vertex failures when utilized in Generalized Petersen Graphs, whose structural characteristics shows that the findings of the paper applies to more complex graph networks.

Keywords: Domination, Secure Domination, Generalized Petersen graphs.

RAG-SCEE: A Retrieval-Augmented Schema-Constrained Framework for Document-Level Event Extraction

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Abstract

Document-level event extraction focuses on identifying event triggers, event types, and argument roles from documents where the relevant information is often spread across several sentences. This makes the task difficult, since accurate extraction depends not only on understanding long-range context, but also on maintaining valid event-role structure and ensuring that the extracted information is actually supported by the document. To address these issues, this manuscript proposes RAG-SCEE, a retrieval-augmented and schema-constrained framework for document-level event extraction.

The proposed framework first represents the document in a contextual form and retrieves the most relevant sentences and entity mentions for a candidate event. It then applies event-schema constraints so that only valid argument roles are considered during prediction. Based on this focused and structured evidence, a large language model is used as a guided reasoning component rather than as a free-text generator. In the final stage, a verification layer checks whether the predicted event structure is consistent with the schema and supported by the retrieved evidence before assigning a confidence score to the extracted event.

By combining retrieval, schema restriction, controlled reasoning, and verification, the proposed framework aims to improve extraction reliability, reduce unsupported predictions, and make the overall process more interpretable. The model therefore offers a practical and extensible approach for document-level event extraction in complex textual settings.

Keywords: Document-level event extraction; retrieval-augmented generation; schema-constrained learning; large language models; event argument extraction

An Analysis of Impact of Telomere Shortening in Diabetic Patients through Mathematical Modeling

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Abstract

Diabetics is the major problem in our day to life of all age groups. The diabetic route cause related with many aspects like heredity, food habit, stress etc. Telomeres are protective caps at the each chromosome ends, which is essential to protect the genomic stability and cellular integrity. The telomere shortening is one of the major problem in our society. This cause fast aging, imbalance health, stress life etc., In this study how telomere shortening affect the diabetics milletus patient is analyzed. The SEIR mathematical model is established. The equilibrium and interior equilibrium point is found. The local and global stability is analyzed for the system of equations. The numerical simulation is presented for the theoretical concepts.

A Heuristic-Accelerated Yen's Algorithm for K-Shortest Time-Dependent Routing under a Fermatean Neutrosophic Framework

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Abstract

Time-Dependent Path Computation and Alternative Route Selection have become an increasingly important area of research in intelligent transportation systems (ITS), logistics planning and network optimization. In this paper, we investigate the K-Shortest time dependent path problem in networks represented by fermatean neutrosophic information. We use time varying membership, in determination and non-membership functions to represent edge weights. In order to overcome the limitations of classical shortest path algorithms that cannot handle uncertainty and temporal variability simultaneously, we propose a heuristic-guided framework for efficient computation of K shortest paths. An analysis of the computational complexity indicates a significant improvement of the practical performance of the proposed method when compared with conventional methods for computing K- shortest paths.

Keywords: K-Shortest Paths, Fermatean Neutrosophic Sets, Heuristic Search, Network Optimization, Routing Problems.

Fractional Network Model for Respiratory Infection: Stability Analysis

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Abstract

This paper introduces a fractional-order network model designed to analyze the spread of respiratory diseases. By utilizing the Caputo fractional derivative, the study incorporates memory effects into the transmission dynamics. The model divides the population into compartments: the Susceptible population, the Exposed population, the Infected population, the Hospitalized population, and the Recovered population, in order to model the progression of the disease. Basic properties of the model, including the positivity and boundedness of the solution, are proved. The equilibrium states, namely disease-free and endemic conditions, are determined, and the basic reproduction number is derived using the next-generation approach. Stability analysis is performed using fractional-order spectral conditions and Lyapunov techniques, showing that the disease-free equilibrium remains stable when the reproduction number is below unity, while persistence occurs otherwise. Numerical simulations support the analytical findings and demonstrate that memory effects inherent in the fractional framework lead to slower transmission dynamics and prolonged infection periods compared to classical models in realistic epidemiological scenarios.

Keywords: Fractional-order model, Network-based modeling, Stability analysis, Caputo fractional derivative

Data-Driven Machine Learning Model for Air Quality Prediction

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Abstract

Air Quality monitoring and forecasting have become critical challenges for public health authorities and policymakers in rapidly growing environments. While machine learning and deep learning models have shown strong performance in capturing complex temporal dependencies in pollution data, most existing approaches treat monitoring stations as independent entities, ignoring the spatial propagation of pollutants between nearby locations. The technique introduced in this work is a Spatio-Temporal Graph Attention Network combining a Graph Attention Network layer for spatial dependency with a Gated Recurrent Unit for temporal sequence learning. The proposed model was evaluated using one year of hourly air quality and metrological data from 13 CPCB monitoring stations across Hyderabad, India, covering the period January 2025 to January 2026.

Evaluation metrics including Root Mean square Error, Mean Absolute Error and R-squared confirmed the proposed model's advantages over reference models including ARIMA, standalone Long Shot-Term Memory and an edge-ablated variant with inter-station connections removed. Spatial influence analysis using learned attention weights, node ablation experiments and Granger causality tests confirmed statistically significant pollution propagation between stations. These findings demonstrate the necessity of network-aware spatio-temporal models for air quality forecasting and their potential for deployment in real-time public health alert systems.

