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Study of Detection Analysis of Cardiac Amyloidosis Heart Disease Using Image Segmentation Technique

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Abstract. Cardiac amyloidosis is a collection of mayhem, which increases the less important disposition of abnormal proteins in the heart. It may happen either in segregation or like a fraction of systemic disease and can be hereditary or attained. The major forms of amyloid proteins, namely Amyloid Light Chain also Amyloid Transthyretin (ATTR), can penetrate the heart. With the enhanced utilization of advanced image techniques and procedures, the identification and diagnosis of cardiac amyloidosis, especially ATTR, has become very easier. In general, congestive heart failure disease has been diagnosed through an electrocardiogram. In this survey, the ultrasound heart image is gathered as an input image to diagnose whether the heart's functioning is normal or abnormal. Based on input ultrasound heart image or picture, the ultrasound high-frequency sound waves afford the heart's image and valves, which allows us to observe the heart-pumping action. The image segmentation technique was well performed in segmenting the specified heart image into high-intensity range, and low-intensity level deliberated to enhance patients' lives with cardiac amyloidosis. The disorders or variations or any abnormalities happening in the heart can be done via a segmentation approach through that intensity level.

Keywords: Cardiac Amyloidosis, Amyloid Light Chain (AL), Amyloid Transthyretin (ATTR), Electrocardiogram, Ultrasound heart image.

1. Introduction

A heart ultrasound is a non-intrusive method to determine how healthy the heart's functioning is, which can be utilized either on its individual or coincidence with doing exercise electrocardiogram or treadmill test. During an exercise electrocardiogram test, the person should connect to monitor individual blood pressure, and also, heartbeat rates are examined while doing treadmill exercise. Amyloidosis is a major heart disease that happens once an abnormal protein known as amyloid is created in an organ (heart), which disturbs the normal working of that specific organ. In general, amyloid cannot be found in the human body; however, it is created as various amino-acid categories (protein)[1]. This amyloidosis disease may affect many body organs, namely the heart, liver, kidneys, nerves, spleen, and gastrointestinal tract. Several types of cardiac amyloidosis occur among relationships with some other syndrome, leading to severe organ malfunctioning. The diagnosis of cardiac amyloidosis can be carried out through

- Electrocardiogram (ECG)
- Echocardiogram
- Blood function
- Urinalysis



- Cardiac Biopsy
- Technetium pyrophosphate scan

Treatment for cardiac amyloidosis encompasses chemotherapy, the same as utilized to treat cancer. Many medical doctors recommend medications/pills to decrease amyloid creation as well as control patient strength that is having cardiac amyloidosis disease symptoms

The main symptoms of cardiac amyloidosis are purpura (purplish patch) around eyes and enlarged tongue, wrinkled around its edges, occasionally. Amyloidosis patients' manifestations rely on exaggerated organs of patients. The indications and symptoms of amyloidosis incorporate

- Severe fatigue and weakness
- Swollen in patient's legs and ankles
- Congestion of breath with less physical exertion
- Cant able to be positioned in bed owing to breathe dumpiness
- An irregular heartbeat
- Having trouble swallowing
- Lack of sensation, itching, or soreness in feet or hand, particularly in the wrist
- Diarrhea probably with blood or constipation
- Loss of weight over 10 pounds accidentally

The aspects which increase the threat of amyloidosis involve gender (especially CA affected mainly male persons), ages (recognize CA occurs mostly in 60-70 years old). Also, people having additional diseases, like kidney disorders, may be under threat of cardiac amyloidosis. One type of amyloidosis called hereditary amyloidosis is inherited from family members.

Some organs are critically affected by cardiac amyloidosis, causing harm to the same, namely kidney disorders, cardiac disease (heart), and nervous system.

- **Kidneys:** The kidney's major function is to confiscate waste products along with surplus fluids from the human body. This function will be reduced if the person is affected by cardiac amyloidosis disease. At a certain period, this leads to kidney malfunction and requires hemodialysis.
- **Heart:** The heart's chief function is to push the blood throughout the human body, passing through the circulatory system. The breathing capability of human beings depends on the well-functioning of the heart. This cardiac amyloidosis disease reduces breath as well as a reduction in heartbeats too.
- **Nervous system:** CA affects the human nervous system having symptoms like pain in fingers, sensation reduction, flaming sensation in feet also toes. This affection leads to early obscure (faint) while standing.

