International Journal of Computer (IJC)
ISSN 2307-4523 (Print & Online)
http://ijcjournal.org/

# Empirical Study of Vessel Extraction Algorithms

Reem Aljeeran[a*], Laila Alsenawi[b], Kalim Qureshi[c]

[a,b,c]*Information science department, Kuwait University*
[a]*Email: reem.aljeran@grad.ku.edu.kw*
[a]*Email: laila.alsanawi@grad.ku.edu.kw*
[c]*Email: kalimuddin.qureshi@ku.edu.kw*

**Abstract**

Medical imaging is a technique for creating an image of the human body in order to diagnose various diseases such as stenosis, aneurysm, arterial venous malformation, thrombus, plaque and internal bleeding. Blood vessel segmentation is critical in the diagnosis of a variety of diseases. Blood vessels that are segmented give much useful information about their anatomy and location. They are important in a variety of medical applications, including diagnostic, surgical therapy, and radiation treatments. A significant amount of research has gone into vessel segmentation, and a variety of techniques has emerged as a result. In addition, there are different segmentation techniques such as active contour segmentation technique, hybrid segmentation technique, thresholding segmentation techniques, watershed segmentation techniques, edge detection segmentation technique, etc. It is also observed that magnetic resonance images of blood vessels were exposed to noise due to selection and inappropriate techniques such poor performance invisibility. In other words, there is no single approach to follow for a perfect outcome of images. There are some of the methods that use gray-level histograms, while there are others that integrate spatial image information, and this causes noisy outcomes. Therefore, we build the medical imaging vessel visualization system using MATLAB as tool. In this study, we empirically investigate the visibility performance vessel extraction algorithm. We implement following vessel extraction algorithms: active contour algorithm and edge detection algorithm. We observed that edge detection algorithm (SOBEL) is the better in term of image clarity as compared to active contour and edge detection algorithm. This project enable IS department to do more advanced level research in medical imaging.

***Keyword:*** Magnetic Resonance Angiography; Magnetic Resonance Imaging; vessels extraction; Edge detection; SOBEL; Active contour; Level Set.

---

* Corresponding author.

## 1. Introduction

Medical imaging is a technique used to generate body and blood vessels images as shown in figure 1. There are various modalities, which have different purposes and advantages such as magnetic resonance imaging (MRI), Computed Tomography (CT), Magnetic Resonance Angiography (MRA), X-ray radiography, and others. The most important modalities are MRI and MRA. Both are preferred over other modalities. MRI stands for Magnetic Resonance Imaging and MRA stands for Magnetic Resonance Angiography. MR imaging differs from all other technologies in that it produces high-quality images of the soft tissues and bones while being relatively safe. The MRI and MRA are similar tests but the primary difference between them MRI generates an image for the human body while MRA generates an image for blood vessels. These modalities based on Nuclear Magnetic Resonance (NMR) principles. These modalities are very important for providing rich information when it comes to clinical applications. In addition, these methods are painless and less expose to radiation. Therefore, it helps the medical professional and doctors easily identify disease at an early stage [1]. The diagnosis of vascular diseases is not only complicated, but also costly. Blood vessel extraction aids in the detection of disease and the advancement of medicine.

**Figure 1:** Retina image sample [5]classification (clustering) methods (a) original image (b) grayscale image (c) vessels extraction [6].

Vascular diseases are one of the most common health issues in the world. These cases are related to blockage of carotid arteries that cause brain attack. As we know that carotid, arteries are major blood vessels Millions of people suffer from vascular diseases. Sometimes vessels damage from accident. The percentage of individuals who face congestive heart failures due to blockage of coronary arteries are estimated in the range from 23% to 73% worldwide. Magnetic resonance angiography help the doctor to diagnosis different vascular diseases. This paper at first we describe brief introduction and motivation. Second, we address the efforts of other researchers for this domain and summary table of related works. Then, explain the detail of vessel extraction algorithms and flow chart. In addition, discuss MATLAB tools. Next, result, description and cons and pros between our algorithms. Finally, Includes conclusion.

