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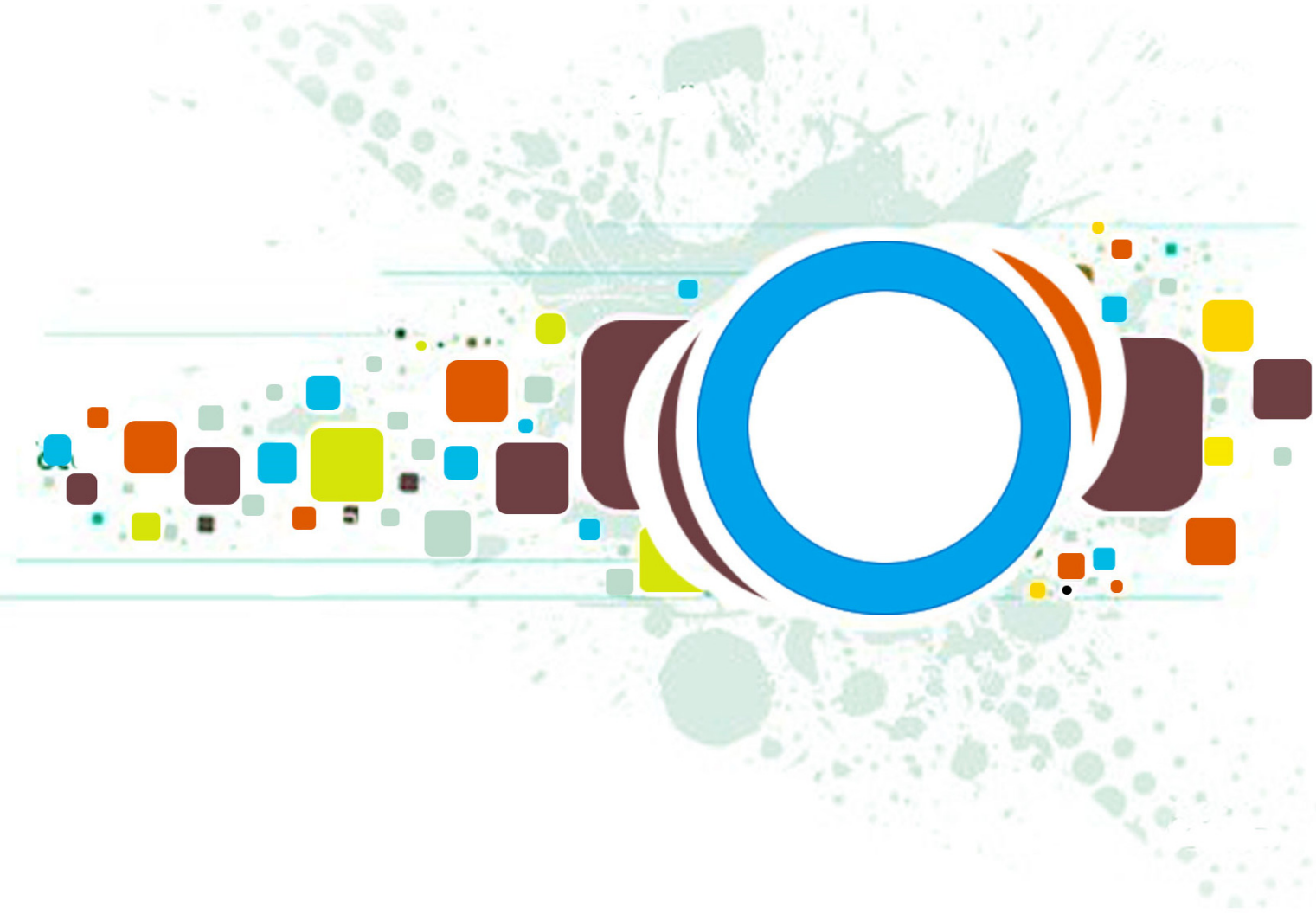

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The International Journal of Image Processing (IJIP) is an effective medium for interchange of high quality theoretical and applied research in the Image Processing domain from theoretical research to application development. This is the *Third* Issue of Volume *Fifteen* of IJIP. The Journal is published bi-monthly, with papers being peer reviewed to high international standards. IJIP emphasizes on efficient and effective image technologies, and provides a central for a deeper understanding in the discipline by encouraging the quantitative comparison and performance evaluation of the emerging components of image processing. IJIP comprehensively cover the system, processing and application aspects of image processing. Some of the important topics are architecture of imaging and vision systems, chemical and spectral sensitization, coding and transmission, generation and display, image processing: coding analysis and recognition, photopolymers, visual inspection etc.

The initial efforts helped to shape the editorial policy and to sharpen the focus of the journal. Started with Volume 15, 2021, IJIP will be appearing with more focused issues. Besides normal publications, IJIP intends to organize special issues on more focused topics. Each special issue will have a designated editor (editors) – either member of the editorial board or another recognized specialist in the respective field.

IJIP gives an opportunity to scientists, researchers, engineers and vendors from different disciplines of image processing to share the ideas, identify problems, investigate relevant issues, share common interests, explore new approaches, and initiate possible collaborative research and system development. This journal is helpful for the researchers and R&D engineers, scientists all those persons who are involve in image processing in any shape.

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A Novel Advanced Approach Using Morphological Image Processing Technique for Early Detection of Diabetes Retinopathy

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Abstract

Diabetic retinopathy (DR) is a common complication of diabetes mellitus and can lead to irreversible blindness. To date, DR is the leading cause of blindness and visual impairment among working adults globally. However, this blindness can be prevented if DR is detected early. Diabetes mellitus slowly affects the retina by damaging retinal blood vessels and leading to microaneurysms. The retinal images give detailed information about the health status of the visual system. Analysis of retinal image is important for an understanding of the stages of Diabetic retinopathy. Microaneurysms observed that appear in retina images, usually, the initial visible sign of DR, if detected early and properly treated can prevent DR complications, including blindness. In this research work, an advanced image modal enhancement comprises of a Contrast Limited Adaptive Histogram Equalization (CLAHE), through morphological image, processing technique with final extraction algorithm is proposed. CLAHE is responsible for the detection, and removal of the retinal optical disk. While the microaneurysm initial indicators are detected by using morphological image processing techniques. The extensive evaluation of the proposed advanced model conducted for microaneurysm detection depicts all stages of DR with an increase in the number of data set related to noise in the image. The microaneurysms noise is associated with stage of retina diseases as well as its early possible diagnosis. Evaluation is also conducted against the proposed model to measure its performance in terms of accuracy, sensitivity as well as specificity in real-time. The results show the test image attained 99.7% accuracy for a real-time database that is better compared with anty colony-based method. A sensitivity of 81% with a specificity of 90% was achieved for the detection of microaneurysms for the e-optha database. The detection of several microaneurysms correlates with stages of DR that prove an analysis of detecting its different stages. This study aimed at early detection of DR with high performance in accuracy.