Cardiac amyloidosis relies on either having other diseases, such as provoking diseases, kidney disorders, or congenital (hereditary). Cardiac amyloidosis is categorized into five types, as shown:

While transthyretin protein is made by the liver (normal); however, it generates amyloid protein without any reason. It mainly affects the liver, spleen, kidneys, heart, and nervous system

- However, the main system to be affected is the heart.

Localized amyloidosis: mysterious cause affects many organs (skin, throat, lungs, and urinary bladder).

Among these five amyloidoses, two core forms of amyloidosis drastically affect the heart, namely AL amyloidosis and transthyretin amyloidosis.

Figure 1 explained the clinically support cardiac amyloidosis for diagnosing normal and abnormal SPIE. If there is abnormal bone scintigraphy, the patient has to go for a further TTR genetic testing test. Suppose if bone scintigraphy is normal, then that individual has cardiac amyloidosis doubtful. The abnormal patient has to take an endomyocardial (EMC) biopsy test. If an amyloid deposit is present, then the patient has ATTR amyloidosis and AL amyloidosis.

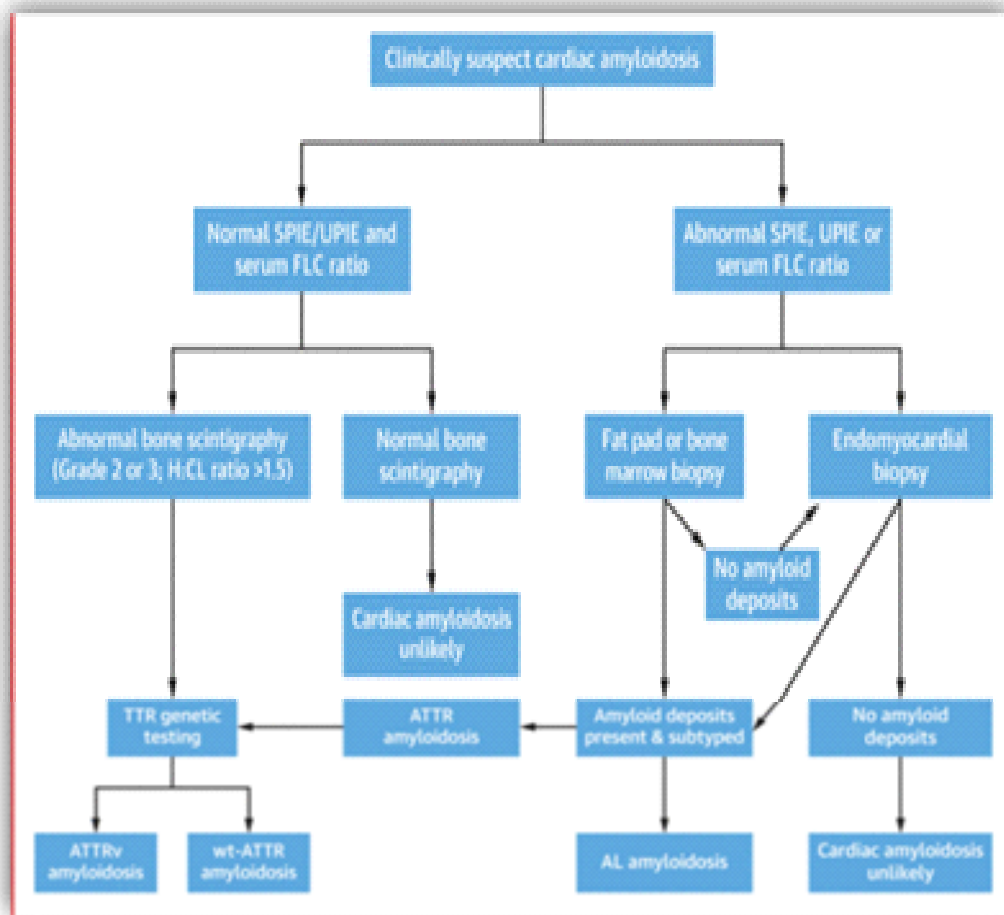


Figure 1: Clinically support cardiac amyloidosis to identify normal and abnormal segment in the heart