## 2. Related work

An overview about the previous works from different authors of the same interests are discussed in this section. They order is from the most recent studies onwards and they show what science and technology has reached so far in this field. This opens the thoughts for more improvements that can be utilized in this study. It is safe noting that not all the related works encountered comparing region growing technique, active contour technique or edge detection technique.

**Ref [1]:** M. Mirzafam and N. Aghazadeh, "Blood Vessels Extraction from MRA Images by a Region Growing Algorithm Based on a New Nonlinear Contrast Stretching Function and Shearlets Frame," Journal of Machine Vision and Image Processing, 2021. Author discusses the various techniques of binary segmentation that have been developed to extract target objects. The common disadvantages have been also discussed as challenges that would not allow the extraction task to be achieved completely. A new nonlinear contrast stretching function has been proposed to this paper to give better result.

**Ref [2]:** F. A. Jibon, An Improved Classification Method of Brain MRI Image for Abnormality Detection, 2019. The paper explores the different image processing techniques that are applied to the MRI image for identification, classification and detection of different brain diseases. It also explores an improved classification method that can detect the MRI images related to brains and that can identify tumors as well. The method uses improved algorithm methods as well to identify such abnormalities [3].

**Ref [3]:** R. Al-Jarrah, M. Al-Jarrah and H. Roth, "A novel edge detection algorithm for mobile robot path planning," Journal of Robotics, 2018, 2018. One of the newest detection algorithms for vision systems has been proposed in this paper and this is based on the combination of fuzzy image processing and bacterial algorithm. Such a combination aims to increase the efficiency of detection and the reduction of computational time. In the paper, many scenarios have been adopted for indoor environments to verify the features that this technique presents with the new algorithm in terms of efficiency and computational time of detection [4].

**Ref [4]:** K. Qureshi, "A systematic survey and evaluation of blood vessel extraction techniques," International Journal of Medical Imaging, vol. 6, no. 5, p. 63, 2017. MRA brain vessels automatic extraction found its application in the diagnosis of vascular disease, endovascular operations as well as neurosurgical planning. Therefore, this paper presents a brief methodology with pros and cons of the common vessel extraction techniques. A survey was also conducted for the latest development in the field of vessel extraction by using region growing algorithms. There was a high level of performance after comparing the traditional region grown algorithms [5].

**Ref [5]:** T. A. Soomro, M. Paul, J. Gao and L. Zheng, "Retinal blood vessel extraction method based on basic filtering schemes," in In 2017 IEEE International Conference on Image Processing (ICIP), 2017. Retinal blood vessel segmentation can identify eye diseases such as Diabetic Retinopathy (DR). There have been many methods that have been developed through the last five years that have been proposed. However, the diagnosis performance of these techniques has missed some tiny vessels. The paper proposes a new algorithm that targets

improving the performance of these tiny vessels. The results have shown greater results compared to the traditional techniques that have been proposed before [6].

To sum up, the recent advancements in both software and hardware have enabled MRI and MRA to have significant changes in both the approaches and techniques. There have been a lot that have been improved ranging

From the overall image quality to the painless processes for a better experience for the patients. It is safe to state that now there are lower rates of cost and risk regarding these technologies and this in turn helped in sparking the ideas for new methods to be implemented in the future.

## 3. Vessel extraction algorithms

One of the most significant treatments that professionals can use to diagnose and treat diseases. It is important in a variety of medical applications, including diagnostic, surgical therapy, and radiation treatments. The extraction of blood vessels is critical in the early detection.

### *3.1. Active contour description*

Advanced method and suitable for the analysis of dynamic image data or 3D image data.

#### *3.1.1 Flow chart description*

- Read image from device
- Check if image is exist or not
- Display RGB image
- Convert RGB image to gray scale
- Display gray scale image
- Applying active contour level set

- Start with loop = 0 (number of iteration)
- Calculate gradient for every pixel (finding the edge)
- Initialize phi and initial level set for 2D image
- Calculate level set function
- Increment iteration
- If I less than 12 then calculate level set function
- If I greater than 12 end

- Display active contour output and end.