Keywords: Retina Image, CLAHE, Retina Optic Disc, Mathematical Morphological Operation, Diabetic Retinopathy, Microaneurysms.

1. INTRODUCTION

Diabetic retinopathy (DR) is a complication of diabetes mellitus that causes damage to the blood vessels in the retina [1][2]. The retina is the nerve layer that lines the back of the eye, senses light, and creates impulses that travel through the optic nerve to the brain and thereafter facilitates vision. Retinal image analysis plays an important role in detecting DR in early stages [1][2]. DR is the leading cause of blindness and visual impairment among working adults globally [3] According to the statistical data of the International Diabetes Federation, the number of adults living with diabetes is going to increase gradually to an estimated 629 million by 2045 throughout the world. Henceforth, diabetic retinopathy has the probability to become a major health issue throughout the world.

It is important to understand that DR progress slowly over time. The occurrence of DR can be prevented, if detected early by conducting health check-ups with a systematic treatment of diabetes [4][5].Therefore, detection of early symptoms, for example microaneurysm that appear in retinal image mutual treatment proves advantageous to prevent further complications. It reduces the risk of loss of visual acuity [6].

Research has proposed the use of a fundus camera, used by an ophthalmologist to capture retinal images. There are various camera settings to diagnose numerous eye-related diseases. Analysis of retinal images includes the identification and extraction of many retinal anatomical structures. It is directly related to the disease like Retinal optic disc. There are several examples of retinal anatomical structures that show the target features for different segmentation techniques [7-10]. DR has four stages: specifically, normal, mild, moderate, severe as well PDR (Proliferative Diabetic Retinopathy) as shown in Figure 2. This clinical manual diagnosis of this disease is error-prone. Routinely detecting DR in its different stages from retina images is proposed in various computer vision-based techniques[11]. This technology can help reduce the manual burden on ophthalmologists and overcome the barriers and challenges of early detection of DR.

In this research work, efforts are made on the outcome of diabetes in the human eye retinal optic disc. The retina optic disc is the brightest part of a retinal image. It has a large number of blood vessels. The Optic disc identification is used to identify the blood vessels as well as the fovea. Moreover, an optic disc of the retina contains most of the retina information used for other analyses of a human being.

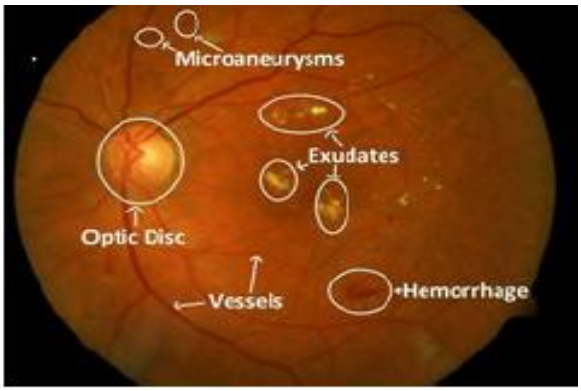


FIGURE 1: Different features of retinal images of human being eye correlated to diabetics [12].

Diabetic retinopathy is divided into numerous stages such as mild, moderate, severe, and proliferative retinopathy.

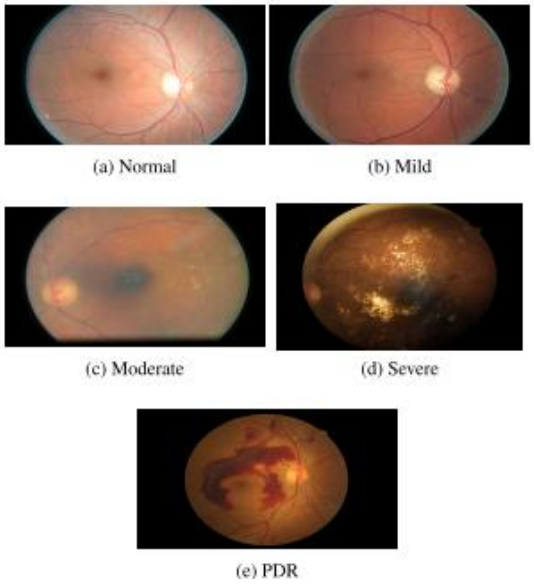


FIGURE 2: Different stages of DR [13].

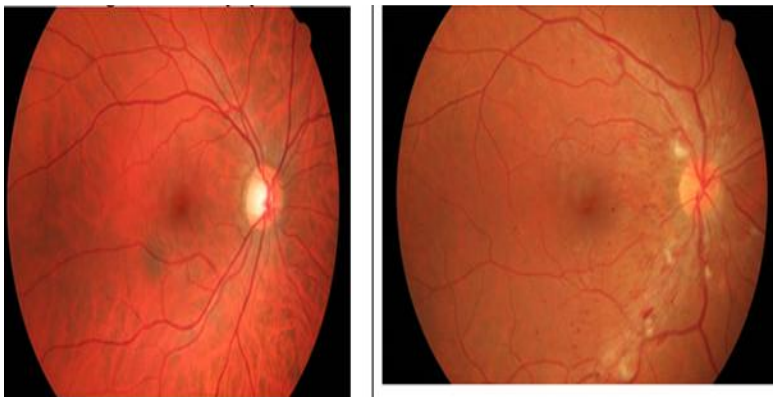
DR stage	Diagnosis	Description	Findings observed in clinics
0	No DR	Normal retina	No abnormalities
1	Mild non-proliferative retinopathy	Micro aneurysms, i.e., small bumps in the tiny blood vessels of the retina made in this stage.	Microaneurysms (MA) only.
2	Moderate non-proliferative retinopathy:	As the disease grows, some blood vessels that promote the retina are blocked.	Two or more of the following features: Microaneurysms (MA), Hard exudates (HE), Haemorrhages (H),
3	Severe non-proliferative retinopathy:	Many more blood vessels are blocked, miserly several areas of the retina of their blood supply.	20 H in for each of the four quadrants or IRMA in one quadrant or Venous beading in two quadrants.
4	Proliferative retinopathy	At this advanced stage, the vasoproliferative factors produced by the retina begin to start the growth of new blood vessels. These fresh blood vessels are fragile and abnormal.	Vitreous hemorrhage or/and Neovascularization.

