

# Digitization of Documented Ecg Signals using Image Processing

Rajesh.R.Karhe, S.N.Kale

**Abstract** – In order to implement the heart disease prediction algorithms, the scanned ECG images need to be digitized. The ECG image digitization from ECG images deals with converting the ECG images in to digital format which can be processed by heart disease prediction algorithms. To present the Heart disease prediction algorithms, the digital signals can be directly applied. In this paper we have presented an effective ECG digitization technique using Dijkstra's shortest path algorithm. The scanned ECG images are oversampled 8 times. Then ECG curve is traced using Dijkstra's shortest path algorithm. The shortest path computed represents the scanned ECG signal in digitized form which can be directly used for heart disease prediction. The proposed method gives the accurate digitization by reducing the complications of the digitization process

**Keywords**—Digitization, ECG, Dijkstra's shortest path algorithm. MATLAB

## I. INTRODUCTION

To detect any abnormalities in Heart's function electrocardiogram (ECG) is one of the most practiced methods. The ECG results are available as paper records .For diagnosis of patient's diseases this ECG paper records are almost used in practice. It requires a large storage space as well as manual efforts for analysis.

This paper discusses the methods involving the process of digital image restoration which changes the images of ECG to digitized signal form. As a result of this there is convenient storage and retrieval of ECG information. In this paper, a MATLAB is implemented for digitization of paper ECG data. This allows oversampling in horizontal direction 8 times, scanning of a paper ECG to an image, and detecting the ECG signal contour. The technique used in this method is validated by showing that the digitized signal and the paper ECG.

By using Dijkstra's shortest path algorithm, the patient's demographic information on the ECG paper is obtained. It is one of the important methods of this process. Thus in this method can quickly digitize a large number of paper ECGs with very minimal human involvement. The paper is draft as follows. Section II gives out the related work in ECG digitization. The process of digitization and the method to validate the digitization describes in section III. In section IV, the Dijkstra's shortest path technique illustrated with example. In section IV, the results are presented followed by discussion and in section V, the conclusion is given.

Revised Manuscript Received on October 15, 2019

**Prof.Rajesh.R.Karhe**,Assistant Professor, Department of Electronics and Telecommunication, Shri Gulabrao Deokar College of Engineering, Jalgaon, INDIA, [rajeshkarhe@yahoo.com](mailto:rajeshkarhe@yahoo.com)

**Dr.S.N.Kale, Associate Professor**, Department of Applied Science, Sant Gadge Baba Amravati University, Amaravati,INDIA,[sujtankale@rediffmail.com](mailto:sujtankale@rediffmail.com)

## II. RELATED WORK

The various types of noise present in the ECG paper records in various types of scenes are reported in the literature are given below.

[1].The source of noise which obstructs the trace of ECG can be the graph grid lines. [2, 3] The ECG paper is damage by the dust particles of paper and salt noise. [4] Unequal contrast, interfering strokes. [5] Background spots, humidity absorbed by the paper. [6] Blur and broken signals in various areas. From ECG printout the grid removal is necessary to bringing the ECG signal. Various methods of grid removal from paper records have reported in the literature by many researchers. [7] These methods are Mathematical morphology. [8] Hough transform [9, 10] projection of lines. [11] Using the histogram, the signal trace is split up from the background grids. [12] A method for the removal of ECG trace from the image is suggested by Baldilinietal.[13] However, the users require to fix the anchor points for missing peaks and hence as per the user input the accuracy is affected, Shi et al. [14] Using K-means method used ECG waveform taken from paper and the limitations were removed. [15] ECG signals extracted by Ravichandranetal. [16] Using optical character recognition (OCR) collaborates with patient's record. To split up the ECG trace from the background grid lines grayscale thresholds and scanning resolution of 200 dpi were used by Lawson et al.

There is loss of data, accuracy and grayscale thresholds give missing pixel due to low resolution. The above mentioned works carried out to obtain digitized signal from latest paper ECG data without noise. Degraded scanned documents and is still a challenge for signal extraction.

Perceptual spectral centroid method for harmonic centroid of string instruments proposed by Hermes et al. was apply for ECG signals, as it relates closely.[17] Different conversion in text, conversion algorithm, faulty algorithm, applications and standardization efforts were received by Waits et al. recently.

The discussion of important points are digital representation of each recorded ECG channel is obtained and convert them into digital ECG and the challenges which are remaining were done. Generally ECG records which are scanned are the RGB images. RGB images are converted into grayscale images for the extraction of ECG signals. Rajani et al. [18] proposed ECG signal extraction from RGB image.

## III. METHODOLOGY

This process takes different steps to achieve the goal. These are following.

