Optimizing Path Costs in Dynamic Network Routing Using a Bio-Inspired 'Sit-and-Wait' Strategy in the Cheetah Chase Algorithm

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Abstract

Routing optimization in dynamic network environments requires innovative strategies to address challenges like high path costs and inefficient resource utilization. Traditional routing algorithms often rely on static or semi-dynamic methods that fail to adapt effectively to changing topologies. To overcome these limitations, this research introduces a **Novel Cheetah Chase Algorithm (CCA)** inspired by the cheetah's "sit-and-wait" hunting strategy.

The "sit-and-wait" approach, observed in predator-prey dynamics, involves strategic patience to identify the most opportune moment for action, minimizing unnecessary energy expenditure while maximizing efficiency. Translating this strategy into network routing, the CCA incorporates an adaptive decision-making mechanism that evaluates multiple routing options before selecting the most cost-effective path. By "waiting" for better opportunities in the network topology and "acting" decisively when the optimal path is identified, the algorithm achieves significant reductions in path costs and enhances overall routing efficiency.

Keywords:
Sit-and-wait strategy, bio-inspired algorithms, network routing, path cost optimization, adaptive decision-making, dynamic networks.

1. INTRODUCTION

Overview of Network Topologies and the Importance of Path Finding

In the realm of computer networks, the structure and organization of network devices are crucial for efficient communication and data transfer. This structure, known as network topology, dictates how different nodes (computers, routers, or other devices) are interconnected and how data flows across the network. The importance of understanding network topology lies in its direct impact on network performance, scalability, fault tolerance, and overall efficiency [1].

Inspiration from the Cheetah's hunting strategy

Artificial Intelligence (AI) has revolutionized problem-solving methodologies across various domains by emulating human-like intelligence in machines. A notable method in AI is Swarm Intelligence (SI), which takes inspiration from the collective behaviours of social creatures like ants, bees, and birds to address complex problems using decentralized control and self-organizing systems.

The Cheetah Chase Algorithm [5] is inspired by the natural hunting strategy of cheetahs, which involves selecting the most optimal path to chase down prey. In the context of Network Ad-hoc routing, this algorithm can be adapted to address the Shortest Path Problem by mimicking the cheetah's approach to dynamically finding the most efficient route in a constantly changing environment.

The fundamental principle behind the CCA is the emulation of a cheetah's hunting strategy, which involves a balance between active pursuit and strategic waiting [6]. Similar to how a cheetah strategically positions itself to intercept prey, the CCA intelligently explores the graph landscape while also pausing to evaluate potential paths. This adaptive behaviour allows the CCA to navigate through complex graph structures more efficiently, leading to improved convergence rates and optimal solutions.

2. Design of the Novel Cheetah Chase Algorithm

2.1 Inspiration from the Cheetah's Sit-and-Wait Strategy

The cheetah is a large and agile carnivore that once roamed across Asia, Africa, and parts of Europe. Known as one of Africa's most dynamic predators, cheetahs are particularly famous for their incredible speed during a chase. Capable of reaching speeds over 60 mph for short distances, they are the fastest land mammals on the planet. Unlike other African carnivores, cheetahs are primarily diurnal, which allows them to avoid competition for food from larger predators such as lions and hyenas that hunt during the cooler night time hours. Cheetahs have exceptional eyesight and rely on this ability to hunt; they typically stalk their prey from a distance of 10 to 30 meters before launching into a chase at the optimal moment.

The cheetah's lightweight and slender body make it well-suited for short, intense bursts of speed, rapid acceleration, and the ability to make sharp turns while running at high velocity. These traits are essential for the cheetah's ability to catch fast-moving prey.

2.2 Algorithm Structure and Workflow

The Cheetah Chase Algorithm is structured in several stages:

Initialization: Nodes and edges of the graph are initialized. Key parameters, such as maximum waiting time and threshold costs, are set based on initial heuristic evaluations.