TABLE 1: A short brief classification of DR based on clinical findings of the retina [14, 23].

DR types	No of MA
Normal	0
Mild	> 0 and < 5
Moderate	> 5 and < 15
Severe	> 15

TABLE 2: Table is shown below microaneurysms numbers (MA) according to their DR types [24].

(1) Proliferative retinopathy:



(a) (b)

FIGURE 3 :(a) health eye units and study area (E-ophtha database); (b) an eye with diabetic retinopathy (E-ophtha database).

In this research work, an advanced model of image enhancement comprises a Contrast Limited Adaptive Histogram Equalization (CLAHE) through morphological image processing technique. Finally, an extraction algorithm is proposed. The CLAHE is responsible for the detection and removal of the retinal optical disk. The microaneurysm initial indicators are detected by using morphological image processing techniques.

1.1. Research Question

To reach the goal of early detection of DR the following research question must be answered. The primary research question in this research paper is:

RQM. Can a mathematical morphology algorithm detect early symptoms of DR with high performance in accuracy?

1.2. Practical Implications of the research

The benefit is a contribution to the field of computer science a new algorithm proposed a new approach for having a mathematical morphology model. The target audience that can benefit from this study is medical expertise as well as patients. It will make a diagnosis of the disease in early stages as well as help the patients to understand their current diabetic situation in accuracy by using the emerging technologies.

The proposed algorithm evaluates microaneurysm detection. It shows all the stages of diabetic retinopathy with an increase in number dataset of noise in the image. An algorithm that comprises three modules will detect the noise of microaneurysms associates with stages of the retina diseases for its early diagnosis.

Experimental evaluation shows proposed algorithm is computationally fast in processing, forceful variation in image contrast and illumination. It is equivalent to the state-of-the-art methodologies in terms of measurable performance metrics. Section 2 introduces the material and method. Section 3 presents the experimental results. Finally, Section 4 highlights the conclusion.

2. THE MATERIAL AND METHOD

2.1 Related Works

The classification of DR is comprehensively studied in the literature review. The literature identified different algorithms deployed for detecting DR that achieved various results and

performances. Lately, plentiful state-of-the-art research significant to the identification of DR reported [25]. This section analyses other existing works that this research intently related, several gaps, as well as strengths of the reviewed works, shown below:

Five deep Convolution Neural networks (CNN) were employed to build a model for the referable Diabetic Retinopathy (RDR) [26]. The proposed model used Kaggle, DiaretDBI, and DiarectDB1 for training and testing, respectively. The binary classification was made as normal and mild stages for non-referable while the rest of the three-stage used as referable DR. The evaluation of the model made using binary classification. The performance of CNN attained 93.6% sensitivity and 97.6% specificity based on DiaretBD1 [27]. A novel architecture classifies the images as normal or abnormal, referable or non-referable DR proposed. The proposed architecture achieves a high AUC of normal versus abnormal and referable versus non-referable in DR task 0.978 and 0.960 respectively, and specificity is 0.5.

Three CNN models for binary classification as well as detection of DR lesions is another proposal [28]. They used Kaggle and DIaretD1 datasets for training and testing, respectively. Another research introduced a CNN model with a dropout regularization technique that trained on the Kaggle dataset and tested [29] on the DRIVE and STARE dataset while attained an accuracy of 94%. Furthermore, the CNN architecture was proposed and applied to the Kaggle dataset [30]. They added a delta value to get an equal level of brightness of the image the accuracy of the model was 74%. The CNN architecture was used for classifying five stages but could not classify the mild stage accurately, due to the nature of architecture [31]. A Method of using left and right eye images separately and applied them to different CNN models [32]. The pre-processing and augmentation phases were performed on the dataset to improve the contrast of images. The results attained 83.68% accuracy. However, in their work, they did not classify the DR stages.

A deep convolution neural network (DCNN) for just two stages of DR (normal and Non proliferative DR (NPDR)) was proposed without consideration of PDR stage [33].

They applied many pre-processing steps [34] like (median, mean, Standard deviation, etc.) after they trained the model on the training dataset. The model was able to achieve an accuracy of 89.6% by using DNN.

Hough transform as well as feature extraction method proceeded by a decision tree. [35]. The algorithm proposed [36] mainly consists of region extraction inclusive morphology, contrast normalization as well as Multimodal based modeling and classification. Their results in terms of accuracy, sensitivity as well as sensitivity 99.4%, 98.64%, and 99.69% respectively. Multiple image scales designed [37], as well as classification, provided using multiple kernel learning methods to minimize false positives of the blood vessels in the retina.

A digital image with morphological processing that consists of mathematical morphology by applying some structure element (SE) [38]; in both images, that is binary images as well as gray-level images. An automated enhancement method as well as a segmentation method for blood vessels; their method decreases the optic disk and underlines the vessels by applying morphological that rotated structuring elements to the retinal image[40]. This method has an average accuracy, sensitivity, and specificity on the DRIVE database of approximately 0.942, 0.735, 0.969, respectively. They require a combination of image processing techniques as well as data mining techniques [41] that are used to extract the required information to build a feature set for prediction in medical image analysis. A proposed network obtained complex classification rates under area accuracy of 0.984, the sensitivity of 0.958 as well as specificity of 0.974 E-optha database [42]. The tracing of exudates presence in the retinal image is been done by, blood vessels segmentation method, with the help of using morphological bottom hat transfer [47]. There is an integration of methodologies that have been proposed, for the fame as well as a decision of DR, specifically two features have been used, the sum as well as the space of MA are settled [48]. There is an intelligent system that is used to detect DR with support of a vector machine, detect DR [49]. Other studies also identify presence of DR with SVM classification

method[50]. A neural network technique has been applied to detect diabetic retinopathy [51]. Human Vision is an important feature in part of image processing [52].