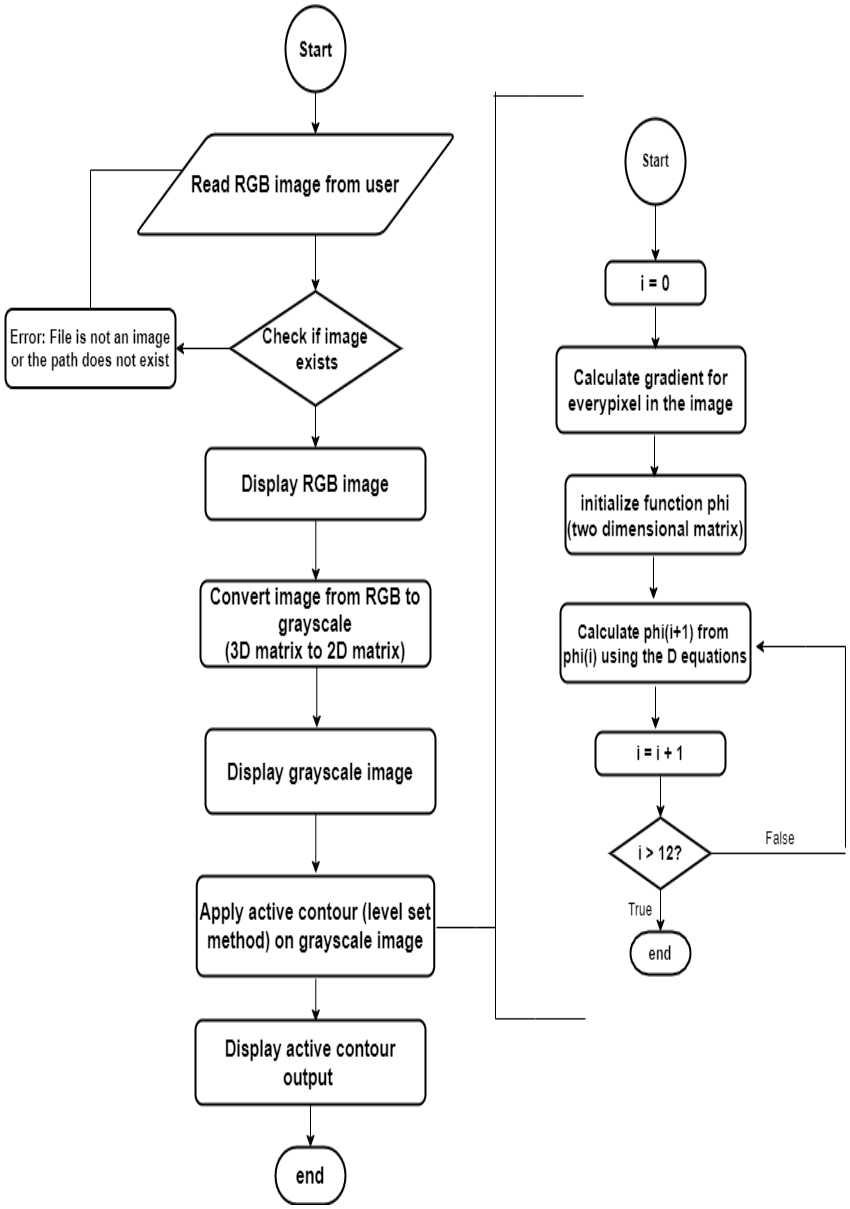


**Figure 2:** active contour flow chart

### *3.1.2 Active contour pros and cons*

**Pros**: The vessels in our image set are highlighted as solid white regions, not just outlines. Also, it's more customizable we can change the parameter so; the output can be change from one to another.

**Cons**: noise and less accurate and the execution time of the algorithm is much higher than other alternatives.

### *3.2. Edge detection*

Refers an image processing technique that can find boundaries of objects within images. In addition, uses multiple mathematical methods to identify edges and curves within a digital image.

### *3.2.1 Edge detection description*

- Read RGB image from image path
- Display the RGB image we read
- Convert to Grayscale
- Display grayscale image
- Use built-in rescaling function to make grayscale image smaller by a factor
- Use built-in Sobel edge detection function
- Display image edge.