Keywords: Graph Attention Network, Spatial Influence, Air Quality Prediction, Spatio-Temporal Graph Neural Network

Visibility Polynomial of Some Graph Operations

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Abstract

Let $G = (V, E)$ be a simple graph and let $X \subseteq V$. Two vertices $u, v \in V$ are said to be X -visible if there exists a shortest (u, v) -path whose internal vertices do not belong to X . A subset $X \subseteq V$ is called a mutual-visibility set if every pair of vertices in X is X -visible. The visibility polynomial of G is defined as $Y(G) = \sum_{i \geq 0} r_i x^i$, where r_i denotes the number of mutual-visibility sets of size i . In this paper, we study the visibility polynomial for some graph operations. Also, we analyze its behaviour for cycles and identify instances where the number of maximal mutual-visibility sets coincide. We derive explicit expressions for the visibility polynomial of the join of two graphs and extend the analysis to the corona product. For the corona product, we introduce c_Q -visible sets and characterize the resulting mutual-visibility structures. These results provide new insights into visibility-based parameters under graph operations.

Keywords: mutual-visibility set, visibility polynomial, graph operations

Optimization of Platelet Ordering Policy Using MINLP and Discrete-Event Simulation for the modified A_1A_2BO Blood Group System

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Abstract

Platelet inventory management (PIM) is challenging due to the short shelf life of platelet products and the heterogeneous demand arising from both emergency and routine patient needs. Ensuring adequate availability while minimizing wastage requires a scientifically optimized ordering policy. Additionally, compatibility requirements for the A_1A_2BO system and Rh factor influence inventory dynamics and must be incorporated to maintain service quality. A Mixed-Integer Nonlinear Programming (MINLP) model is developed to determine an optimal platelet ordering policy under heterogeneous demand with an (R, s, S) policy for the modified A_1A_2BO system. The model minimizes total operational costs, including ordering, holding, wastage, shortage, subtyping, and penalty costs, while accounting for issuing-related constraints, such as cross-matching and compatibility, as well as cutoff policies. To evaluate model performance, scenario-based discrete-event simulations are conducted using real-world data. Integrating compatibility constraints significantly enhances service levels by improving the fulfillment of both emergency and routine demands. The proposed policy demonstrates strong robustness across varying demand and supply conditions. Compared to conventional approaches, it substantially reduces platelet wastage and shortage rates. The combined optimization–simulation framework provides healthcare facilities with a reliable strategy to maintain consistent platelet supply and improve transfusion service quality.

Keywords/Phrases: Heuristic approach, MINLP, Ordering policy, Platelet products, Simulation-Optimization

Domination on Cycle with Chords

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Abstract

Let $G = (V, E)$ be a graph. A subset S of V is a dominating set of G if every vertex in $V \setminus S$ is adjacent to a vertex in S . The minimum cardinality of a dominating set of G is called the domination number of G and is denoted by $\gamma(G)$. In this paper we found the domination number for cycle with $n - 4$ chords, cycle with $n - 5$ chords and cycle with 3 chords.

Keywords: Domination, Cycle with chords.

Support Strong Coalition in Line graphs, Total graphs, Middle graphs and Quasi - Total graphs

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Abstract

This study introduces a Support Strong Coalition in Line graphs, Total graphs, Middle graphs and Quasi – Total graphs. A support strong coalition in a graph $G = (V, E)$ consists of two disjoint sets of vertices V_1 and V_2 , neither of which is a support strong dominating set but whose union $V_1 \cup V_2$ is support strong dominating set. We say that the sets V_1 and V_2 form a support strong coalition, and are support strong coalition partners. Next, we define a support strong coalition partition, henceforth called a $supp_{sc}$ - partition, in a graph G is a vertex partition $\pi = \{V_1, V_2, \dots, V_k\}$ such that every set V_i of π is either a singleton support strong dominating set, or is not a support strong dominating set but forms a support strong coalition with another set V_j in π . The support strong coalition number $supp_{sc}(G)$ equals the maximum order k of a $supp_{sc}$ - partition of G , and a $supp_{sc}$ - partition of G having order $supp_{sc}(G)$ is called a $supp_{sc}(G)$ - partition. In this study, we investigate the concept of support strong coalition in various graph structures, namely line graphs, total graphs, middle graphs, and quasi-total graphs. Further, we determine the support strong coalition number for the given graph structures. This work contributes to the study of domination theory and its applications in network analysis, communication systems.

Keywords: Support strong domination, Support strong coalition, Support strong coalition number, Total graphs, Middle graphs

A Hybrid Model for Traffic Pattern Prediction Using J48 Decision Tree and Fuzzy Petri Nets

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Abstract

This paper integrates fuzzy petri nets (FPNs) and the J48 decision tree to present a Hybrid model for traffic pattern prediction. Vehicle counts, time, and day-by-day data are recorded in a vision-based dataset that is updated every 15 minutes for a month. Traffic conditions are classified as Heavy, High, Normal, or Low. To model traffic situations under uncertainty, interpretable rules are extracted using J48 and then run via FPNs. The hybrid method effectively addresses real-time traffic monitoring and intelligent transportation systems by fusing dynamic rule-based reasoning with categorization accuracy.

Keywords: Traffic Prediction, J48 Decision Tree, Fuzzy Petri Nets, Rule-Based Classification, Machine Learning, Computer Vision Data, WEKA, Intelligent Transportation Systems.

Distance-Hereditary Coalitions in Graphs

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Abstract

This paper introduces the concept of a distance-hereditary coalition in graphs, a parameter that combines the structural stability of distance-hereditary graphs with cooperative domination. A distance-hereditary coalition is a pair of disjoint vertex sets that are individually non-dominating but union dominate the graph, with the additional requirement that this property and the distance between the sets are preserved in every connected induced subgraph containing them. We define the distance-hereditary coalition number $C_{dh}(G)$ as the maximum number of sets in a partition of the vertex set where each set either dominates the graph or forms a distance-hereditary coalition with another set. We investigate this parameter for various graph families including paths, cycles, complete graphs, star graphs and bipartite graphs, providing exact values and characterizations. A real-world application in smart fire department resource allocation is discussed, demonstrating how the concept models resilient emergency coverage under network disruptions. Algorithmic aspects are also explored, including complexity results and polynomial-time solutions for certain graph classes. This work establishes a foundation for further research in hereditary coalition structures and their applications.