Node Evaluation: Each node is evaluated for its potential to lead to an optimal path. This involves assessing the cost of traversing each edge connected to the node.

Waiting Strategy: The algorithm employs a dynamic waiting strategy, where it pauses at certain nodes based on the evaluation criteria. During this wait, it collects additional information about the surrounding nodes and potential paths.

Path Selection: After the waiting period, the algorithm selects the next node to move to, based on the cumulative path cost and the heuristic value obtained during the waiting period.

Iteration and Termination: The process iterates until the destination node is reached or all possible paths are evaluated. The algorithm terminates by selecting the path with the least cost.

3. Execution and Results

Input – for finding Optimal route using CCA

- Topology – Mesh Topology, Nodes used – 1000, Source Node – 1, Destination Node - 990
- Formation of **Adjacency Matrix**: It is 1000 * 1000 matrix, If weighted network, the weights are updated in the matrix. After the formation of Adjacency matrix, **Routing table** is constructed using Distance Vector Routing Algorithm.
- Using **sit and wait strategy** of CCA algorithm, The path cost values are updated by multiplying the randomization Parameter and step length in each edge of the path.
- Table 3.1 shows the sample path costs derived by the execution of the algorithm.

S.NO	Sample path	Path Cost	Edges	Optimal Path cost Using CCA
1	1-4-90-348-542-672-724-753-812-867-901-990	745	11	723.67
2	1-7-23-56-198-203-345-412-586-609-741-823-990	741	12	719.45
3	**1-23-513-723-823-990**	**724**	**5**	**701.54**
4	1-54-238-428-603-720-819-903-990	739	8	734.28
5.	**1-23-513-675-823-990**	**724**	**5**	**702.37**

Table 3.1 Sample path costs using CCA

Table 3.2 shows the comparison results between algorithms

S.NO	ALGORITHMS	Shortest Path Distance (Path Cost)	Time Required to find the Shortest Path (Secs)
1	Dijkstra's Algorithm	745	58
2	Warshall Floyd Algorithm	736	52
3	Bellman Ford Algorithm	732	51
4	**CCA Algorithm**	**701.54**	**45**

Table 3.2 Comparison with Traditional Algorithms

Fig 3.1 shows the comparison chart for the execution between traditional algorithms and CCA.

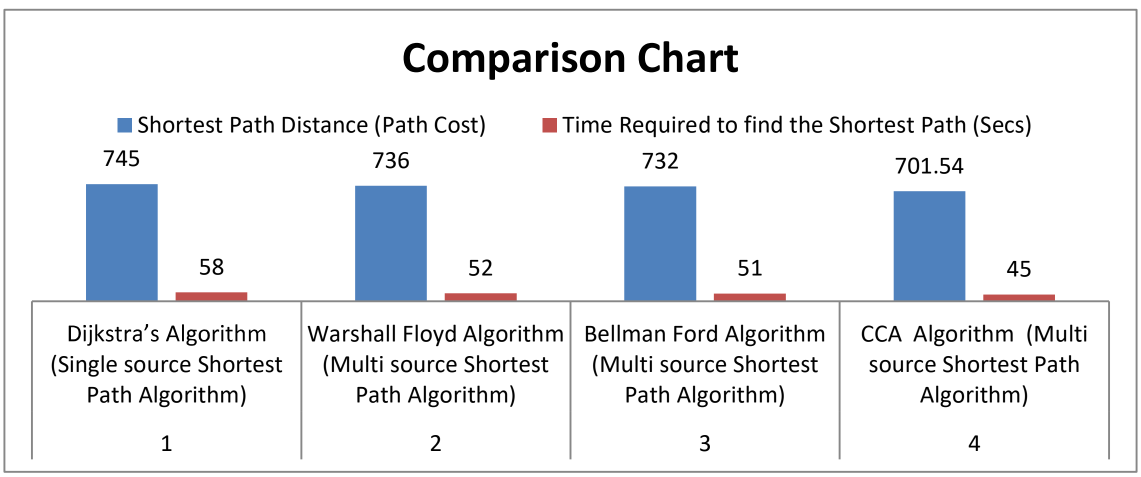

Figure 3.1 Comparison with Traditional Algorithms

S.NO	ALGORITHMS	Shortest Path Distance (Path Cost)	Time Required to find the Shortest Path (Secs)

