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# Sustainable Diabetic Retinopathy Diagnosis System Using Iot

**C. Balaramesh[1*], L. Jerin[1], K. Hari Krishna[1], G. Shanmugam[1], L. Asbin Thomas Wizar[1]**

*[1] UG Student, ECE Department, DMI Engineering College, Aralvoimozhi, Kanyakumari District, Tamil Nadu, India.*
**Corresponding author E-Mail ID: balaramesh8265@gmail.com,*

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## ABSTRACT

Supportable processing gives a remote access to the finding framework for simple and quick usage. The proposed approach estimates glucose level in the blood through Dexcom G4 Platinum sensors on diabetic patients. In light of the readings, Internet of Things (IoT) stage offer a reasonable answer for Diabetic Retinopathy. The motivation behind this research is to spare the life of the patient from vision misfortune. The procedure begins from the gadgets themselves which safely move data with IoT stage and vow the regular language for the portable applications to work together with one another. This stage always accumulates a huge number of data from the gadget and store in a protected database. It fuses the information got from IoT gadgets and applies investigation to anticipate significant information to address clinical needs. The outcomes shown by the execution of the proposed methodologies are practically identical with the modern frameworks in relations of exactness, particularity and affectability. The proposed method performs superior to different systems by accomplishing a normal 99.58% Precision, 72.51% Sensitivity and 99.83% Specificity in the trial arrangement.

***Keywords: Sustainable Computing, Internet of Things, Image Segmentation, Diabetic Retinopathy, Health Care, Smart Devices.***

## 1. INTRODUCTION

Sustainable computing reduces the energy consumption of computational devices and the supporting electronics. Any device is connected to Internet and do work without human interactions and send data for analysis is called IoT. It provides a challenged application domain for new approaches which are necessary to be incorporated in cloud centric realizations. There are opportunities to improve the patients experience through sustainable IoT systems. Physicians are forced to take treatment on limited or partial data. But the Physicians to have and had a holistic view of the patient's health. IoT start the change in electronic medical data from more comprehensive views of patient's health and treatments.

IoT is a next phase of Internet where machine talking to machines autonomously. The apps are designed to analyze the data and provide instant solution. Noticeably improvements in health care areas as the advent of IoT. There are many opportunities overcome by intelligently combining the clinical and consumer's source data and passive technologies to track the patient to significantly improve healthcare. Smart healthcare applications bring solutions through human centered innovations on IoTsystem for smart living and sustainable development. IoT and healthcare brings lot of changes in the life of people to live healthy life. The following sustainable networking technologies enable IoT system to perform storage and processing of data such as, Wireless Sensor Network and Radio Frequency Identification. Cloud computing infrastructure provides end to end communication for accessing the information on demand through Internet technologies. The sustainable computing power is important in devices point of view. In case of treatment, time matters. The smart sustainable IoT system enables the doctor to analyze the image of retina faster to prove the disease. It makes the patient sooner on the way to recovery. Maximize the smart connective devices with predictive maintenance, smart software updates fundamentally help and analyze rich data. The future of healthcare is one of the most pressing global issues. Images help to diagnose the disease. Analyzing patient's population profile is time consuming and complex. Gaining medical data, merging and validating data from different sources are challenging in sustainable computing.

Diabetic Retinopathy (DR) is a disorder produced from progressive high blood sugar level in the human body. It causes injury to the delicate blood vessels lining inside retinal layer and started leaking lipids and proteins to distort the human vision. There is increase in impaired vision and blindness universally in the past two decades is originated due to diabetes.Due to inadequate access to eye health service and poor glucose control, there are many constituents of the world contribute for this disease. A retinal blood vessel plays a cardinal role in transmitting the light signals from retina to the brain as information signals. The blood flow starts from the optic disc through optic nerves. The retinal disorder occurs in the human eye is due to changes in the dimensions of blood vessels. In the advanced stage, there are chances for new abnormal vessel growth inside retina may defile retinal layer and directing to indelible vision impairment. Bursting of nerves made to settle unwanted particles in macula. It deposits exudates, lesions, micro aneurysms, hemorrhages and cotton wool spots. The manual assessment of retinal blood vessel is impossible, since measurement of vascular width is most crucial.This automated sustainable disease detection system significantly reduces the load of ophthalmologists. The spontaneous generation of retinal app is used for age related macular degeneration treatment.