Keywords: Domination, Coalition, Distance-hereditary, Distance-hereditary coalition.

Beyond Static Topologies: Real-Time Misinformation Detection via Distributed Semantic Knowledge Graphs and GNNs

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Abstract

The proliferation of sophisticated misinformation demands detection mechanisms capable of matching its velocity and structural complexity. Current leading academic frameworks predominantly rely on static, precomputed graphs, rendering them highly ineffective against rapidly mutating, contemporary synthetic narratives. To overcome this critical limitation, we introduce a scalable computational architecture that dynamically constructs and analyses Semantic Knowledge Graphs from streaming social network data streams. Our novel approach leverages a distributed pipeline to continuously ingest unstructured textual information, mapping nuanced weighted edges that capture semantic alignment, sentiment volatility, and complex entity relationships instantaneously. We then deploy an advanced Graph Neural Network over this continuously evolving topology in order to capture hidden propagation patterns immediately. Extensive empirical evaluations on standard benchmark datasets demonstrate that our dynamic model significantly outperforms traditional baseline static models in both superior predictive accuracy and overall processing efficiency. By prioritizing robust architectural scalability and rapid semantic integration, this framework successfully provides a highly adaptable proactive defence mechanism for identifying emerging threat actors and automated bot clusters across vast digital ecosystems.

Keywords: Graph Neural Networks, Semantic Knowledge Graphs, Misinformation Detection, Distributed Computing, Dynamic Network Analysis.

**Elliptic Sombor Invariant of $\Gamma(\mathbb{Z}_n)$ for
 $n \in \{l^3m^3, l^3m^2, l^3m, l^2m^2n, l^2m^2n^2\}$**

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Abstract

This work discloses the Elliptic Sombor invariant associated with the zero-divisor graph of \mathbb{Z}_n , indicated as $\Gamma(\mathbb{Z}_n)$ for $n \in \{l^3m^3, l^3m^2, l^3m, l^2m^2n, l^2m^2n^2\}$ where l, m and n are distinct prime numbers.

Keywords: Zero-divisor Graph, Elliptic Sombor Invariant, Ring, Degree, Index.

On Product Elliptic Sombor Invariant of Graphs

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Abstract

The Elliptic Sombor invariant, a remarkably simple node-degree-based topological invariant, is induced by the area of the ellipse. The focal points of an ellipse that represents the degrees of two adjacent nodes serve as the foundation for this technique. The Product Elliptic Sombor invariant of a graph is stated as

$$IELSO(\mathcal{G}) = \prod_{\mu, \nu \in \mathbb{E}(\mathcal{G})} \left(\underline{d}_{\mathcal{G}}(\mu) + \underline{d}_{\mathcal{G}}(\nu) \right) \sqrt{\underline{d}_{\mathcal{G}}(\mu)^2 + \underline{d}_{\mathcal{G}}(\nu)^2},$$

where $\underline{d}_{\mathcal{G}}(\mu)$ indicates the degree of a node μ in \mathcal{G} . The present article introduces certain graph transformations that lead to either an increase or a decrease in the Product Elliptic Sombor invariant. By employing these transformations, the extremal values of the Elliptic Sombor invariant for trees and unicyclic graphs are rigorously characterised.

Keywords: Product Elliptic Sombor Invariant, Extremal Value, Unicyclic Graph, Tree.

GAIN-HealthNet: Learning Feature-Level Graph Representations for Joint Imputation and Disease Risk Prediction

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Abstract

Electronic Health Records (EHRs) are inherently incomplete, with missing clinical measurements arising from irregular testing, cost constraints, and data collection inconsistencies. This challenge is particularly critical in real-world clinical environments where timely and accurate decision-making is essential. Conventional approaches typically perform data imputation as a preprocessing step, followed by predictive modeling, which often propagates imputation errors and ignores underlying relationships among medical variables. In this work, we propose GAIN-HealthNet, a unified graph-aware framework that jointly performs missing data imputation and disease risk prediction. Unlike traditional methods that treat features independently, GAIN-HealthNet models patient data as a feature-level graph, where nodes represent clinical variables and edges capture physiological and statistical dependencies (e.g., blood pressure–heart rate, glucose–BMI). A Graph Neural Network (GNN) is employed to learn these inter-feature relationships and propagate contextual information across the graph. Leveraging these representations, an adaptive imputation module estimates missing values using both local feature dependencies and global patterns. The imputed representations are simultaneously optimized for downstream prediction through a task-specific prediction head. GAIN-HealthNet's architecture, which combines imputation and prediction in a single process, reduces the spread of errors and improves its ability to handle incomplete data. The experimental results show that this method performs better than traditional pipelines that first impute data and then make predictions. This highlights its potential for creating reliable and understandable systems to support healthcare decisions. Furthermore, the proposed framework offers scalability and adaptability across diverse healthcare datasets and varying levels of data incompleteness.

Keywords: Graph Neural Networks, Joint Imputation-Prediction, Healthcare Analytics, Feature Dependency Modeling, Disease Risk Prediction

YOLOv11-TAGNet: Texture-Aware Gated Attention for Robust Cotton Boll Detection in Complex Agricultural Fields