The main objective of this survey is to:

- Develop various algorithms to predict heart abnormalities using ultrasound heart images as input data.
- Develop segmentation technique to isolate ultrasound heart image. Calculate the efficacy of the utilized algorithm in determining the high-intensity portion and low-intensity portion of heart image.
- Determine segments of the image using an image segmentation technique followed by labeling segments marked in the image.

2. Literature Survey

Panagiota Kyriakou et al. [2] summarized much investigation along with phasing concepts that have been ascertained for cardiac amyloidosis in current year's Figure 2 includes clinical picture, imaging, ECG markers, serum biomarkers, and endomyocardial biopsy (EMG).

The research mainly focuses on legalizing these new concepts by collecting larger patient databases and medical observation recovery. The diagnostic algorithm utilized here is simple and commercial. It has sensitive tools to validate disease (cardiac amyloidosis) and compute amyloid load are the main solution for CA prediction, hence enhancing disease patients diagnosis.

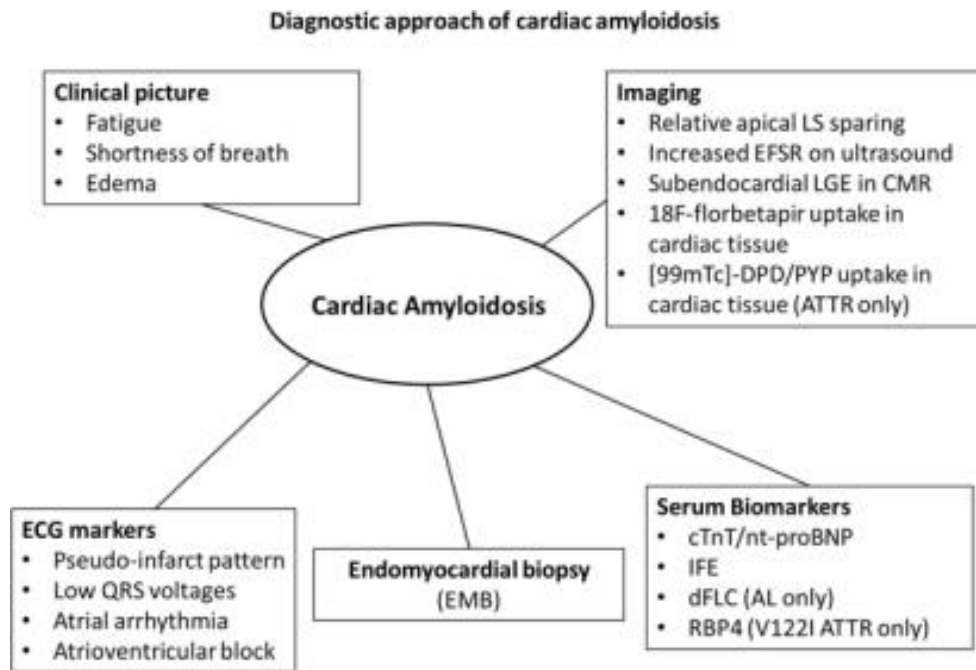


Figure 2: The diagnostic approach of cardiac amyloidosis

Rebacca et al. [14] explained that the foremost analysis of how the heart is functioning (heart damage or failure or working well) could be identified via echocardiography, which provides helpful data about the thickness of ventricular walls and systolic also diastolic function in the heart. Also, analysis of infiltrative cardiomyopathy from an enduring person having LVH phenotype is clinically tricky. In addition to that, assimilation of medical evaluation, cardiac imaging via intermodality, and endomyocardial biopsy lead to accurately diagnosing heart disease.