Funds imaging imparts a valuable resource for analysis of retina. The manifestation of low contrast background in the funds images induces unpredictability in vessel width. The pathological effects make segmentation particularly challenging. The retinal blood vessels existing in the funds images are encountered with poor contrast. It is very hard to diagnose Diabetic Retinopathy hence, it is essential to apply appropriate image segmentation procedure for faultless diagnosis of retinal blood vessels.

The key motivation of the proposed method is to progress the quality of funds images via enhancing and segmentation. The method required for segmentation of retinal vessels are classified into two main groups: supervised and unsupervised. The supervised methods are trained by a model to distinguish a pixel as vessel pixel or non-vessel pixel. The manual method is extremely higher owing to extraction of diverse features. Also training is complex among the classifiers which refer large quantity of data. In contrast to supervised methods, automatic unsupervised algorithms are stead faster and to face the related choices given to the ophthalmologists. Despite large number of researches on extraction of retinal blood vessels, there are requirement of accurate and precise blood vessel extraction system. There are certain failures required to be upgraded encompassing false vessel extraction, which is made by nanoscopic dissimilarity among the retinal blood vessels and contextual image. Also, connectivity loss of the retinal vessel trees topological structure is comparatively challenging. Grounded on the motivation, an automatic retinal blood vessel segmentation technique that incorporates CLAHE, Kirsch's template and Fuzzy C-Means clustering techniques are presented in the proposed work. The following issues are addressed in this article.

- In some method there are inadequate to present the entire segmentation result in case of blood vessels fade away from the mid to its extendeddirection.
- Losing one branching point while tracking may lead to an incomplete blood vessel network and raiseserror.
- Algorithms paid no attention to minor blood vessels at branchingpoint.

- Premature termination of tracking process took place and diminishes the vesselnetwork.

## I. METHODOLOGY

To test diabetes, people have to prick their finger several times a day. But the proposed system uses Dexcom G4 Platinum sensors which monitors the patient's glucose level continuously. The sensor piece is inserted and worn on the skin of the patient. Hence it avoids finger pricks and its readings are more accurate. This sensor records the data and gives readings on every five minutes. This sensor is comfortable, safe and painless than the other sensors. As shown in Fig. 1the readings of the sensor are transferred to DRapp device, where the recorded glucose level is categorized as Type I or Type II. If it is Type I, patients are instructed for treatments and to fix appointments with doctors. In case of Type II, the patients are instructed to capture their eye fundus images using iPhone device application. The captured fundus images are loaded into DRapp for Diabetic Retinopathy diagnosis, which detect the retinal blood vessels through the proposed segmentation algorithm and classify the disease; also it assigns grade as mild, severe or moderate. Based on the grade of disease diagnosis, notifications are given to the patient to meet the ophthalmologists for treatment.

The complete medical data provided from different devices are merged to organize and process the data beyond typical clinical scenarios. IoT provides an opportunity to improve the patients experience also it is potentially lifesaving application in the health care industry. Through single application on a mobile device enable the patients and staff to effectively manage the data. At the same time advance in new technology provide new and low cost ways to detect the diseases. It holds promise of life changing technology. The proposed sustainable computing based IoT system helps the patients to get treatment at the early stage of DR. The massive fail in identifying the disease causes 100% vision loss. At the last stage it causes retinal detachment from the eye.

### 1.1 Architecture of Sustainable IoT Network Platform

The physical and functional organization of sustainable IoT network is modeled as different layers such as Data Link Layer, Network Layer and Application Layer. The working principles of the layers are described as follows.

#### 1.1.1 Data Link Layer

The data link layer comprises funds images datasets. The funds images uploaded by the patients are stored in a Novell Cloud Server. The images needed for analysis are fetched and transmitted through the Transport Layer. To test the application, we have used publically accessible databases such as, DRIVE (40 images), STARE (400 images), REVIEW (16 images), HRF (15 images) and DRIONS (110 images).

Totally, 581 images are used in this experimental setup. The ground truths images exist inside the databases are obtained manually from the ophthalmological experts. In addition, there are 234 images with lesions and 104 images with large hemorrhage in STARE database, 7 images with DR in DRIVE database, 7 images with lesions in REVIEW database and 8 images with hemorrhage in DRIONS database are used for testing the proposed segmentation techniques.

Often, these datasets are used by various researchers to exhibit the performance of the proposed solutions. The proposed system detects the blood vessels through Kirsch's template; the identified blood vessels are segmented by Fuzzy C-Means and the optic disc is removed by region based active contour model. The vessel tracking mechanisms are systematic and always provide the significant representation of the vessel network.