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Abstract

The identification of agricultural objects in real-field conditions is a challenging task due to background interference caused by variations in illumination, scale differences, and the low-texture characteristics of many agricultural objects such as cotton bolls, fruits, and immature crops. These challenges often reduce the accuracy and stability of traditional object detection systems. To address these limitations, this paper proposes YOLOv11-TAGNet, a lightweight yet powerful extension of the YOLOv11 model that incorporates a novel Texture-Aware Gated Attention (TAGA) module designed specifically for agricultural scene understanding. The proposed TAGA module integrates multi-scale texture descriptors using spatial gradients and edge-enhanced representations, unlike conventional attention mechanisms that mainly rely on semantic feature maps and feature intensity. This approach enables the network to distinguish subtle agricultural objects from visually similar foliage and cluttered backgrounds by explicitly capturing texture variations and boundary information. Additionally, a gated adaptive feature fusion strategy is introduced to dynamically combine texture-enhanced representations with deep semantic features extracted from convolutional layers. This adaptive gating mechanism selectively emphasizes discriminative texture signals while suppressing irrelevant background noise, thereby improving detection robustness in conditions such as occlusion, low contrast, and heterogeneous field environments. The proposed architecture remains computationally efficient, requiring minimal additional parameters, and can be easily integrated into existing YOLOv11 pipelines without compromising real-time inference performance. Extensive experiments on agricultural object detection datasets demonstrate that YOLOv11-TAGNet significantly outperforms baseline detectors, including YOLOv8 and standard YOLOv11, in terms of mean Average Precision (mAP), recall, and detection stability under challenging field conditions. The results highlight the effectiveness of texture-sensitive attention for fine-grained agricultural object detection. Overall, the proposed framework provides a lightweight, scalable, and practical solution for precision agriculture applications, supporting improved crop monitoring, automated harvesting, and smart farming robotics.

Keywords: Cotton Boll Detection, YOLOv11-TAGNet, Texture-Aware Gated Attention, Precision Agriculture, Deep Learning

On Modified Euler Sombor Descriptor of Trees

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Abstract

An important and fascinating topic of research in graph theory is the investigation of limits for topological descriptors based on different graph characteristics, as well as the finding of extremal graphs when these bounds are obtained. Gutman proposed the Sombor descriptor, a novel node-degree-based topological descriptor based on Euclidean metrics. Subsequently, the modified Sombor descriptor, a modified version of it was presented. In this study, we compute upper limits of the modified Euler Sombor descriptor of the tree \mathbb{T} with maximum degree Δ and order n . The modified Euler Sombor descriptor of a graph \mathcal{G} is defined as follows: ${}^m\text{ESO}(\mathcal{G}) = \sum_{\mathfrak{b}\mathfrak{h} \in E(\mathcal{G})} \frac{1}{\sqrt{\mathfrak{d}_{\mathcal{G}}(\mathfrak{b})^2 + \mathfrak{d}_{\mathcal{G}}(\mathfrak{h})^2 + \mathfrak{d}_{\mathcal{G}}(\mathfrak{b}) \mathfrak{d}_{\mathcal{G}}(\mathfrak{h})}}$, where $\mathfrak{d}_{\mathcal{G}}(\mathfrak{b})$ is the degree of the node \mathfrak{b} in \mathcal{G} .

Keywords: Tree, Modified Euler Sombor Descriptor, Limit, Degree, Topological Index.

Structured Hollow Matrices, Graph Representations and Applications in Matrix-Based Cryptography

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Abstract

In this paper we study a class of structured hollow matrices and their applications in matrix-based cryptography. A hollow matrix is a square matrix whose diagonal entries are zero. These matrices naturally arise in the study of graphs. We propose a construction method for generating hollow matrices of order $n \times n$ using a difference-avoidance rule that ensures all off-diagonal entries are distinct and satisfy specific difference constraints. The constructed matrices admit a natural interpretation as weighted adjacency matrices of complete directed graphs without self-loops. We show that in the 3×3 case, the constructed hollow matrices are invertible. This property allows them to be used as key matrices in matrix-based encryption and decryption schemes. We further illustrate this application with examples.

Keywords: Hollow Matrices, Difference-Avoidance Construction, Weighted Directed Graphs, Matrix Invertibility, Matrix-Based Cryptography

Efficient Construction of Minimum Spanning Trees via Graceful Labeling of Lexicographic product Graphs

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Abstract

In this research, we examine the creation of a minimum spanning tree of Lexicographic product of path graphs using Kruskal's algorithm under the background of graceful labeling. To discover the minimum spanning tree, we execute Kruskal's algorithm, which chooses edges in growing order of their weights, although guaranteeing that no cycle is designed throughout the process. The study reveals that the usage of graceful labeling offers a systematic way to create edge weights, empowering well – organised creation of the minimum spanning tree. The outlined scheme emphasizes the correlation between graph theory and Combinatorial optimization techniques, with probable claims in network design and communication systems.

Keywords: Graceful labeling, kruskal's algorithm, Lexicographic product, Minimum, Spanning tree.

Encryption and Decryption through Even-Odd Harmonious Graph

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Abstract

Cryptography plays a vital role in today's digitally connected world, serving as a foundational pillar for ensuring the confidentiality, integrity, and authenticity of data. It involves the use of mathematical algorithms and cryptographic keys to encode (encrypt) data in a way that it can only be decoded (decrypted) by individuals or systems possessing the appropriate keys. Encryption is a fundamental technique for safeguarding sensitive data, and its effectiveness relies on innovative approaches to protect against evolving threats. Graph labeling is crucial in cryptography, playing a pivotal role in the broad field of techniques designed to ensure the confidentiality and security of information. This article explores the application of even-odd harmonious labeling in the field of cryptography, with a specific focus on encryption and decryption processes. The article presents an encryption algorithm that employs RSA algorithm and even-odd harmonious labeling to convert plaintext data into ciphertext, making it resistant to unauthorized access. This encryption system aims to enhance data security and efficiency of data protection.

Keywords: Ciphertext, Encryption, Decryption, RSA algorithm, Even-odd harmonious graphs

On the Domination Integrity Degree of Standard Graph Transformations

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Abstract

Domination and integrity are two important parameters in network analysis. Domination focuses on controlling or monitoring a network through a selected set of vertices, while integrity measures the network's robustness or vulnerability when certain vertices are removed. Sundareswaran et al. introduced the concept of domination integrity to capture the vulnerability of a network after the removal of a dominating set. Extending this idea to the vertex level, a new graph parameter called the domination integrity degree of a vertex was introduced. For a vertex u , the domination integrity degree, denoted by $d_{DI}(u) = \min\{|S|: S \text{ is a minimal DI - set containing } u\}$, that is, the minimum cardinality of a minimal domination-integrity set containing u . This paper focuses on determining this parameter for various graph transformations derived from standard graphs. In particular, we analyze the domination integrity degree of vertices in line graphs, middle graphs, total graphs, and quasi-total graphs associated with selected classes of standard graphs like paths, cycles, complete graphs, complete bipartite graphs, star graphs, bistar graphs, book graphs, and windmill graphs. For each of these graph families, we establish results that characterize the domination integrity degree and provide explicit values or bounds.