After seen different researchers, that have proven their worth of using Mathematical morphology as brilliant techniques applied on blood vessels gray-scale images [39] prove that and conclude on the method has an average of 0.943,0715,0.977, accuracy, sensitivity as well as specificity respectively.

To date, many scholars have used machine learning, deep learning algorithms, to improve the performance of their works. According to [42] fifty-one (51) scholars used machine learning and deep learning-based early DR diagnosis with eighteen (18) scholars of image processing-based MA detection algorithms.

Most of these approaches in benchmark are having their advantages and disadvantages that distinguish them from others. Nevertheless, little research is based on image processing techniques. Therefore, in this paper, an advanced system with enhancement capability of the retina optical disk using morphological image processing technique and a connected component extraction algorithm is proposed. The proposed model manages to remove connected vessels by taking into account various structural elements and morphological properties. We observe many approaches lower the performance, this mainly caused of noise, to resolve those noise we perform enhancement operation. This model will add value to the MA detection and is different from the former models.

2.2 Contribution of the paper

1) The proposed algorithm enhances the Retinal image that involves background standardization by improving the contrast of an image.
2) The proposed algorithm detects and removal of retina optic disk.
3) The proposed algorithm implements morphological image processing techniques as well as a connected component extraction algorithm by removing blood vessels in operation.

3. METHODOLOGY

The proposed methodology consists of three main phases; image enhancement phase, detection as well as extraction of the optical disk phase, and morphological techniques phase. Fig 4 shows the methodology flowchart of this research. In this research image enhancement and morphology, techniques are used to conduct retinal analysis. The image enhancement process is used to enhance the contrast of the image. Afterward, mathematical morphology techniques were deployed in the optic disk of the enhancement image. This is to identify an anatomical structure such as a microaneurysm. Figure 4 depicts the following of our proposed model design in the work. First, the input image has to be transformed from RGB form into a grayscale form by using the following equation [46].

$$\text{GRAY}=(R + G + B)/3 \qquad (1)$$

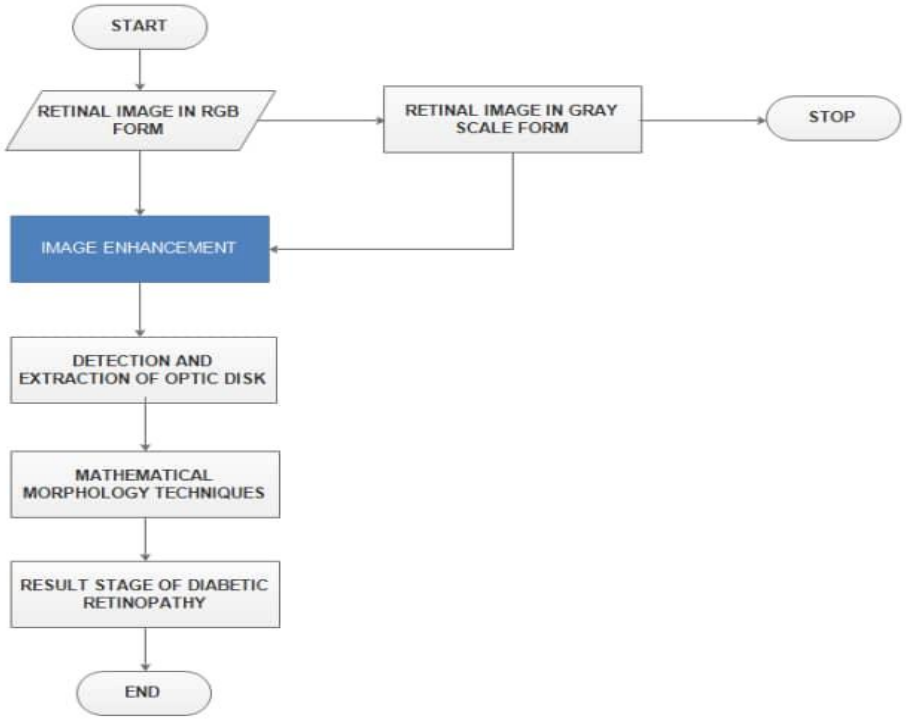


FIGURE 4: Methodology flowchart of this research.

3.1 Image Enhancement

The CLAHE is one of the enhancement techniques that improve the quality of the images. This increases the contrast in a low contrast image.

It usually operates on the small regions in the image. It uses the contrast amplification limiting procedure that happens in neighbouring pixels. Especially in the homogeneous areas to avoid any kind of noise that might happen in the image.

Detection of Optical disk

This is the process of detecting the optic disk.

Algorithm steps:

Step 1: Start

Step 2: Declare variables radius, grayimage, minlocation, maxlocation

Step 3: Read value radius

Step 4: Set radius == 100

if (radius%2==0)

r←--r

else

display ("its ok")

Step 5: Load(image, maxinlocation ,radius)

Step 6: circle (image)

Step 7: display "image"

Step 8: stop

Extraction of the Optical disk

This is the process of extracting the optic disk after detection.

Algorithm steps:

Step 1: Start

Step 2: Declare variables radius, grayimage, minlocation, maxlocation, destination

Step 3: Read value r

Step 4: if (radius%2==0)

r←--r

else

display ("its ok")

Step 5: Load (image, maxinlocation, radius)

Step 6: circle (image)

Step 7: original image copy to (destination, image)

Step 8: display "destination"

Step 9: stop

3.2 Morphological Techniques

This stage details the implementation of morphological image processing techniques.
In this case enhanced grayscale image, Dilation operation with linear structure element. It is used through the help of mathematical morphology algorithms that are connected component extraction algorithm.