### 1.1.2 Network /Transport/ CommunicationLayer

We have used, Novell Cloud Server network available in our premises to host the applications. This layer is capable of transfer the data between devices and minimizes the latency time. The Novell Cloud Server enables us to follow up the history of patients records which are stored in the databases.

### 1.1.3 ApplicationLayer

The application layer comprises a Graphical User Interface (GUI) enabled DRapp, which is integrated with Matlab applications for fundus image processing. This interface enables the patients to load the fundus images for diagnosis. The GUI application contains the following process

## II. Proposed Retinal Blood Vessel Segmentation Techniques

The pictorial representation of proposed retinal blood vessel segmentation technique is constituted in Fig. 1. This system takes a retinal image from the fundus camera as input. The intensity of a funds image pixel is shadier while compare to the background pixels. The contrast of the vessel pixel is most probably present in the green channel. The pixel intensities are taken from the green channel for further operations. At the preliminary phase, Contrast Limited Adaptive Histogram Equalization (CLAHE) is conceded for band selection, brightness correction and to denies the image. Then, two levels of segmentations are conducted.

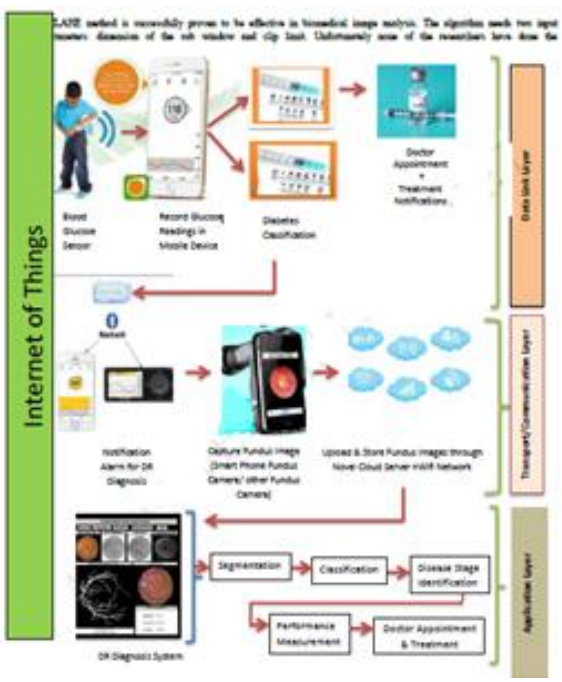


*Fig 1. Proposed retinal blood vessel segmentation technique.*

First level isto extract blood vessels from funds image using Kirsch’s 5x5 kernel template and second level of segmentation is completed usingunsupervisedFuzzy.

The novel extension of conventional CLAHE algorithm, where sub window and clip limit parameters are calculated automatically thereby the algorithm is fullyadaptive.

The extended 5x5 kernel kirsch’s operator is to find the maximum edges by convolving 24 pixels with eight templates to provide 24 outputs for each pixel to find the maximum magnitude. It increases the chances for more pixels to be connected in the vascular map with its nearest neighborhood in fundusimages.