Keywords: Domination integrity, minimal DI-sets, middle graphs, quasi-total graphs, total graphs.

On Finding Traffic Strength Of Railway Route Using Colouring

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Abstract

In this paper, the design of real time railway traffic strength is derived by means of Coloring method from Chennai to Coimbatore. There are more possibilities for a train running delay from one destination to another like infrastructure issues, weather conditions, heavy traffic, technical problems, emergency rescheduling etc. by identification of traffic strength helps to minimize the waiting time of the passengers of that route and rescheduling.

In this paper we design traffic flows into compatible graph, vertices are represented as the flow connected by an edge if and only if the flow at the crossroads can be moved simultaneously without causing crashes. This traffic strength of the train is determined by using the speed of the train with the help of GPS signal.

Keywords: Infrastructure issue, real-time information on railway systems, train timetable rescheduling, Traffic strength, technical issues in railway system, GPS integration

A Graph-Theoretic Shortest Path Framework Integrated with ANN for Intuitionistic Fuzzy MAGDM

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Abstract

Multi-Attribute Group Decision Making (MAGDM) is essential for addressing complex decision problems involving multiple alternatives, criteria, and expert opinions. Conventional aggregation methods, such as weighted averaging, often fail to capture structural relationships among decision elements. This study proposes a novel graph-theoretic framework for MAGDM under an intuitionistic fuzzy environment, integrating Dijkstra's shortest path algorithm with artificial neural networks (ANN). Expert-provided intuitionistic fuzzy decision matrices are transformed into weighted bipartite networks, where alternatives and criteria are represented as nodes and evaluation values as edges. These values are converted into cost-based distances, enabling shortest path analysis. Dijkstra's algorithm is applied to compute minimum accessibility costs, and the average shortest path distance is used as a measure of decision efficiency. To enhance decision accuracy, ANN is employed to learn complex nonlinear relationships and rank alternatives effectively. A multilayer aggregation mechanism combines expert-level outputs to determine the optimal alternative. The proposed hybrid model captures structural dependencies, improves decision robustness, and provides a scalable framework for advanced MAGDM applications.

Keywords: MAGDM, Dijkstra's Algorithm, Bipartite Graph Model, Network Optimization, ANN.

Structural Decision Optimization in MAGDM using Graph Centrality and ANN under Linguistic Intuitionistic Fuzzy Setting

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Abstract

Multi-Attribute Group Decision-Making (MAGDM) problems often involve uncertainty, hesitation, and linguistic evaluations from multiple experts. Existing approaches primarily rely on aggregation-based techniques, which fail to capture the underlying structural relationships and influence patterns among decision elements. This limitation highlights a critical research gap in integrating graph-theoretic insights with intelligent learning models under a linguistic intuitionistic fuzzy environment. To address this, the present study proposes a novel Linguistic Intuitionistic Fuzzy Artificial Neural Network (LIF-ANN) framework combined with a graph centrality-based approach. Initially, linguistic intuitionistic fuzzy decision matrices are constructed to model uncertainty and hesitation. These matrices are transformed into weighted graphs, where alternatives and criteria are represented as nodes and their interactions as weighted edges. Centrality measures are then computed to evaluate the structural importance of alternatives. The derived centrality scores are fed into a Perceptron-based ANN to learn nonlinear relationships and generate refined rankings. The proposed hybrid model enhances decision accuracy, captures connectivity patterns, and provides a scalable and interpretable framework for complex MAGDM applications.

Keywords: Intuitionistic Fuzzy MAGDM, Graph Centrality Analysis, Artificial Neural Networks (ANN), Linguistic Decision Making, Hybrid Graph–Neural Framework.

Analysis of Chemical Effects of Paddy Cultivation Using Graph Neural Networks

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Abstract

Paddy (*Oryza Sativa*) is one of the Main Crops used in Agriculture, which acts as a main source of Human livelihood. However, the use of Chemicals in agriculture has reduced crop yield in recent years. Conventional Machine Learning Algorithms do not consistently yield the desired results when it comes to predicting the effects of chemicals. To overcome these constraints, this study proposes a Graph Neural Network (GNN)-based model for predicting the effects of nitrogen-based fertilizers on paddy. The Edges of a graph data structure made from a crop recommendation dataset are constructed using the K-Nearest Neighbor (KNN) algorithm. A GraphSAGE-based GNN is used for classification. Thus, the proposed approach outperforms conventional algorithms with an Accuracy of 99% and high values for Precision, Recall, F1 score, R^2 , MAE, and RMSE.

Keywords: Graph Neural Networks, GraphSAGE, Precision agriculture, Paddy (*Oryza sativa*), Fertilizer impact prediction.

SMART GUARDIAN – An API-Driven AIoT Safety and Health Monitoring System for the Elderly

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Abstract

Smart Guardian is a safety and health monitoring device which is proposed to enhance the security, independence, and comfort of the elderly. Due to the increased susceptibility of the elderly to health challenges, falls and delayed reaction to emergencies, there is an increased demand to have efficient and reliable monitoring solutions. The suggested system is a hybrid of wearable sensors and Internet of Things (IoT) sensors that will be applied to track important health indicators such as heart rate, fall detection provided by motion sensors and real-time location determination provided by GPS. The caregiver receives a message alerting him or her about a fall, abnormal health conditions, and travel outside the predetermined areas of safety in real time in the event of an emergency. In addition, AI-based analytics can be incorporated in the system to detect abnormalities and anticipate risks. With such information, the caregivers will be able to react in time with alerts and the elderly people can lead an independent life with timely assistance to keep them safe.