Cristina et al. [13] described the disease called cardiac amyloidosis, its features, its types, namely AL amyloidosis, transthyretin-related amyloidosis, also explained the way how to diagnose cardiac amyloidosis, how to detect cardiovascular obstacles, finally discussed the remaining varieties of cardiac amyloidosis might arise in an organ (heart).

Asan et al. [12] carried out machine learning algorithms to predict cardiac amyloidosis by gathering some patient's data from the medical laboratory. The first and foremost algorithm utilized here is logistic regression to predict cardiac amyloidosis, further proceed with some other ML algorithm like gradient boosting to predict the same disease. Finally, a comparison was done to evaluate all algorithms' performance applied to diagnose cardiac amyloidosis. The algorithm which achieves high accuracy is highly suitable for diagnosing disease, namely cardiac amyloidosis.

Tanja et al. [4] evaluated the probability of semiautomatic software tools for diagnosis and prophecy C-PIB left ventricular retention index (RI) in cardiac amyloidosis. In this survey, patients with systemic amyloidosis besides cardiac attachment (n=10) and well organized (n=5) were investigated with a C-PIB technique supportive of diagnosing CA.

Giancula et al. [5] suggested an endomyocardial biopsy (EMB) invasive tool diagnose patients with HF. Recent advanced technology for processing images like DCE, CMR, echocardiography, and nuclear medicine approaches makes it very efficient to predict earlier stages and advanced cardiac amyloidosis stages non-invasively.

Alexander et al. [6] exposed a new proposal that applies cardiovascular magnetic resonance (CMR) diffusion tensor imaging (DTI) in cardiac amyloidosis to evaluate microstructural modifications that occur in patients and also their penalties for myocardial function when compared to hale and hearty controls.

Mirela et al. [7] assess up-to-date perceptives along with novel investigations on identification and handling strategies in patients having cardiac amyloidosis. Mainly, amyloid and transthyretin amyloidosis severely damage the heart. This survey found that successful treatment based on a premature prediction of disease for AL amyloid patients and putting forth some drop in the creation of transthyretin amyloid proteins are important procedures to diagnose cardiac amyloidosis.

Nicolosi et al. [8] outcomes considered that conditional determination of 2D echocardiographic images was utilized to distinguish variations in myocardial echogenicity related to an activist biopsy result for diagnosing cardiac amyloidosis heart disease.

Stalin et al. [9] focused on how noise is reduced in image processing, especially in ECG signal using filters, namely median filter, Gaussian filter, Butterworth filter, finite impulse response filter. Here the filter is applied to thirty ECG signals to remove noise from the image. The performance metrics like mean square error, peak signal-to-noise ratio were evaluated for the noise removal approach.

Mavrogeni et al. [10] approached a new technique. Namely, cardiovascular magnetic resonance (CMR) was applied in systemic lupus erythematosus (SLE) patients out of ordinary signs and scrutinized cardiac amyloidosis, whichever was neglected by echocardiography. Michelle et al. [11] explained highly advanced imaging techniques to diagnose cardiac amyloidosis, especially cardiomyopathy (ATTR-CM).

3. Proposed Work

3.1. Algorithm for proposed work (watershed segmentation)

1. Get the input ultrasound heart image (color) and convert it to grayscale.
2. Removal of noise from the given image using a median filter similar to the preprocessing technique.
3. Mark the foreground objects found in the image.
4. Compute background markers.
5. Analyze the **Watershed** transform of the **Segmentation** function.
6. Envision the outcome image.

3.2. Proposed Method-Watershed algorithm

Dakota et al. [3] demonstrated that cardiac amyloidosis through clinical suspicion had been shown in Figure 3. Cardiac amyloidosis disease diagnosis can be done through ECG or MRI. The lab test investigation regarding heart disease includes cardiac biomarkers, serum-free light chains, immunofixation electrophoresis. Cardiac amyloidosis heart disease is present in patients if any proliferative disorder is found in a laboratory test. Proteomic analysis confirms amyloid light chain (AL amyloidosis), intermediate (endomyocardial biopsy), and negative result occurs via bone marrow biopsy test or else non-cardiac biopsy. Otherwise, consider CA disease not present.