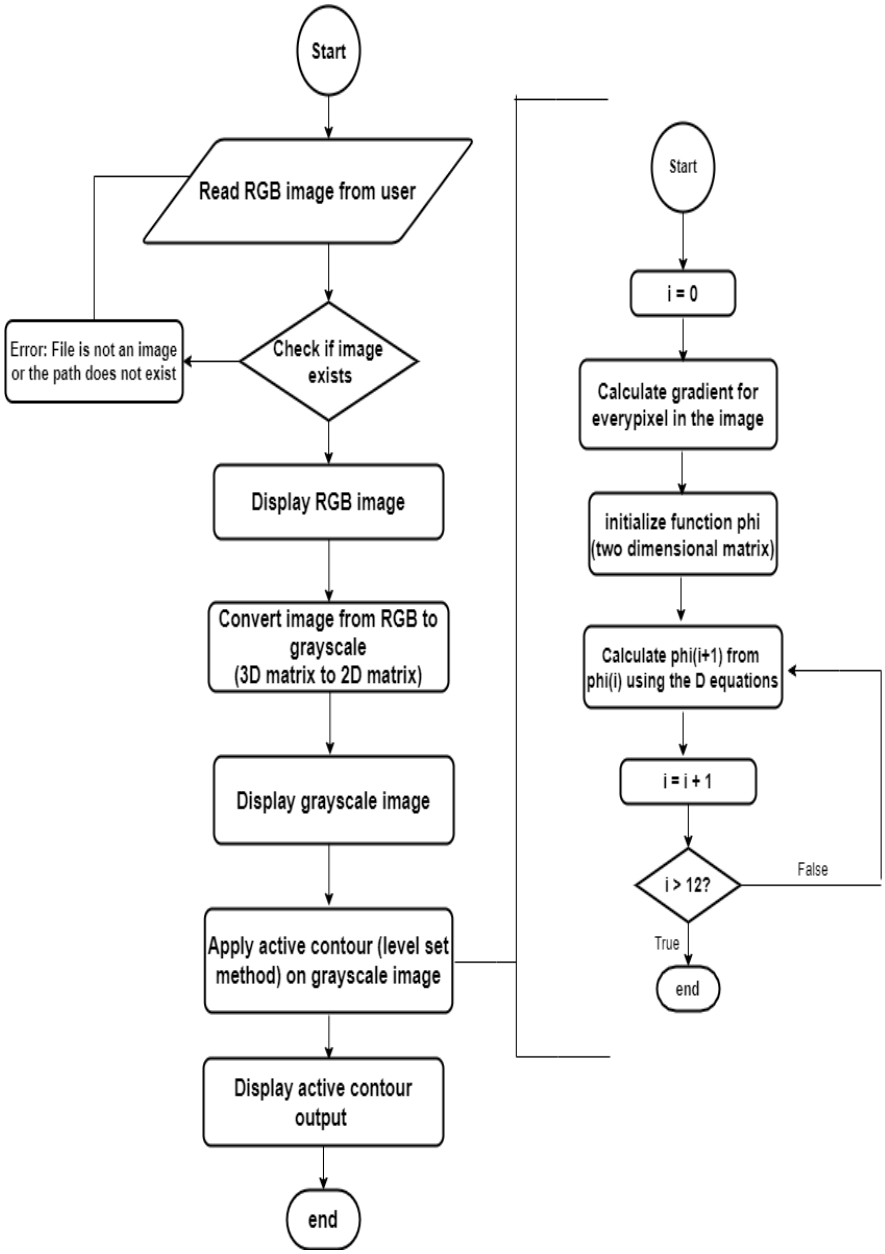


**Figure 3:** edge detection flow chart

### *3.2.2 Edge detection pros and cons*

**Pros**: Execution time is much faster than active contour. Only has one parameter to change (threshold) which makes trial-and-error much easier.

**Cons**: Sensitive to noise, Requires post-processing in most cases to show the edges. Also, since it is an edge detection filter, only the outlines of the vessels are shown as a result.