Algorithm: Removing a connected component.
This is the process of removing connected components (connected blood vessels) in the optic disk after detection.

Algorithm steps:

Step 1: Start

Step 2: Declare variable Point A, Y, B

Step 3: Read Set at Point A.

Step 4: Assuming Y= connected components in set A

Step 5: Extract all connected point in set A belongs to Y

$$X_k = (X_{k-1}B) \oplus \cap A. \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

i. *Has to be computed in various steps*

ii. *Where B is the structuring element*

Step 6: The algorithm will terminate when we nd out Xk = Xk−1

Step 7: Y = Xk

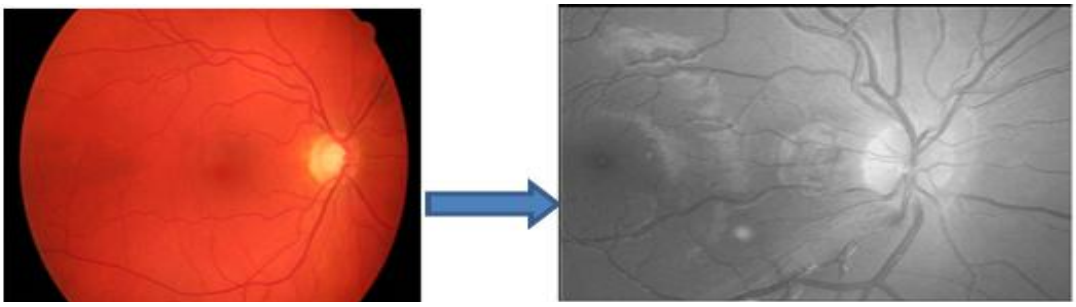
Step 8: Stop

4. EXPERIMENTAL RESULTS

4.1 Healthy Eye and Diabetic Retinopathy Eye

Figure 5 depicts the model to read both normal and abnormal retina observed. The input retinal image in RGB forms has converted into a grayscale image. An image converted to the red channel, green channel as well as blue channel.

To extract red channels and blue channels then the background plane, as well as retinal blood vessels, get brighter. This becomes too dark for the retinal images. Then the green channel s used only to increase the contrast between the background planes with the retinal blood vessels.

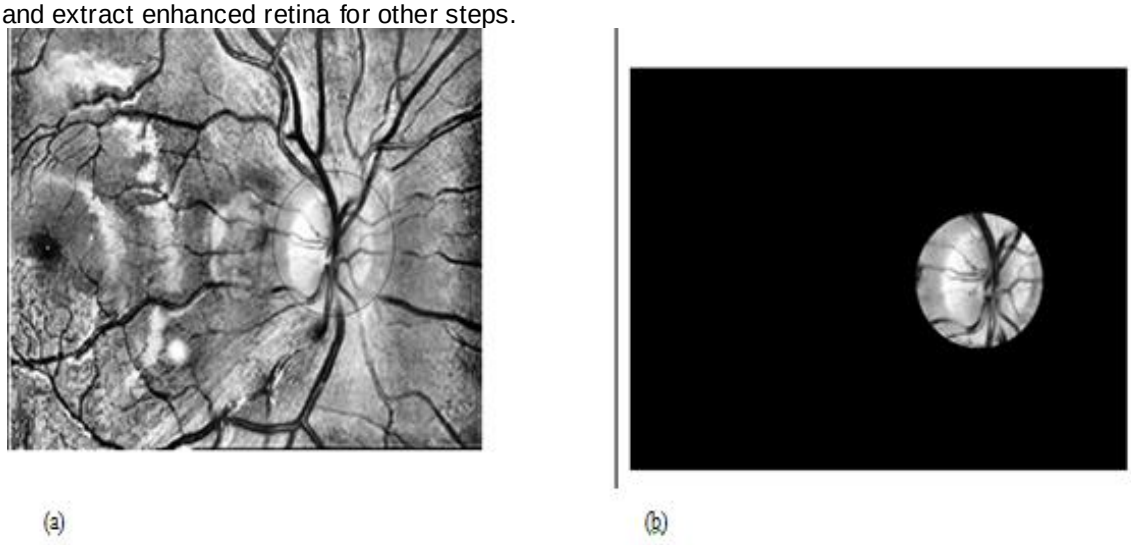


(a) (b)

FIGURE 5: (a) Showing Retinal image in RGB form (E-ophtha database); (b) Showing a Retinal image in Grayscale form (paper).

4.2 Enhancement by using CLAHE

A diagnosed image is enhanced using CLAHE so that can get clear blood vessels after to detect and extract enhanced retina for other steps.



(a) (b)

FIGURE 6 :(a) Showing Enhancement of retina as well as to detect its optic disk; (b) Showing an extract optic disk in enhancement retina.

4.3 Morphological Operations

Figure 7 shows the Mathematical Morphology operations used. The structural elements are determined using prior heuristic knowledge of enhancement retina images. The enhanced image undergoes several morphological openings by using structuring elements to eliminate the vessels. Different structural as well as morphological properties of vessels occupied into account for successfully extracting the retinal vessels skeleton in this stated approach. The performance of the morphological operation is contingent greatly on the size as well as shape of the SE. Mathematical morphology is a method for extracting geometrical structures from signals based on set theory [45].