Figure 3: Work Model to diagnose cardiac amyloidosis to isolate ATTR-CA and wild-type (ATTR-wt)

The study's findings suggest a marker watershed technique in which "watershed" refers to a significant partition point or switching between two segments and clauses. This algorithm mainly works on a grayscale image as an input image (ultrasound heart image). If the grayscale value release successively overflows the whole time, then the neighboring catchment and watersheds are created. A group of markers or pixels are mentioned where deviation occurs in a given image which should be labeled separately. The watershed algorithm has four categories which are summarized below:

3.3. Proposed workflow

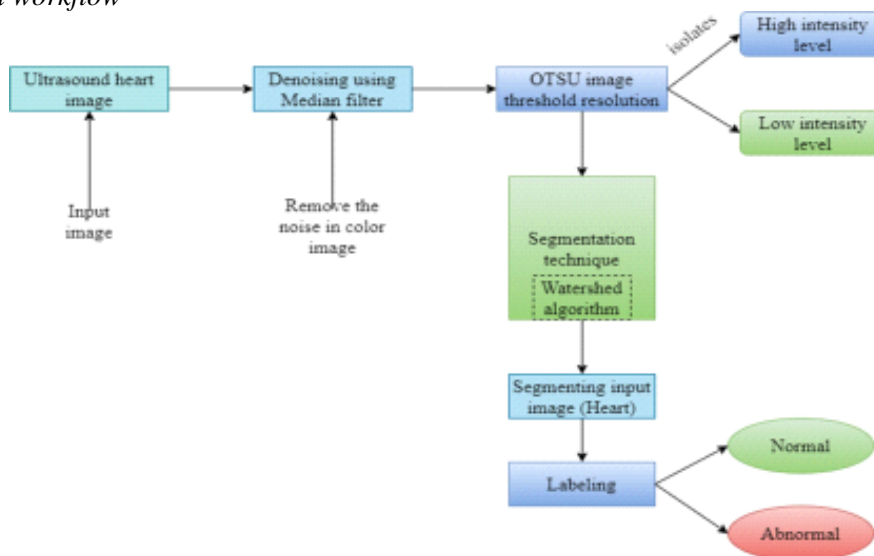


Figure 4: Proposed workflow to classify disease (cardiac amyloidosis)

This paper surveys the workflow of the proposed approach mentioned in Figure 4. The first and foremost step is to gather an ultrasound heart image as an input image specified as a color image, converted into a grayscale image. The image processing domain's basic challenges are image denoising; thereby, it undergoes denoising technique using a median filter, a non-linear digital filtering method frequently used to eliminate noise from the input image (ultrasound heart). Such types of noise reduction similar to the preprocessing phase to enhance image outcomes (instance: region-based, segment markers). OTSU (Operational Test Support Unit) approach, which is familiarized to carry out automatic image threshold. This Otsu threshold method is used to split an input ultrasound heart image into smaller segments to describe the boundary and finally evaluating the measure of abnormality for pixel levels on each side of the threshold, i.e., pixels either fall in foreground or background (high intensity or low intensity). Consequently, the segmentation technique, namely, the watershed algorithm applied for segmenting images and labeling images, has been done to point out the normal region and abnormal region called "Cardiac Amyloidosis."

4. Results And Discussion

The input heart image (data) has been taken as an ultrasound heart image to evaluate the heart's health, making it helpful for diagnosing cardiac Amyloidosis patients. Here the specified portion denotes sedimented protein amyloids connecting four ventricles.