Keywords: AIoT, Elderly Monitoring, Fall Detection, Health Monitoring, Smart Healthcare

A Node Degree Based Quantum Neural Network Framework for MAGDM under Intuitionistic Fuzzy Graphs

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Abstract

Existing methods for Multiple Attribute Group Decision Making (MAGDM) under Intuitionistic Fuzzy Set (IFS) environments often depend on matrix based representations, which may fail to effectively capture the relationships among alternatives and may also deal with limitations in handling complex valued information within advanced learning frameworks. In particular, the integration of graph based intuitionistic fuzzy structures with Quantum Neural Networks (QNN) remains largely undiscovered. To address this gap, this paper suggests a novel graph based QNN framework for solving MAGDM problems using IFS data. In the proposed approach, the IFS information is represented as an intuitionistic fuzzy graph, where alternatives are modeled as nodes and their relationships are described by membership and non-membership values. The fuzzy degree of each node is computed to capture the overall influence of alternatives within the network. These degree based representations are then normalized and encoded into quantum states, which serve as inputs to the QNN model. The proposed framework effectively combines structural information, uncertainty handling, and quantum learning. A numerical example illustrates that the model attains improved convergence behavior and enhanced decision accuracy compared to existing approaches.

Keywords: Quantum Neural Network (QNN), Intuitionistic Fuzzy Set (IFS), Intuitionistic Fuzzy Graphs, Node Degree, MAGDM

Optimizing Retrieval-Augmented Generation (RAG) for Question Answering System: A Comparative Study of Chunking and Retrieval Strategies on the Indian Lok Sabha Dataset

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Abstract

Retrieval-Augmented Generation (RAG) performance in domain-specific question answering, such as parliamentary proceedings, is highly sensitive to document chunking and retrieval mechanisms. This study investigates the Lok Sabha question-answer dataset by comparing three retrieval strategies: Naïve Retrieval, Sentence-Window Retrieval, and Auto-Merging Retrieval. By experimenting with multiple chunk sizes, retriever ensembling, and reranking, we identify optimized configurations. Our experimental evaluation shows that the Sentence-Window Retrieval approach, combined with reranking, achieves a superior retrieval accuracy of **89.3%**, significantly outperforming the Naïve (76.5%) and Auto-Merging (83.7%) methods. The results confirm that fine-grained chunking with contextual reconstruction improves retrieval precision for large-scale Indian parliamentary datasets.

Keywords: Retrieval-Augmented Generation, Chunking Strategies, Sentence-Window Retrieval, Auto-Merging Retrieval, Reranking, Indian Parliament, Lok Sabha, Governmental Datasets.

On Topological Operators in Pythagorean Fuzzy ${}^eG^*_{PF}$ Topological Structure Derived from Pythagorean Fuzzy Graphs

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Abstract

Pythagorean fuzzy structures have attracted significant attention in the literature due to their ability to effectively model uncertainty. However, constructing such a structure from a Pythagorean fuzzy graph introduces a novel perspective and provides additional insight into the interaction between fuzzy graph theory and fuzzy topology. In this study, a new Pythagorean fuzzy ${}^eG^*_{PF}$ topological structure is constructed from Pythagorean fuzzy graphs. The proposed structure is developed based on the adjacency relation between vertices together with the corresponding edge membership values. Fundamental topological operators such as PF - ${}^eG^*_{PF}$ interior, closure, exterior and boundary are defined and investigated within this framework. Several basic properties of these operators are discussed. Moreover, as the law of complements does not generally hold in the Pythagorean fuzzy environment, properties involving open and closed sets and their associated boundaries are examined from an alternative perspective.

Keywords: Pythagorean fuzzy set, Pythagorean fuzzy graph, Pythagorean fuzzy topology, Pythagorean fuzzy ${}^eG^*_{PF}$ topological structure.

Solving Fuzzy Game Problem using Symmetric Trapezoidal Fuzzy Numbers

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Abstract

In this study matrix games with fuzzy payoffs that are represented by symmetrical trapezoidal fuzzy numbers rather than ordinary fuzzy numbers. Using Mehar's method, a new method for solving the Fuzzy Game Problem (FGP) with symmetric trapezoidal fuzzy numbers is proposed. To find the best tactics, we transform the FGP into an analogous crisp game problem (GP) and use the dominance approach to solve the crisp problem. We illustrate the proposed method with a numerical example.

Keywords: Symmetric Trapezoidal Fuzzy Number (SymTrapFN), Dominance Method.

Directed Hypergraph-Based Analysis of Protein–Protein Interaction Networks for Identifying Hub Proteins in Parkinson’s Disease

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Abstract

Most efficient approach for identifying key proteins, key enzymes, and underlying biological structures associated with diseases using mathematical modelling is the Protein–protein interaction (PPI) analysis. A mathematical framework for analyzing PPI networks is proposed and applied specifically to Parkinson’s disease in this study. The PPI interactions are represented using a directed hypergraph model, which captures complex relationships among multiple proteins involved in the disease pathway. A peculiar directed hypergraph depth-first search algorithm is introduced to select the longest interaction paths within the network. Subsequently, a minor hypergraph is built to reduce the capacity of the directed hypergraph while conserving the significant interaction paths, resulting in a unimodular hypergraph structure. The properties of the unimodular hypergraph enable the clustering of influential proteins and enzymes associated with Parkinson’s disease, thereby providing valuable intuitiveness into the disease mechanism and highlighting potential targets for therapeutic intervention.

Keywords: PPI networks, Parkinson’s disease, directed hypergraph.