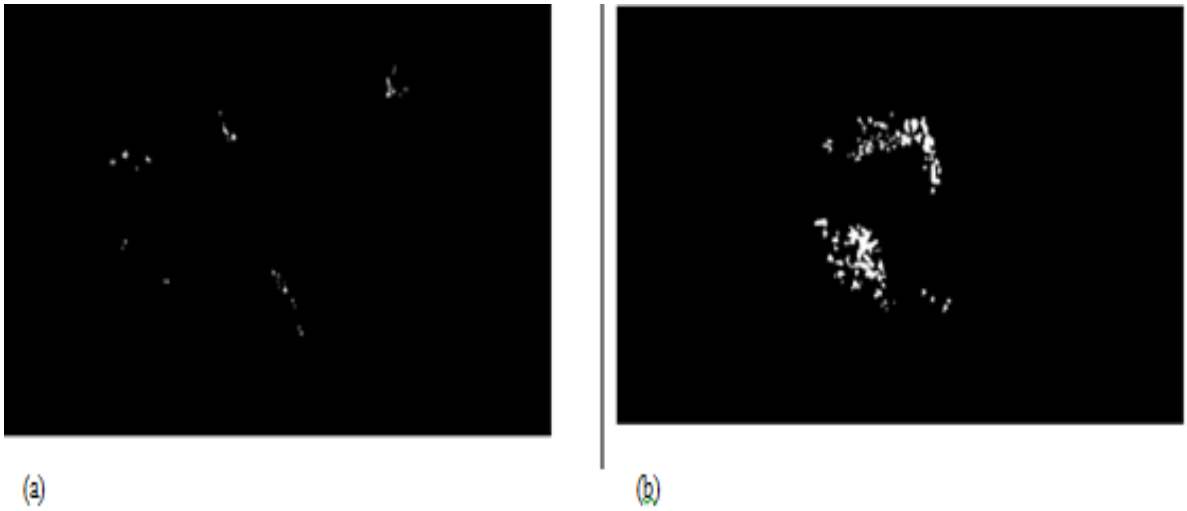


FIGURE 7: Image obtained after Mathematical morphology operations (a) Showing mild stage of diabetic retinopathy; (b) Showing moderate stage of diabetic retinopathy.

The performance of this approach on the E-ophtha database compared to different approaches. Table 3 illustrates the performance of our approach against the above approaches on the E-ophtha dataset.

Approach	Accuracy
Memon, et al [27]	74%
Dutta ,et al [31]	89.6%
Akram M U et al [36]	99.4%
M.S. Miri and A. Mahloojifar [39]	94.3%
Y. Hou [40]	94.2%
Shilpa Joshi & P. T. Karule [42]	92%
Selçuk T, Alkan[43]	93%
Our approach	99.7%

TABLE 3: Area Accuracy performance of proposed algorithm with benchmark algorithm in detecting microaneurysms (MAs) by using E-ophtha database.

The specific graph for detecting micronrurms for E-optha database, the graphs shows the area accuracy of different images that are used in terms of sensitivity as well as specificity.

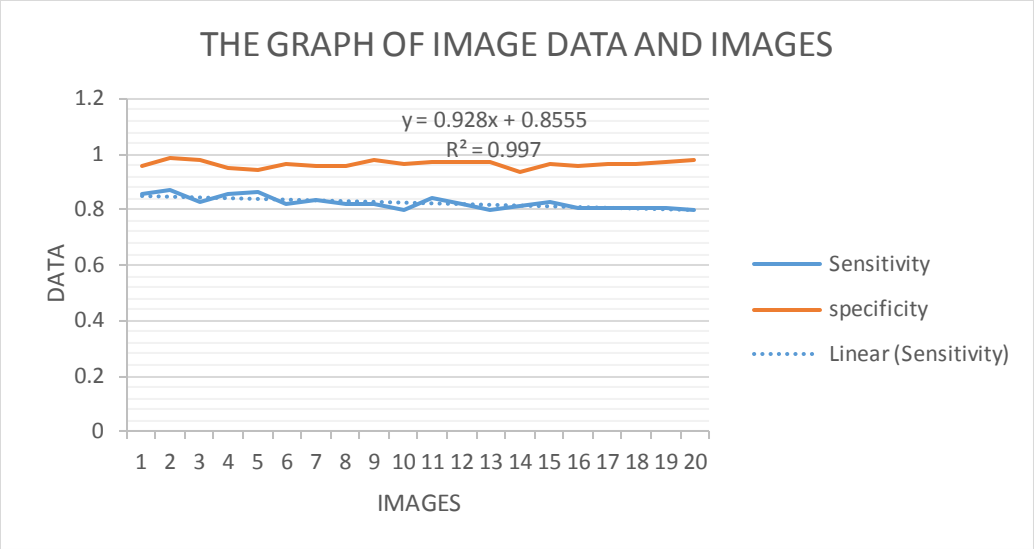


FIGURE 8: Accuracy graph of different images used concerning sensitivity as well as specificity.

The accuracy depends significantly on the sensitivity as well as specificity of an experiment. An experiment that has high specificity and sensitivity with a low rate of false positives and false negatives has higher accuracy.

The proposed approach reaches better accuracy equating with the approaches that implement morphological processing. Based on the results above prove that this method produces as good results and very effective.

5. CONCLUSION

An advanced model of image enhancement comprised of a CLAHE through morphological image processing technique for early detection of DR presented shows accurate results for the data used in our model. An enhancement of the retinal image involves background standardization by improving the contrast of an image. Precise detection and removal of retina optic disk of a retina for both normal and abnormal were successfully determined. Abnormal retina images, the microaneurysms were detected and shown in different stages with the help of structure morphology techniques, and blood vessels removed in the optic disk image by morphological opening by reform using multi-structure elements. The high ability of CLAHE for retinal image contrast improved and make it better for other essential steps.

The structure morphology of using multi-structure elements scratches increases the accuracy of this model by 99.7% in terms of sensitivity as well as specificity. Since microaneurysms (MA) are one of the main symptoms of diabetic retinopathy then through Mathematical Morphology within retinal images an early detection was observed.

6. ACKNOWLEDGMENTS

Authors thank the inventors of the E-ophtha database for making the image database simply available.

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A Smart Receptionist Implementing Facial Recognition and Voice Interaction

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Abstract

The purpose of this research is to implement a smart receptionist system with facial recognition and voice interaction using deep learning. The facial recognition component is implemented using real time image processing techniques, and it can be used to learn new faces as well as detect and recognize existing faces. The first time a customer uses this system, it will take the person's facial data to create a unique user facial model, and this model will be triggered if the person comes the second time. The recognition is done in real time and after which voice interaction will be applied. Voice interaction is used to provide a life-like human communication and improve user experience. Our proposed smart receptionist system could be integrated into the self check-in kiosks deployed in hospitals or smart buildings to streamline the user recognition process and provide customized user interactions. This system could also be used in smart home environment where smart cameras have been deployed and voice assistants are in place.

Keywords: Face Recognition, Deep Learning, Django Framework, Image Processing.