1	**Ant Colony Algorithm**	728	54
2	**Particle Swarm Optimization Algorithm**	736	65
3	**Cheetah Chase Algorithm**	**711.89**	**47**

Table 3.3 Comparison with Bio Inspired Algorithms

Table 3.3 shows the sample path costs comparison derived by the execution of the bioinspired algorithms and CCA [2,3].

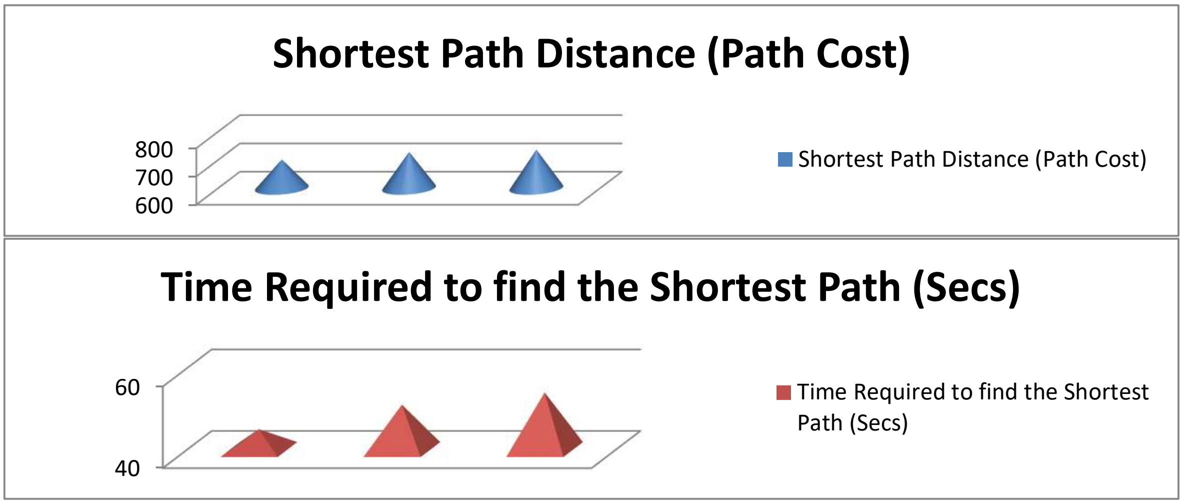

Figure 4.2 Comparison with Bio Inspired Algorithms

4. CONCLUSION

In conclusion, the objective of this work was to introduce the Novel Cheetah Chase Algorithm (CCA) as a promising approach for achieving the least path cost in graphs through a strategic hunting strategy. In summary, the development of the Novel Cheetah Chase Algorithm represents a significant step forward in the field of optimization, particularly in the context of network routing [7]. By leveraging the hunting strategy of cheetahs, CCA has the potential to achieve least path cost in graphs and improve algorithm effectiveness in various optimization tasks.

5. REFERENCES

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Biography

Dr. M. Goudhaman received the bachelor's degree in electrical and electronics engineering from Bharathiar University in 1996, the master's degree in computer science and engineering from Anna University in 2010, and the philosophy of doctorate degree in computer science and engineering in Saveetha University, Chennai in 2024. He is currently working as faculty in the Department of Computer Science and Engineering, Rajalakshmi Institute of Technology, Chennai. His research areas include evolutionary computing in artificial intelligence and experts in recent trend technologies. He has been serving as a reviewer for many highly-respected journals, session chair for many international conferences.