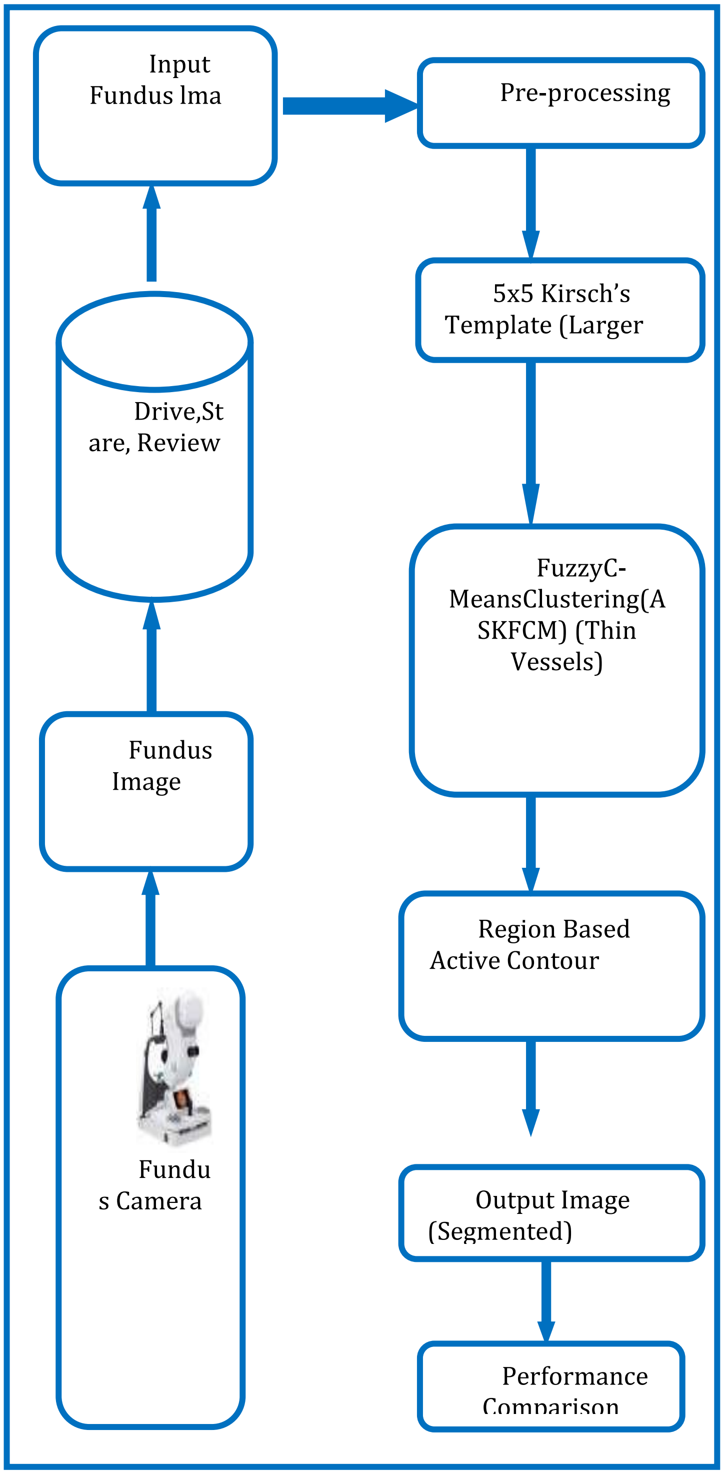


***Fig 2. Proposed scheme for blood vessel segmentation.***

The novel Adaptive Spatial Kernel distance measure based Fuzzy C- Means (ASKFCM) method combines the kernel and spatial information of neighborhoods. The spatial features increase the possibility of neighborhood pixel with similar features while clustering.

### 2.1 Preprocessing: Contrast Limited Adaptive Histogram Equalization (CLAHE)

CLAHE method is successfully proven to be effective in biomedical image analysis. The algorithm needs two input parameters:

## 2.2 Extended Kirsch's Edge Detection Template

The segmentation of blood vessels from upgraded fundus image is emanated using Kirsch's method. The benefit of this approach is to identify the blood vessels with dissimilar width and length. While observing the results of Kirsch's 3x3 kernels [38, 43, 44, 45], the blood vessels detected by this algorithm are over segmented. To reduce the over segmentation of 3x3 convolution kernels of the Kirsch's operator, 5x5 kernels is projected. A1, A2, A3, A4, A5, A6, A7, A8 templates are rotated at 0°, 45°, 90°, 135°, 180°, 225°, 270°,315° on West, South West, South, South East, East, North East, North and North West directions respectively to detect the edges of the image successfully.

The edge detection operator performs differential operation of gradients and detects very thick complicated edges and not smooth edges. As shown in Fig. 3, values such as, -3,-7, 5, 9 are obtained from Kirsch's template for different kind of neighborhood pixels The values of the operators are selected based on edge orientation, edge structure and noise environment to optimize the edges to be detected on horizontal, vertical and diagonal orientations. The target value '0' is the vessel pixel which has to be detected. The target pixel is detected based on the direction of search from external to internal. Hence it reduces the searching space on whole image. The kernel 'A' is applied on the entire image then each pixel is substituted by average value of 5x5 neighborhoods.