## 4. Experimental setup

The task of retinal vessels segmentation tends to be a very difficult task. This is because the fundus images of the retina are often noise. It makes it a difficult task for the medical professionals to accurately address the extracted blood vessels.

There have been multiple techniques to be used for extracting the images that can show the retinal blood vessels segmentation. In this report, I focus on two techniques edge detection technique (SOBEL) and active contour technique for extracting retinal vessels. It is safe to note that the pictures have been taken from the reference entitled as 'Blood Vessel Extraction in Color Retinal Fundus Images with Enhancement Filtering and Unsupervised Classification' [7].

### *4.1 Image format*

MATLAB (MATrix LABoratory) commands read, write, and display several types of graphics file formats for images. DCM files refer to image files that are saved in the format of Digital Imaging and Communication in Medicine. These files are known for storing medical images such as Computed Tomography (CT) scans and ultrasounds. They also can store information related to patients to pair these formats with the recorded patients.

## 5. Result and description

### *Active contour result and description*

First, Read original RGB image. RGB: means (read, green and blue) each pixel in image contains three value as shown in figure 4:


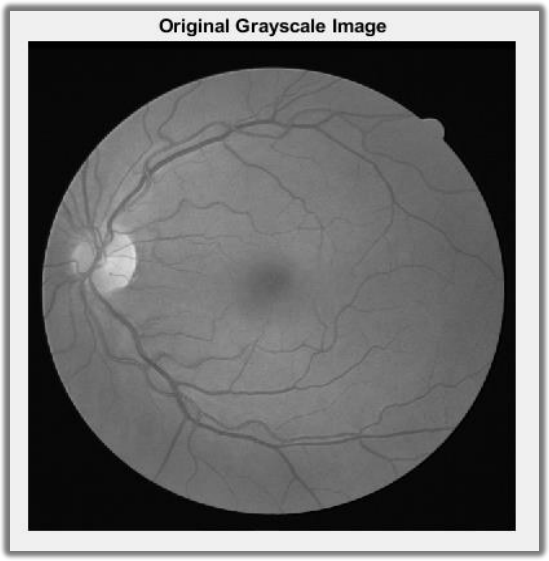


**Figure 4:** Original RGB Image

**Figure 5:** Original Grayscale Image

After converting from RGB to grayscale from 3D to 2D, it is very easy to filter one value for each pixel **(**3D = each pixel in image contains three values, 2D = each pixel in image contains only one value) as shown in figure 5. Finally, the result after applying level set. We apply 12 level as shown in figure 6:

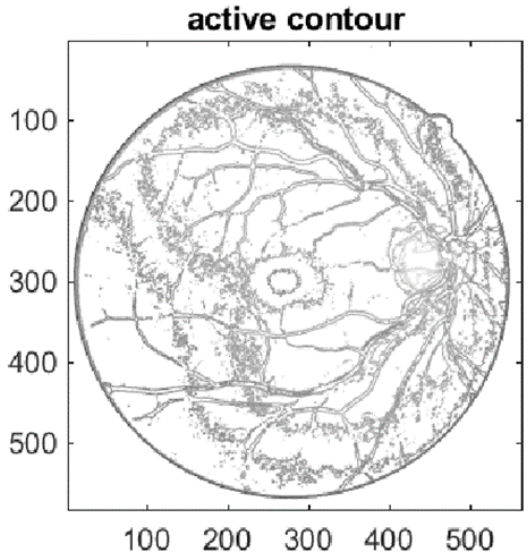


**Figure 6:** active contour

Finally, the difference between figure 4 and 5. As shown in figure 6 more clear and high quality and contains a lot of information.

***Edge detection result and description***

- First, converting RGB (Read green and blue) image to grayscale image.
- (From 3D matrix to 2D matrix), 3D matrix each pixel in image contain three value and 2D matrix each pixel in image contain only one value. Converting image are very important because it is easy to filter only one value.
- Identify value of THRESHOLDING 0.021 (static value). This value can be change.
- Apply SOBEL edge detection steps
- Finding gradient for x and y vertical and horizontal
- Applying gradient equation by combining both horizontal and vertical gradient.
- Condition for THESHOLDING
- THRESHOLDING (allows only gradient larger than THRESHODING value to be visible).
- Finally the result after applying edge detection technique SOBEL type.