A Novel Ranking Method of Complex Pythagorean Neutrosophic Fuzzy Sets Applied to Renewable Energy Resource Selection

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Abstract

Strong decision-making frameworks that can manage the uncertainty, contradiction, and periodic fluctuation present in real-world data are required due to the growing demand for sustainable energy resources. In order to expand conventional neutrosophic and Pythagorean fuzzy sets into the complex domain, this work presents a novel ranking mechanism based on Complex Pythagorean Neutrosophic Fuzzy Sets (CPNFS). CPNFS efficiently captures both magnitude and phase information by representing truth, indeterminacy, and falsehood as complex-valued functions. This allows for sophisticated modeling of oscillatory and imperfect knowledge. To assess options under various criteria, a potential degree-based ranking method and a new score and accuracy function are created. The suggested framework is used to solve a multi-criteria decision-making (MCDM) problem that involves choosing sustainable energy sources while taking reliability, cost, efficiency, and environmental impact into account. Comparative study shows that, especially in situations with conflicting expert opinions and cyclic data patterns, the CPNFS-based ranking system yields more consistent and comprehensible results than current fuzzy and neutrosophic approaches. The results demonstrate the potential of CPNFS as an effective tool for researchers and policymakers to advance resource allocation and sustainable energy planning.

Key words: Complex Pythagorean Neutrosophic Fuzzy Set (CPNFS), Multi-Criteria Decision-Making (MCDM), Sustainable energy resources.

A Graph-Theoretic Framework for Heterogeneous Multiplex Networks with Unequal Node Sets

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Abstract

Multilayer and multiplex networks provide a powerful framework for representing systems composed of multiple interacting subsystems. Classical multiplex models typically assume identical node sets across layers, an assumption that is often violated in real-world systems such as brain networks, biological regulatory systems, and heterogeneous temporal processes. In this work, we introduce a fully explainable, graph-theoretic formulation of **heterogeneous multiplex networks** in which layers may contain unequal node sets and are coupled through explicitly defined inter-layer adjacency matrices. Using a block-structured supra-adjacency matrix representation, we unify intra-layer and inter-layer connectivity into a single global graph operator. The proposed framework preserves analytical tractability, supports spectral and dynamical analysis, and provides transparent interpretability by construction. This formulation extends classical multiplex network theory and enables principled analysis of heterogeneous, multilayer systems.

Keywords: supra-adjacency matrix; heterogeneous networks; spectral graph theory; heterogeneous multiplex networks; explainable models.

AI-Powered Intelligent Web Platform for Personalized Skill Development and Industry Training

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Abstract

The present studies present the proposal of designing and developing an intelligent web platform based on AI to promote customized learning and skill acquisition among students and professionals. The classic web-based learning systems serve up fixed content without responding to the needs of individual learners, leading to the decrease in the level of engagement and effectiveness. The suggested system combines the methods of Artificial Intelligence, including machine learning and recommendation systems with the current web technologies to provide custom learning paths, real-time performance analysis, and adaptive assessment. The platform examines actions, and learning rates, and performance data of the user to provide dynamic suggestions on appropriate material, quiz, and practical activities. Also, the system has predictive analytics to detect learning gaps and propose specific interventions. The web platform is built on scalable technologies, i.e., React.js on the frontend, and Node.js on the backends combined with AI models through Python frameworks. The findings are reflected in higher participatory levels among learners, enhanced knowledge retention and effective acquisition of skills which qualifies the suitability of the system in academic institutions, training institutions and industrial skill development programs.

Keywords: Intelligent Web Systems, Recommendation Systems, Human-Computer Interaction, Data-Driven Decision Making

K-Means Clustering and Regression via Combinatorics-Based Benders Decomposition for Bivariate Data with Outlier Detection

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Abstract

This manuscript proposes a novel model for improving the performance of cluster-wise regression, and outlier detection tasks. By integrating Benders decomposition into mixed-integer linear formulations, the approach improves computational efficiency. The decomposition breaks down complex problems into smaller subproblems, simplifying the solution process. To improve stability, the model combines a linearized Huber loss with a linearized distance measure. The decomposition method reduces the complexity of the problem and makes the approach more scalable. The method is intended for heterogeneous bivariate data, where different clusters may follow different regression patterns. The proposed method was tested on eight synthetic bivariate datasets and four real datasets. The results showed strong performance, with average Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), and co-efficient of determination (R^2) values of 0.99, 0.77, and 0.93, respectively. The proposed method has detected outliers consistently while preserving cluster quality. Statistical tests further indicated that the method achieved improvements in clustering structure and regression accuracy.

Keywords: Cluster-wise regression, Benders decomposition, outlier detection, k-means clustering, mixed-integer linear programming, bivariate datasets, runtime efficiency.

The Sombor Connection Index: A Novel Hybrid Descriptor for Nanostar Dendrimers Modeled as Generalized Abid–Waheed Graphs

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Abstract

Nanostar dendrimers can be represented well as Abid Waheed graphs. For instance, the first-generation dendrimer corresponds with the same correspondence of the Abid Waheed graph. Research article on Dendrimers and Connection-based Indices, by Sattar et al. 2022, highlights that: Connection-based indices surpass traditional methods, we also take a privilege to thank Ali and Trijanstic who came up with the idea of connection number on the topological indices. Hence, we come up with a new kind of index: The Sombor Connection Index. In this study we calculate this new index for Generalized Abid-Waheed graphs: Compare its predictive power against the standard Sombor Index and the ZCIs from Sattar's paper.

This work reports a preliminary theoretical definition and computation derivation of the index; more exhaustive validation to experimental physicochemical data is to be done in future. Developing this mathematical scheme, fills the gap between degree-based and degree-distance-2 expressions and provides a powerful new instrument to the rational design of sustainable, polymeric materials and network system.

Keywords: Connection Number, Generalized Abid–Waheed Graphs, Nanostar Dendrimers, Sombor Connection Index and Topological Indices.