The result of 3x3 Kirsch's kernel and extended 5x5 Kirsch's kernel shows more blood vessels are detected by 5x5 Kirsch's operator were considered as non-vessel by 3x3 operators. The highlighted red color circles are vessel pixels and identified as vessel pixels in ground truth; it is detected by 5x5 operators but considered as background pixel by 3x3 operators. Finally, the identified edges are merged together and kernel scale factor increase or decrease the power of convolution results. To reduce the possibility of overflows, the scaling factor is considered as 1/25 in 5x5 operators. The cast function truncate too large values in the image and clipping limit returns the values of the scaled image. In 3x3 kernels, each pixel in the specified images is convolved with every template and yields eight outputs. The maximum value is demarcated as edge magnitude whereas, in 5x5 kernel, the Kirsch's operator find the maximum edges by convolving 24 pixels with eight template and provided 24 outputs for every pixel to find the largest magnitude. Kirsch operator condenses the blood vessel than it looks. To reduce the morphological operations, erosion is to be made.

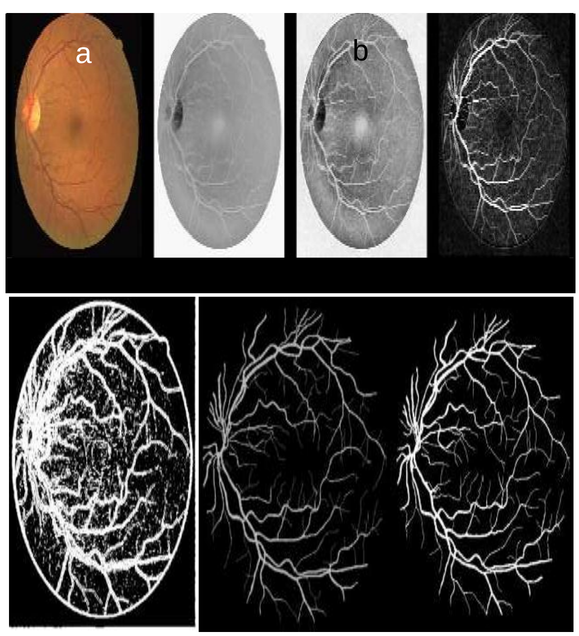


***Fig 3. DRIVE database image's segmentation outputs by the proposed method: (a) Input funds image of DRIVE, (b) Extracted green channel (c) Enhanced CLAHE Image, (d) – (e) Segmentation of larger vessels by CLAHE +***

***Kirsch's template (f) Segmentation of vessels by CLAHE+ Kirsch's template + ASKFCM +Region Based Active Contour methods, (g) Ground Truth Image.***

To resolve the inadequate segmentation of tinny retinal vessels by the Kirsch templates method, Fuzzy C-Means is pertained to segment thin curved vessels. The vessels highlighted in third column are the vessels which are present in ground truth and detected by proposed method but are failed to detect by other competitive methods. This demonstrates that, the performance of the proposed scheme is progressing while distinguishing blood vessel pixel from non- blood vessel pixel accurately. The proposed iterative clustering algorithm produces an optimum partition by means of minimizing the weights inside the cluster. The spatial features increase the probability of neighborhood pixel with related features while clustering. The experimental results show that the two parameters $\sigma$ and $\beta$ plays the most important part in clustering results.

Grounded on the experimental results, it is decided that the proposed ASKFCM with spatial kernel data has improved the performance than other conventional FCM methods without using spatial information.

### 2.3Region Based Active Contour

The fundamental knowledge of an active contour model is to focuses on constraints of the given image to identify the objects in that image. The curve travels near to its interior normal and stop at their boundary. In the conventional snake model, an edge detector is used to stop generation of evolving curve gradients of the boundary of an anticipated object. The removal of optic disc is done by the following steps: first, to select the initial mask for the input segmented image and apply region based active contour to obtain the mask. Then, subtract this mask from the input image which results in a new mask. Finally, subtract the new mask from the old mask; the resulting image will be a non-masked segmented image. The region of lesions is spot like structure, which is eliminated by this technique. It extracts the curve like vessel structure based on the constraints.

### 2.4 Training Set Creation

A reference image is taken from STARE dataset is to perform training and to obtain the parameter σ and $\beta$. The effect of neighborhood pixels is controlled through these parameters. The one time trained values on the test data set images are implied without adjusting the values of the parameters. In fact, training the classifier for similar kind of images has obtained from identical databases which are fine tuning the parameters. This process produces better results.

## III. EXPERIMENTALRESULTS

The retinal blood vessel segmentation method contributes knowledge of vessel locations. The proposed method results on DRIVE database is shown in Fig. 5. The obtained retinal vessel map image of STARE database is assessed with ground truth vasculature is shown in Fig. 4.There are overlaps among the boundary vessels which are acknowledged and linked with equivalent vessel center line. All non-blood vessel pixels are dropped out for configuring the final vessel structure.