**Figure 7:** Original RGB Image

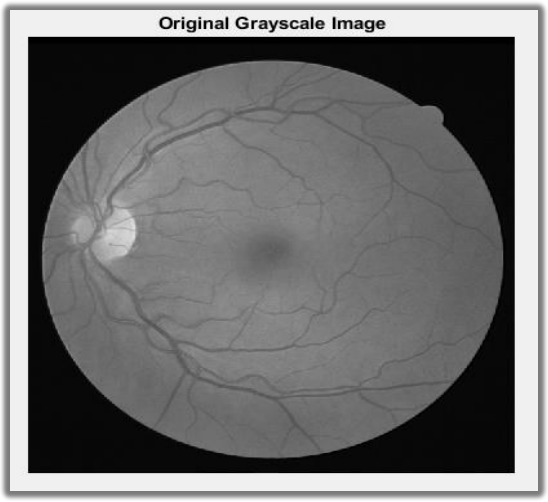


**Figure 8:** Original Grayscale Image

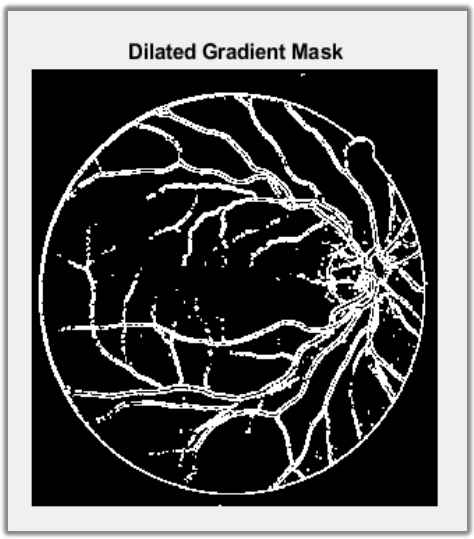


**Figure 9:** Dilated Gradient Mask

Finally, the difference between figure 7 and 9. As shown in figure 9 the vessels are accurate and visible also, it's give us a lot of information that help doctors to diagnose different vascular diseases. In addition, there is less noise than active contour result.

## 6. Conclusion

There is still no single segmentation algorithm that is applicable for medical imaging applications. Edge detection algorithm is one of these segmentation algorithms, which has gained importance due to high performance and visibility of complex retinal blood vessels.

## References

[1] E. A. Zanaty and S. Ghoniemy, "Medical image segmentation techniques: an overview," *International Journal of informatics and medical data processing*, vol. 1, no. 1, pp. 16-37, 2016

[2] M. Mirzafam and N. Aghazadeh, "Blood Vessels Extraction from MRA Images by a Region Growing Algorithm Based on a New Nonlinear Contrast Stretching Function and Shearlets Frame," Journal of Machine Vision and Image Processing, 2021

[3] F. A. Jibon, An Improved Classification Method of Brain MRI Image for Abnormality Detection, 2019.

[4] R. Al-Jarrah, M. Al-Jarrah and H. Roth, "A novel edge detection algorithm for mobile robot path planning," *Journal of Robotics, 2018*, 2018.

[5] K. Qureshi, "A systematic survey and evaluation of blood vessel extraction techniques," *International Journal of Medical Imaging*, vol. 6, no. 5, p. 63, 2017.

[6] T. A. Soomro, M. Paul, J. Gao and L. Zheng, "Retinal blood vessel extraction method based on basic filtering schemes," in *In 2017 IEEE International Conference on Image Processing (ICIP)*, 2017.

[7] MathWorks, "Techniques for Visualizing Scalar Volume Data," MathWorks, [Online]. Available:https://in.mathworks.com/help/matlab/visualize/techniques-for-visualizing-scalar-volume-data.html. [Accessed 24 November 2021]