Directed Network Motif Analysis of Cardiac Circulation Graphs in Congenital Heart Disease

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Abstract

A directed graph $G = (V, E)$ is modelled as the human heart graph. Congenital heart disease (CHD), structural abnormalities of the heart or great vessels present at birth, is naturally expressed as modifications to this normal adjacency structure. Network motifs have elucidated organizational principles across many biological systems, yet their application to anatomical cardiovascular circulation graphs remains unexplored. In this article, we perform triadic network motif analysis on ten CHD types. The triad 102 (mutual pair) emerges as a unique structural descriptor of bidirectional intracardiac shunts among the ten types, occurring solely in defects with ventricular septal mixing. Graph edit distance (GED) from the normal heart aligns with clinical complexity in this set (GED = 1 for simple defects to GED = 8 for Fontan palliation). Unsupervised clustering of motif frequency profiles groups the ten CHD types and the normal heart into shunt-positive and unidirectional-flow classes, with Fontan uniquely identified by a disconnected graph signature.

Keywords: Network motifs, congenital heart disease, directed graphs, graph edit distance

Deep Learning Approaches for Pneumonia Detection: Comparative Analysis of ANN, CNN and UNet Models Implemented in PyTorch

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Abstract

This study presents an integrated deep learning approach for detecting and segmenting pneumonia from chest X-ray images using PyTorch. The methodology combines Artificial Neural Networks (ANN), Convolutional Neural Networks (CNN) and a U-Net architecture to perform both classification and pixel-level segmentation. The dataset includes labeled pneumonia-positive and pneumonia-negative chest X-rays. Prior to training, data augmentation techniques such as normalization, rotation, flipping and brightness adjustment were applied to improve model generalization. A simple ANN was implemented as a baseline for binary classification, followed by a CNN that leveraged spatial features for improved accuracy. For precise localization of infected regions, a U-Net model was employed, enhancing diagnostic interpretability. Experimental results show that the CNN achieved nearly 95% classification accuracy, significantly outperforming the ANN baseline. Additionally, the U-Net model achieved a mean Intersection-over-Union (IoU) score of 91%, demonstrating effective segmentation performance. Overall, the results highlight that CNN and U-Net-based models offer reliable and efficient solutions for pneumonia detection and diagnosis.

Keywords: Pneumonia Detection, Deep Learning, Convolutional Neural Network, PyTorch

A study on Fuzzy shortest path problem using Dijkstra algorithm under α – cuts trapezoidal fuzzy number

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Abstract

The shortest path problem involves determining the shortest interval distance between two fuzzy arc lengths. This work proposes a generalized Dijkstra's algorithm for handling the Shortest Path Problem (SPP) in uncertain situations. Two major issues with fuzzy parameters. We use α -cuts to include a trapezoidal fuzzy number in a path and canonical representation to establish the membership function. The second one is how to compare the path's interval distance to the edge lengths provided by fuzzy numbers. A numerical illustration of a transportation network is provided to showcase the efficacy of the new method in comparison to the previous research.

Keywords: Fuzzy shortest path problem Dijkstra algorithm, trapezoidal fuzzy number, α -cut, distance function, dynamic programming.

Early Prediction of Student Dropout in Higher Education using Explainable Machine Learning

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Abstract

Student dropout has been a major challenge in higher educational institutions across the world, damaging sustainability, student welfare and socioeconomic outcomes. Early identification of students at risk of dropping out allows universities time to deploy targeted support before withdrawal happens. This paper shows a machine learning framework for predicting student dropout using the publicly available UCI student academic success dataset, which contains 4424 students across different academic, demographic, and financial dimensions. Seven classification algorithms namely Logistic Regression, Random Forest, Support Vector, Machine, Naive Bayes, K- Nearest Neighbors, Perceptron, and XGBoost were evaluated. To understand how prediction progressively evolves as more student information becomes available, four experiments were designed using incrementally expanded feature sets ranging from admission data only through to full two-semester academic records. The Random Forest classifier was found to achieve the best overall accuracy of 89.4% in the full feature configuration. A key finding is that incorporating the academic performance by the first-semester itself gives a strong model at 86.0% accuracy, demonstrating that reliable predictions can be made well before the end of the academic year. To make predictions interpretable and actionable, SHAP analysis showed that approved curricular units and semester completion are significant indicators of whether a student will drop out.

Keywords: Student Dropout Prediction, Random Forest, SHAP, Explainable Artificial Intelligence, Higher education.

QSPR Analysis of Sulfonylurea Antidiabetic Compounds using Degree-Based Topological Indices

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Abstract

Sulfonylurea compounds represent a key class of oral antidiabetic agents extensively prescribed for the management of Type-2 diabetes mellitus due to their ability to stimulate insulin secretion from pancreatic β -cells. Their oral administration ensures a convenient and patient-friendly approach for long-term management of blood glucose. They effectively lower both fasting and postprandial blood glucose levels, contributing to the maintenance of overall metabolic balance. In this work, a class-specific Quantitative Structure Property Relationship (QSPR) study is undertaken for a homogeneous set of sulfonylurea antidiabetic drugs. Degree-based topological indices derived from the corresponding molecular graphs are employed as structural descriptors to encode essential connectivity information. The relationships between degree-based descriptors and physicochemical properties of drugs are examined through correlation analysis and regression modeling. Linear, quadratic and cubic regression formulations are independently applied to investigate the predictive characteristics of the descriptors across increasing levels of model complexity. Model adequacy and predictive reliability are evaluated using standard statistical indicators, including the coefficient of determination and error-based criteria. The regression outcomes collectively illustrate the descriptive sufficiency of degree-based indices for capturing structural influences on physicochemical properties within the Sulfonylurea compound class. Overall, the findings underscore the effectiveness of graph-theoretic descriptors in class-focused QSPR analysis and contribute to a deeper understanding of structure property relationships in sulfonylurea compounds.

Keywords: Sulfonylurea antidiabetic drugs, Molecular graph, Topological index, QSPR analysis.