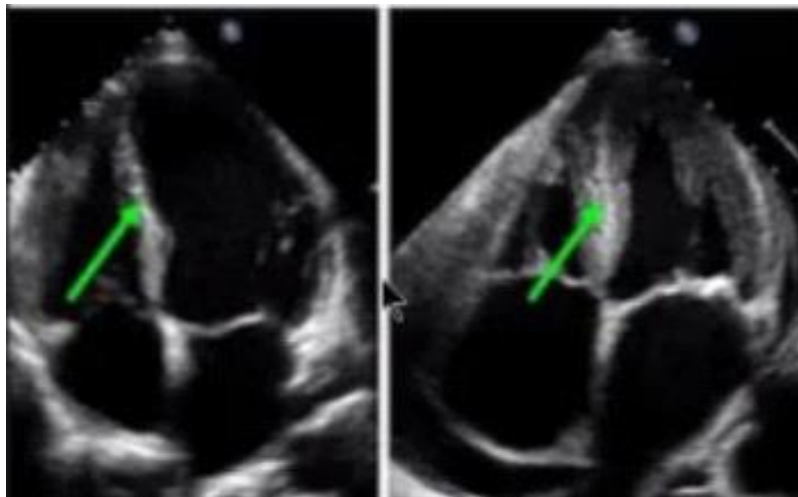


Figure 5: Input (Ultrasound heart) image

The next step is to remove the unwanted noise in the image, similar to the preprocessing technique [15] comes under the machine learning technique. In this proposed work, the median filter is used to eliminate the deviating portion by varying the deviating value in a limited sequence with the medium value in a similar series. The median filter for images has been developed, as shown

$$m(k)=\text{med } w(k)=\text{med}\{X-n(k),..X-1(k), X0(k),X1(k),....Xn(k) \} \quad (1)$$

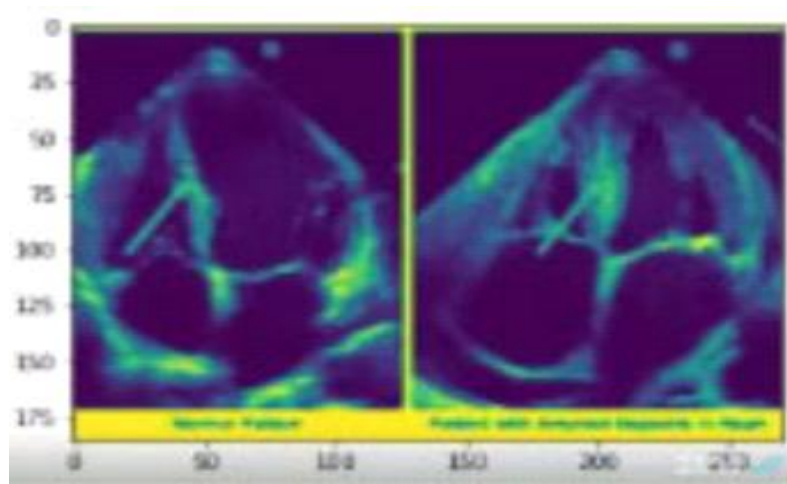


Figure 6: Depicts noise removal using a median filter similar to preprocessing

After noise reduction through the median filter, the OTSU method is helpful to perform thresholding an input image automatically. Also, the OTSU algorithm precedes a particular intensity threshold that isolates pixels into two classes, namely low intensity and high-intensity regions. The high-intensity image portion is mentioned as 255 pixels, and the low-intensity image is specified as pixel 0. Figure 5 shows Input (Ultrasound heart) image and Figure 6 depicts noise removal using a median filter similar to preprocessing.