# Digitization of Documented Ecg Signals using Image Processing

- A. Scanning the 12-lead ECG and select the desired signal.
- B. The desired signal is oversample in horizontal axis direction. The desired signal oversample is find out by its maximum slope.
- C. Calculate shortest path with Dijkstraws shortest path algorithm using 255 - image intensity as energy function
- D. Down sample path to account for original oversampling
- E. Plot on the top of original image.

## A. Scanning:

Scanning requires scanned ECG papers. Resolution of scanning can be 300 dpi (dots per inch) JPEG is the algorithm used for image compression. Scanned ECG paper is represented by fig. 1.

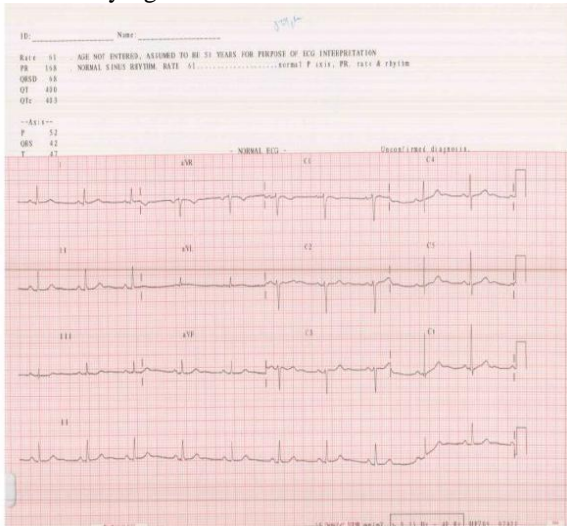


Fig. 1: Shows raw ECG sample

The first step is to select and crop one of the 12-lead ECG signals as shown in the figure (2) for cropping III lead

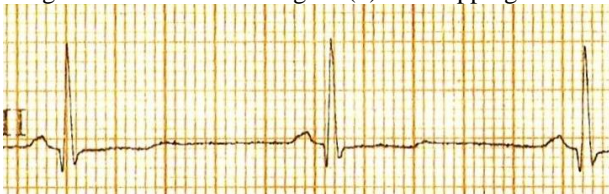


Figure 2: Cropped ECG image

## B. Oversampling the ECG:

The ECG image is over sampled in horizontal axis direction in 8 times then the desired signal oversample is find out by its maximum slope. For example if maximum slope is 16%, then desired signal oversample by 16 times. The MATLAB function interp2 is used for oversampling.

## C. Shortest Path Calculation

The shortest path is computed using 255 - image intensity as energy function. The Dijkstraws Shortest path algorithm is used for finding the shortest path.

## D. Down sample

The computed shortest path is downsampled 8 times to account for oversampling.

## E. Plot the Curve

The shortest path found is the ECG curve traced in the ROI image. The curve is plot on the original image to account for accuracy as shown in figure 3.

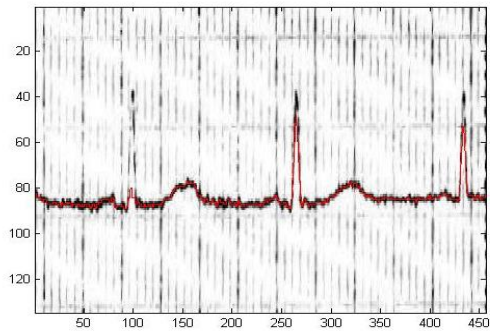


Figure 3: ECG curve plot on the original ECG image

## II. DIJKSTRA'S SHORTEST PATH ALGORITHM

In a graph, there is a problem of finding the shortest path from location to target. This problem explains and clarifies by the Dijkstra's algorithm in the given time. It can find graphically the shortest path from a given source to all points. Dijkstra's algorithm denotes to every node label  $j$  a pair of labels  $(p_j, d_j)$ , where preceding node is denoted  $p_j$  as  $j$  in the given shortest path from 1 to  $j$ ,  $d_j$  is the length of this shortest path. In Dijkstra's Algorithm content tags are define as temporary, permanent tags, which are fixed and the shortest path from 1 to a node that is permanently labeled has been developed.

We denote by  $d_{jk}$  the length of curve  $(j, k)$ .

**Step1.** Tag node 1 with the permanent tags  $(\emptyset, 0)$ . Each node  $j$ , such that  $(1, j)$  is a curve in the graph, with changeable tags  $(1, d_{1j})$ . Tag all other nodes in the graph with temporary labels  $(\emptyset, \infty)$ .