The proposed technique is ahead of existing techniques in its performance by achieving an average value of 72.51% Sensitivity, 99.83% Specificity and 99.58% Accuracy. Qualitatively, the proposed methods segment all the vessels without keep hold of any pixels disconnected by the background noise. The experimental solutions shown proved that the proposed method segments both wide as well as thin vessels accurately while compare with competitive methods. Additionally, the proposed sustainable scheme is unsupervised and does not requisite manual intervention of training.

### 3.1Proposed Method Results

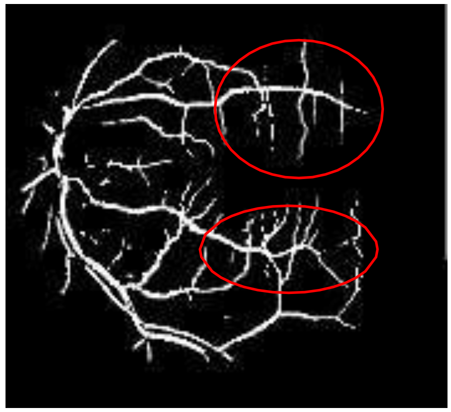

*Fig 4.Image of Retinal Vessel Map*

The factors for examining behavior of segmented images are: Sensitivity, Specificity and Accuracy. True Positive (TP) is a pixel categorized as vessel like structure but they are truly vessels pixel in ground truth image.

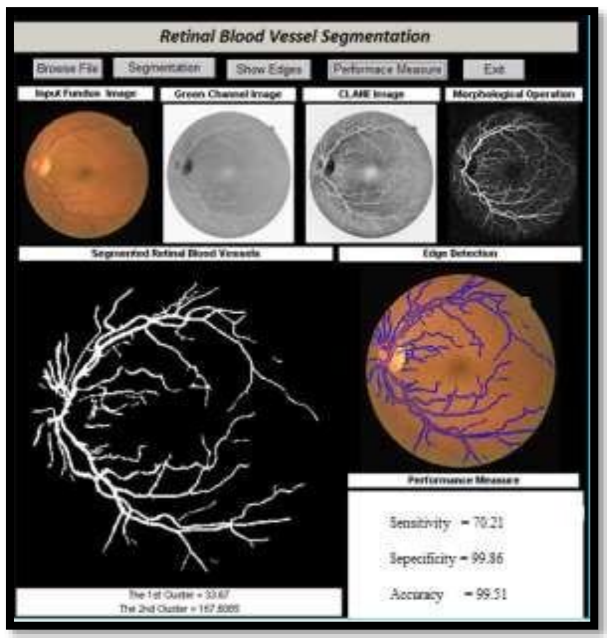


*Fig.5.Retinal Blood Vessel Segmentation*

False Negative (FN) is a pixel categorized as non-vessel pixel and they are truly vessel pixel in the ground truth image. True Negative (TN) is a pixel categorized as non-vessel and they are infactof background pixel in the ground truth image. False Positive (FP) is a pixel categorized as vessel-like although they are actually background pixels in ground truth image. Sensitivity is the ratio of pixels exactly categorized as vessel pixels. Specificity is the ratio of pixels exactly categorized as background pixels. Accuracy is the ratio of pixels exactly categorized as vessel and background pixels.

## CONCLUSIONS

In clinical analysis, it is essential to distinguish the blood vessels from non-blood vessels for examining various stages of Diabetic Retinopathy. There are several methods which is incompetent to discern the blood vessels from pathological images. We have developed a novel unsupervised sustainable segmentation technique to locate the blood vessels from funds images. There are 581 funds images experimental results are obtained from DRIVE, STARE, REVIEW, HRF and DRIONS databases. The results prove that the proposed CLAHE method eliminate the noise present in the depigmented retinal images. The novel 5x5 Kirsch's operator with Adaptive Spatial Kernel distance measure based FCM (ASKFCM) methods segmented all blood vessels accurately. The proposed sustainable IoT technique minimizes the work of ophthalmologists in diagnosing the retinal vessel map of the patients with DR. The smart IoT system initiates medical care by analyze large dataset in real time no matter of resources and formats. It extracts medical history of patients in terabytes of data in known time. Providing health care is far simpler than its today through better technology. This work is extended by extracting the vessel features and to measure the tortuosity to find the severity level of the disease.

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## Conflict of Interest

None of the authors have any conflicts of interest to declare.

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