1. INTRODUCTION

The tasks of a receptionist depend on the sector he/she works in and automation of such a job can be in high demand in hotels, commercial complexes or even for security purposes in certain organizations. Considering a hotel room reservation system, a receptionist needs to interact with the customers, getting his/her information, identification, booking and payment of the rooms, etc. Further, in businesses, scheduling appointments with individuals can be automated where security is an important factor to be considered and these systems can be strengthened by imposing features such as facial recognition, voice interaction and server-side security such that this automation that would help making the tasks of a receptionist system more secure and reliable to recognize and interact efficiently with the customers. The process of accepting, addressing and guiding the customers' needs can be done easily such that the users have no inconvenience to be recognized by the automated receptionist system.

Authentication is necessary in order to implement security and present systems allow for some methods to incorporate authentication. Traditional systems use either biometric authentication or non-biometric authentication. Non-biometric authentication allows for the use of physical objects such as a swiping card or a key. These systems are further classified into object-based authentication or knowledge-based authentication. They also allow for the use of passkeys,

tokens, PINS, etc which are prone to be guessed or accessed by attackers. In order to overcome these limitations posed by non-biometric authentication systems, modern systems now use more advanced authentication systems that implement Biometric authentication systems. These systems allow identification of an individual through physiological traits and real-time behaviour which makes the passkey unique. These kind of authentication systems include fingerprints, retina scans, electronic signature, voice or face recognition, which are difficult to imitate or be stolen or duplicated by attackers as they're unique to that user.

Face recognition has gained a lot of popularity in implementing secure systems and have been constantly in use to improve the accuracy of the systems. This is done to tackle the challenging tasks because most methods don't really provide a robust solution to different situations. Example of these simulations include different expressions, pose invariants, lighting variations, etc. Furthermore, capturing real-time face recognition has a higher overhead computational cost when it is implemented with Deep Convolutions Neural Networks.

With advancements in technology, machine learning is now covering vast areas of application fields wherein implementations of certain algorithms allow for systems to be more discrete, secure and time saving to automate a lot of different sectors. The accuracy and easy deployment of these algorithms are the main reasons why these systems are trusted in many fields and require less manpower. The vast areas of application include automatic driving and self-transportation vehicles, smart gaming and other entertainment systems, healthcare, home business security, etc. These systems take in a lot of raw data that and process it to generate desirable outputs. They learn by repeatedly processing the information and use that experience to make the systems better.

FIGURE 1: Face Recognition Parameters.

One major application is facial recognition that is used in security systems and business companies where certain algorithms can detect the face of an individual, store the data and learn them, and later use the data mining techniques to identify that individual. It is a way to recognize the human face by using certain biometrics to map the different facial features as depicted in Figure 1 and compare them with all the other existing faces in the database to find a match. In business organizations, facial recognition can be used as a security feature, as well as identifying individuals to automate the task of receiving the clients data and proceeding them to their required destination. For a commercial complex or office system, a smart receptionist system can capture the data of the customers and interact with them. This reduce the need of manpower, time, and money. Unlike humans who need to look up for the records, smart receptionists can store large amounts of data in their database and use the machine learning techniques to identify the individuals faster and more efficient.

2. RELATED WORK

Face recognition has been a booming topic in the field of automating certain tasks in establishments and smart receptionist implement several different algorithms and systems to execute efficient reception tasks. In a research done by Hteik et al. [1], face recognition was executed by using a MATLAB program on a PC where the access control is done by a microcontroller. The system that is used in [1] is less efficient as modern-day systems require faster response and interaction, more accuracy, and better security.

In the papers written by Salvador and Foresti [2], facial recognition was done by implementing Regularized Linear Discriminant method that only captures frontal facial data by assuming that user cooperation is present. This might not be the case in every situation and to allow for little or no inconvenience it is more acceptable to have a more robust and dynamic method to have a quick scan of the whole picture in lesser time.

Rohit et al. developed their system [3] using IoT devices by integrating Raspberry Pi to detect a person coming at a door. This allows for efficient face detection but has a higher response time due to the lag that is generated from using IoT devices.

[4] describes their design and implementation of a smart e-receptionist that can greet visitors and talk to them with natural language understanding. However, it can only sense a nearby visitor through motion detection, it doesn't have the capability of recognizing a user, which we have via facial recognition and can thus provide more customized interactions.

An interactive robot receptionist system was proposed and designed in [5] that is able to provide directional guidance using physical gestures and answer simple questions with speech recognition. Similarly, a smart humanoid receptionist was developed in [6] using WeegreeOne robot that is connected to several IoT sensors, camera, databases and AI services to enable the functionalities of user recognition and voice interaction. They tested their humanoid receptionist in a smart office environment and demonstrated its effectiveness.

In [7], the authors proposed a cloud-based robot receptionist that works in a home environment to provide both reception and home assistance. The authors in [8] focus on helping the receptionist to gain context-aware capability and to interact with people in a natural way.

Hwang et al. [9] focused on the dialog system in human robot interaction, and proposed a recurrent neural network based dialog system. Their proposed system has been validated in the context of hospital receptionist and their evaluation result shows it is able to efficiently choose responses and gestures to welcome and help check-in users.

In this work, our main focus is on facial recognition based user authentication and voice interaction part of a smart receptionist. The chatting, conversation and question understanding part could be implemented using Google Dialogflow service [10] or word embedding algorithms such as bert or word2vec [11][12].

3. METHODOLOGY

Our goal is to build a system that manages users who login with a face ID using facial recognition concepts of machine learning. We have created a web application that can be set up in offices or business establishments, or even at a certain individual's reception who might have to schedule meetings with other people. The system would recognize people who have already visited the office. For a person who is visiting the first time, the system asks the user to feed in his/her information. Then, the next time the user makes a visit, the system uses the user stored data to recognize the user.

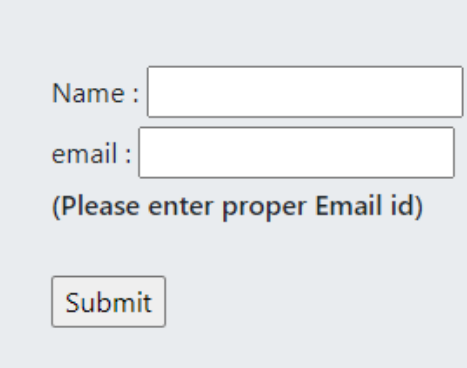

FIGURE 2: User details for first time users.