**Step2.** Let  $j$  be a changeable tag node with the minimum tag  $d_j$ , i.e.

$$D_j = \min \{d_l; \text{node } l \text{ is changeable tagged}\}.$$

For every node  $k$ , such that  $(j, k)$  is in the graph, if  $d_k > d_j + d_{jk}$  then retag  $k$  as

$$p_k = j, d_k = d_j + d_{jk}.$$

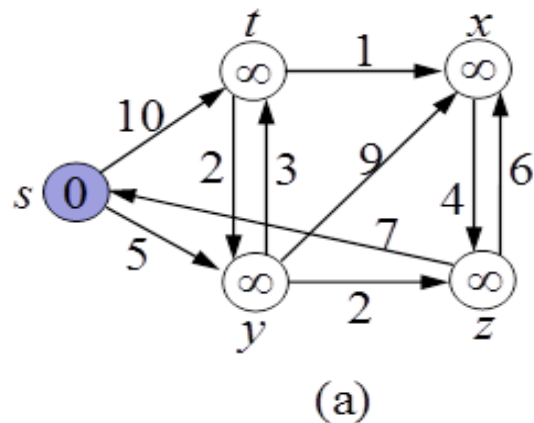
Now observe the tags of node  $j$  to be permanent.

**Step3.** Do again step 2 until all nodes in the graph are permanently tagged.

The shortest paths can be found by reading labels  $p_j$ .

## Example.

To search the shortest paths from node S to all other nodes.



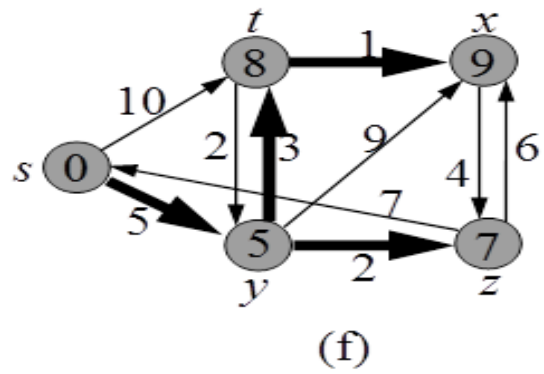
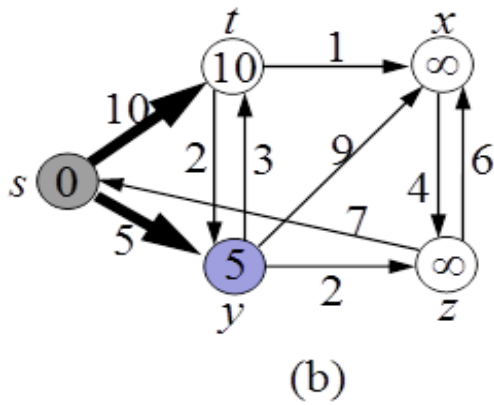


Figure 4: Dijkstra's Shortest Path Example

### III. RESULTS AND DISCUSSIONS

For the study of ECG database, we examine ECG paper records of 20 patients. The digitization based on scanning resolution. As scanning of ECG paper records are poor there may lead to loss of vertical grids lines. In this method, background grids are automatically eliminated as we have used Dijkstra's shortest path algorithm for tracing the ECG signal. Our Method shows a higher accuracy in digitization process for almost every ECG scanned signal image.

Figure 5 shows the recording of ECG Paper which is scanned.