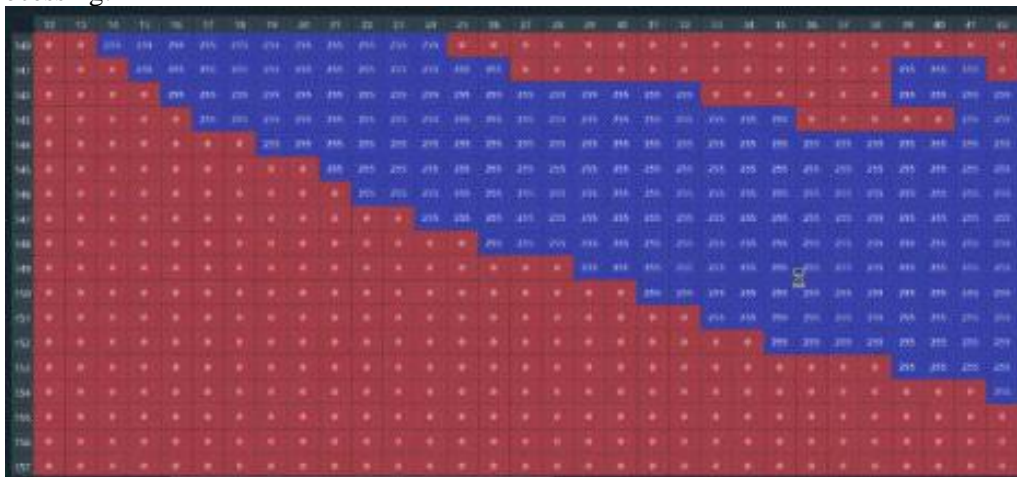


Figure 7: OTSU threshold determination

Perform morphological operations to remove the remaining small noise present in a predetermined heart image to mark cardiac amyloidosis's intensity level. In this morphological operation, every pixel's value in the output image is based on evaluating equivalent pixel in the input image along with its neighbors. Figure 7 explains about OTSU threshold determination and Figure 8 works on reduction of small noise

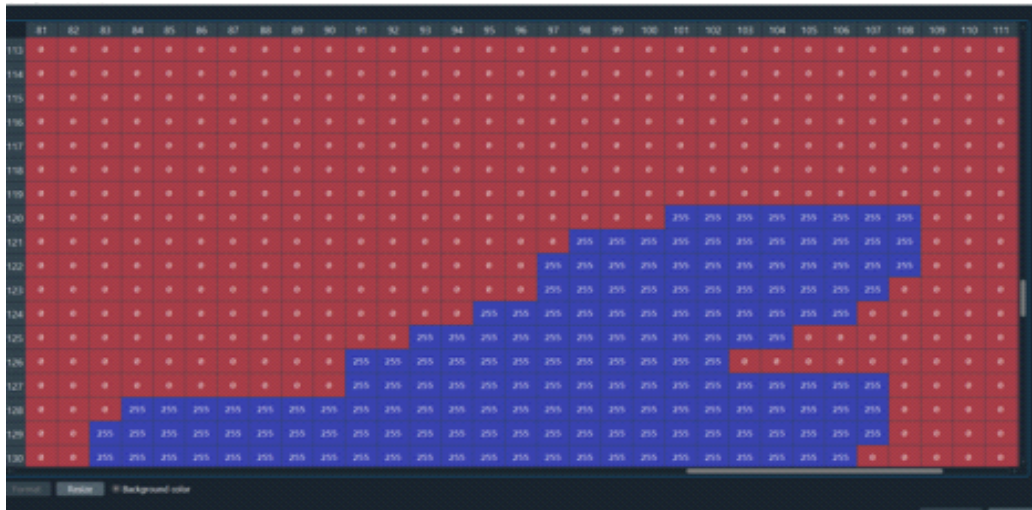


Figure 8: Reduction of small noise using morphological operations

The image depicts a normal patient without cardiac Amyloidosis disease and also a patient having Amyloid deposits in the heart. The high-intensity pixel must match watershed lines that symbolize region boundaries. Water placed on any pixel enclosed by an ordinary watershed line flows downwards to a common low-intensity segment. The identification of cardiac amyloidosis has been done through the watershed segmentation technique to isolate the patients having Cardiac Amyloidosis along with patients not having cardiac amyloidosis.