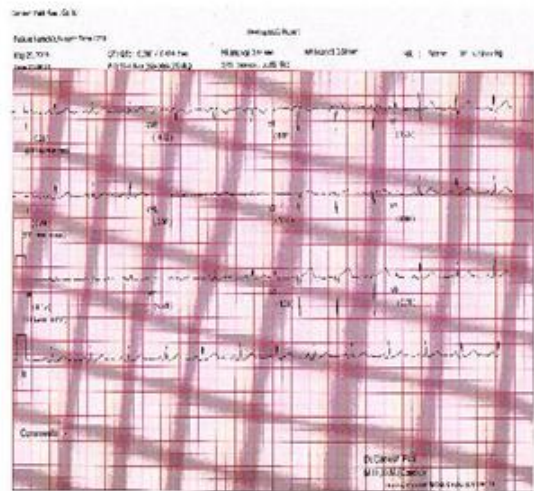
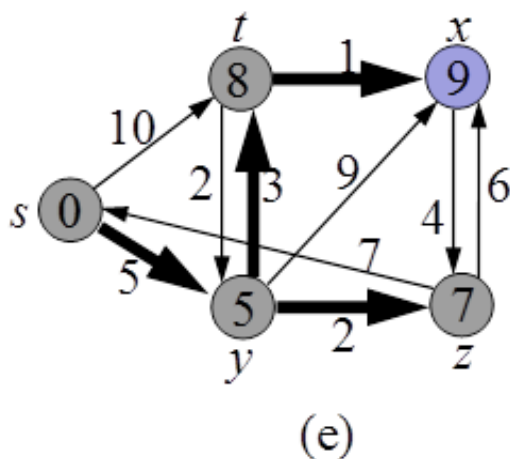
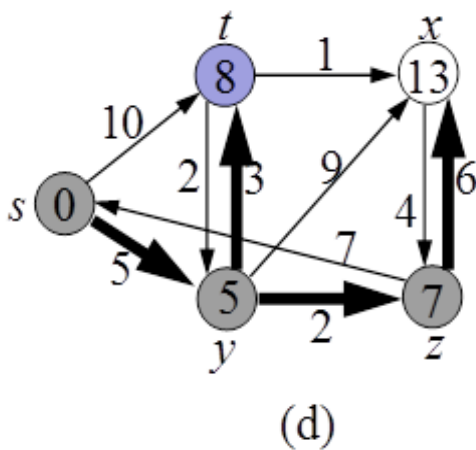
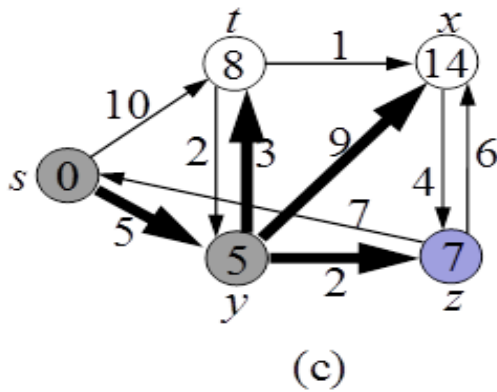


Figure 5 scanned ECG paper recording.

The first process is to select and crop one of the 12-lead ECG signals as shown in the figure (6) for cropping III lead

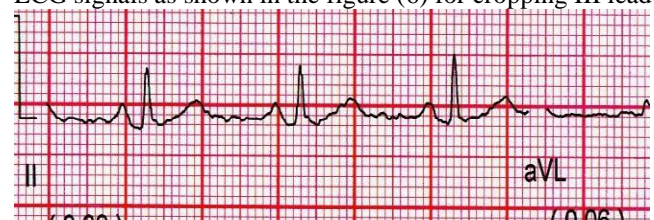
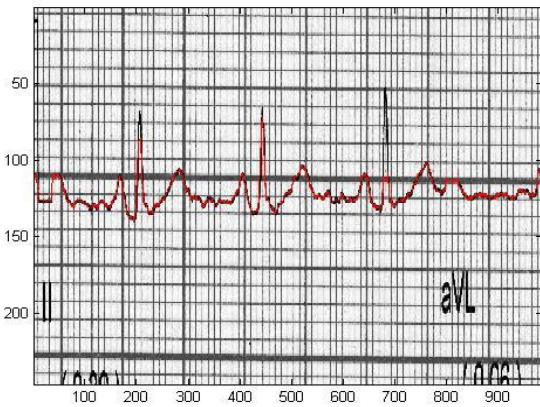


Figure 6: Cropped ECG image

The shortest path found is the ECG curve traced in the ROI image. The curve is plot on the original image to account for accuracy as shown in figure 7.



**Figure 7: ECG curve plot on the original ECG image**

## IV. CONCLUSION

A Matlab-based tool is implemented for digitizing an ECG signal from paper ECG records. The ECG signal is traced using Dijkstra's shortest path algorithm. The background grids are automatically eliminated. This ECG digitization tool implemented to a number of patients ECG records. As an application of algorithm to a patient ECG data for conversion into digitized ECG signal becomes more applicable for analysis of heart disease.

## ACKNOWLEDGMENT

Myself is very much thankful to the department of Applied Electronics, Sant Gadge Baba Amravati University, Amravati for providing me the research laboratory to carry out this research.

## REFERENCES

1. A.D. Jeyarani and T. Jaya Singh, "Analysis of Noise Reduction Techniques on QRS ECG Waveform-by applying Different Filters", Proceedings of IEEE R ASTSCC, 2010.
2. Guy A. Story et al., "The Right Pages Image-based Electronic Library for Alerting and Browsing", Computer, Vol. 25, No. 9, pp. 17-26, 1992.
3. Nucharee Premchaiswadi, et.al "A Scheme for Salt and Pepper Noise Reduction and its Application for OCR Systems", WSEAS Transactions on Computers, Vol. 9, No. 4, pp. 351-360, 2010.
4. Atena Farahmand, et.al "Noise Removal and Binarization of Scanned Document Images Using Clustering of Features", Proceedings of IMCECS, Vol. 1, pp. 1-5, 2017.
5. Atena Farahmand, Abdolhossein Sarrafzadeh and Jamshid Shanbehzadeh, "Document Image Noises and Removal Methods", PIMCEngineers and Computer Scientists, Vol. 1, pp. 101-105, 2013.
6. William T. Baxter et al., "Technical Features of a CCD Video Camera System to Record Cardiac Fluorescence Data", Annals of Biomedical Engineering, Vol. 25, No. 4, pp. 713-725, 1997.
7. Joseph N. Said, et.al "Dynamical Morphological Processing: A Fast Method for Base Line Extraction", Proceedings of 13th ICPR, Vol. 2, pp. 15-20, 1996.
8. Lei Xu, Erkki Oja and Pekka Kultanen, "A New Curve Detection Method: Randomized Hough Transform (RHT)", Pattern Recognition Letters, Vol. 11, No. 5, pp. 331-338, 1990.
9. Huaigu Cao, et.al "A Stroke Regeneration method for Cleaning Rule-Lines in Handwritten Document Images", Proceedings of IWM OCR, pp. 10-16, 2009.
10. Zhixin Shi, Srirangaraj Setlur and Venu Govindaraju, "Removing Rule-Lines from Binary Handwritten Arabic Document Images using Directional Local Profile", Proceedings of 20th ICPR, pp. 1916-1919, 2010.
11. T.W. Shen and T.F. Laio, "Image Processing on ECG Chart for ECG Signal Recovery", Proceedings of IEEE Computers in Cardiology, pp. 20-24, 2009.

12. Fabio Badilini et al., "ECGScan: A Method for Conversion of Paper Electrocardiographic Printouts to Digital Electrocardiographic Files", *Journal of Electrocardiology*, Vol. 38, No. 4, pp. 310-318, 2005.
13. Guojie Shi, Gang Zheng and Min Dai, "ECG Waveform Data Extraction from Paper ECG Recordings by K-means Method", *Proceedings of IEEE Computing in Cardiology*, pp. 1-5, 2011.
14. Lakshminarayan Ravichandran et al., "Novel Tool for Complete Digitization of Paper Electrocardiography Data", *IEEE Journal of T E H M*, Vol. 1, pp. 1-7, 2013.
15. W.T. Lawson et al., "New Method for Digitization and Computerized Analysis of Paper Recordings of Standard 12-Lead Electrocardiograms", *Proceedings of IEEE Computers in Cardiology*, pp. 340-347, 1995.
16. Kirsten Hermes, Tim Brookes and Christopher Hummerson, "The Influence of Dumping Bias on Timbral Clarity Ratings", *JOURNAL OF AES*, pp. 1-139, 2015.
17. George S.Waits and Elsayed Z. Soliman, "Digitizing Paper Electrocardiograms: Status and Challenges", *Journal of Electrocardiology*, Vol. 50, No. 1, pp.123-130, 2017.
18. A. Rajani, "Digitization of Electrocardiography Data Sheet Through Image Processing Techniques", *IUP Journal of EE E*, Vol. 9, No. 2, pp. 116-120, 2016.

## AUTHORS PROFILE



**Mr.Rajesh.R.Karhe**, is pursuing his Doctorate in Electronics Engineering from Sant Gadge Baba Amravati University, Amravati. and done M.E. in Electronics from Sant Gadge Baba Amravati University, Amravati. He has been working as the Assistant professor of Department of Electronics and Telecommunication Engineering at Shri. Gulabrao Deokar College of Engineering Jalgaon, Maharashtra and also visiting faculty in Government College of Engineering, Jalgaon. He has total academic teaching experience of 23 years with more than 25 publications in reputed national and international journals .His research area include Digital Signal Processing, Biomedical Engineering and Artificial Neural Network. He is also a member of National professional societies in the field of Engineering.



**Dr.S.N.Kale** is born in Amravati, Maharashtra, India. She received her PhD degree from Sant Gadge Baba Amravati University, Amravati. Currently she is Associate Professor in PG Department of Applied Electronics, Sant Gadge Baba Amravati University, Amravati. She has 26 years of teaching experience. with More than 52 Publication in reputed National and International Journals. Her current research interests focus on the areas of Soft Computing, Learning Machine; Image processing, Signal processing, neural networks. Dr. Kale is a Life Member of the Indian Society for Technical Education (ISTE), Indian science congress, Instrument society of India, Indian Women Scientist Association and Fellow of the Institution of Electronics and Telecommunication Engineers (IETE).