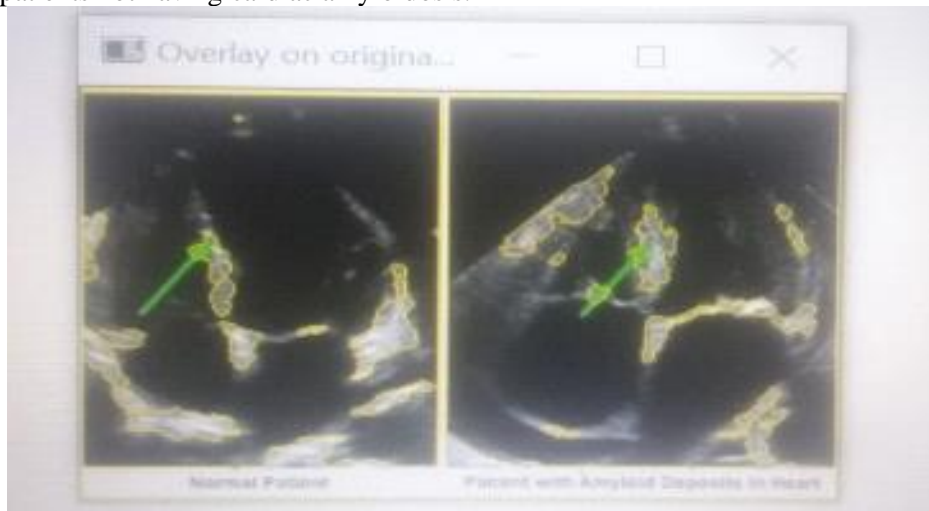


Figure 9: Segmented image as a normal or affected portion (abnormal)

Finally, the segmented image should be labeled for cardiac amyloidosis patients' diagnosis perfectly done in image processing. At this juncture, each segment specified in the heart image is marked as a unique label, thereby easily diagnosing cardiac amyloidosis patients by dividing high-intensity segments and low-intensity segments. Figure 9 displays segmented image of affected portion and segmented image with labelling are given in Figure 10.

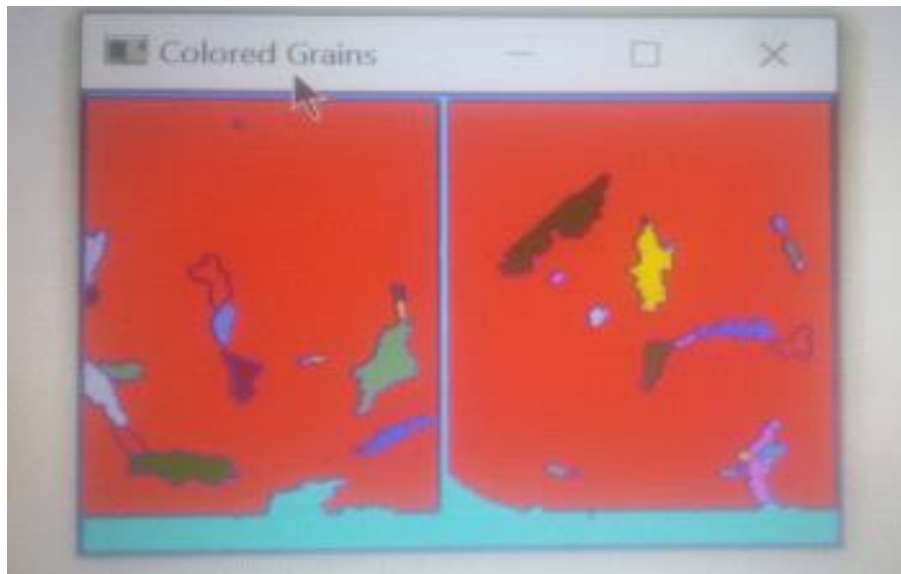


Figure 10: Segmented image with labelling

5. Conclusion

Cardiac Amyloidosis is the major reason for morbidity and death in AL and ATTR Amyloidosis. Heart malfunction is almost predictable during Cardiac Amyloidosis disease. Cardiac amyloidosis is extraordinary penetrative cardiomyopathy resultant from an extensive collection of hereditary, inflammatory, neoplastic, as well as self-immune causes. This survey focused on the diagnosis of cardiac Amyloidosis through image segmentation technique, especially watershed algorithm to mark the normal (low intensity) segment and also abnormal (high intensity) segment in the heart image based on variation occurs in heartbeat rate, the pumping rate of heart, the thickness of arterial valves. This work's future scope is the gathered input ultrasound heart image being applied to both training and testing phases using several machine learning algorithms to estimate perfect accuracy via marking the abnormal portion accurately.

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