Our smart reception system uses facial recognition that allows the user to log in to the system with his/her facial ID which is unique to user. We have implemented different concepts of machine learning to perform deep facial recognition using certain libraries in python which will be discussed later. To be specific, we have used python's libraries that implement OpenCV that uses a form of deep Convolutional Neural Networks to allow for a deeper scan of the picture in real time which can scan all sides including frontal and the sides. Our system takes care of the limitations of existing system and is relatively more accurate.

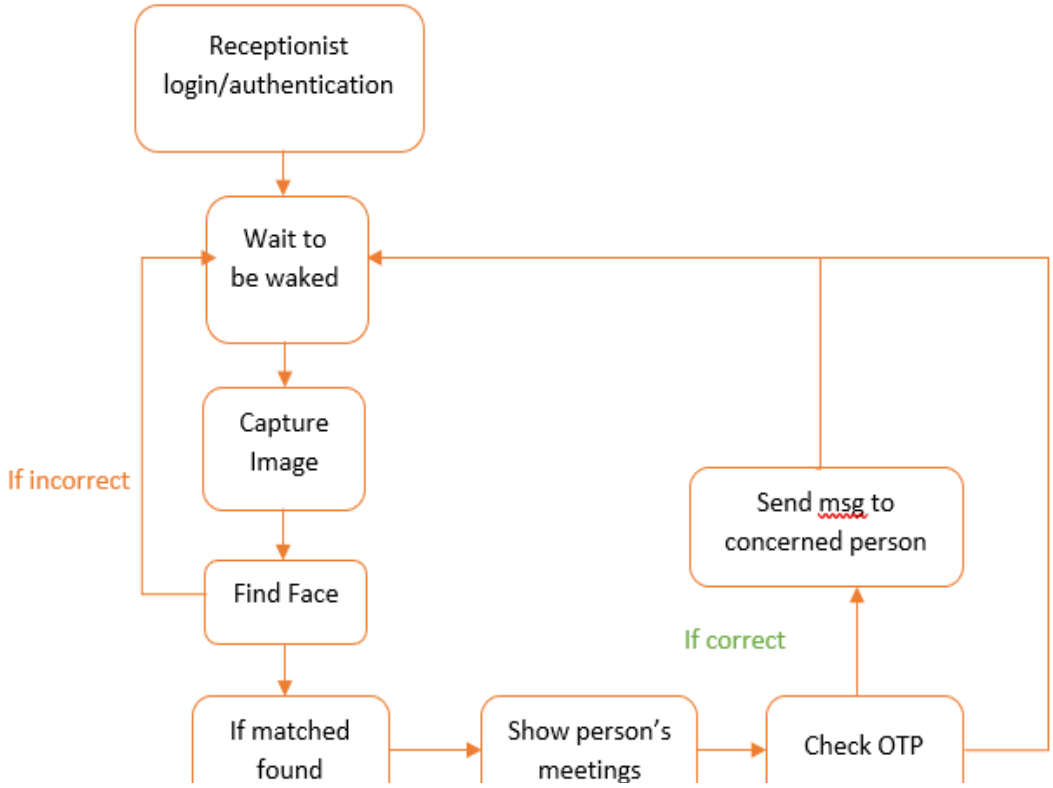

FIGURE 3: System Workflow.

This system can be enhanced further to add other essential tasks of a smart receptionist and thereby creating a perfect application that can be used in large scale commercial complexes. Our system is embedded in a GUI that gives reliability for both client and server side. Figure 2 shows the login page where one can log in as a user or the manager. The manager is the one who manages the Reception.

3.1 Basic Workflow

Figure 3 shows the detailed outline of the system workflow. The system will have the Receptionist's 'Wake me Up' module for a user to come up and use it to record the user face. The steps include:

a. A user clicks on the button that initializes the face recognition. For first time users, the system asks for the name and email address as shown in Figure 2.
b. The manager will then be able to schedule new meetings with that new user or other users as shown in Figure 4.

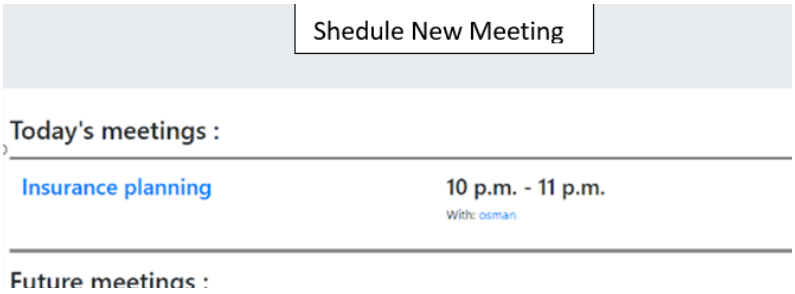

FIGURE 4: List of Meetings.

c. The manager then schedules a new meeting adding necessary details and the user will be able to view the same as in Figure 5.

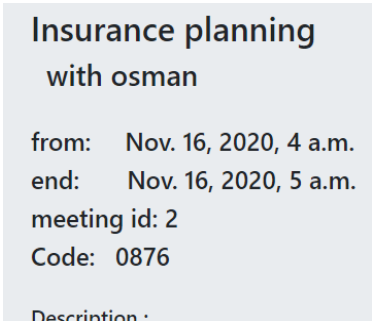

FIGURE 5: Meeting Details.

d. User receives an email with a code from the manager along with meeting details.
e. User logs in the system again using face recognition that opens the page where he/she enters that code in the system, where the receptionist asks the user to click on a button and enter the meeting ID by giving audio input of the meeting ID.
f. After the user speaks the id, the receptionist again asks the user to enter the meeting code, again giving audio input of that code.
g. If the code is correct, the receptionist sends an alert to the manager saying that the user has arrived, and the manager can authorize that meeting.
h. Finally, the receptionist tells the user to proceed and attend the meeting.

3.2 System Architecture

Figure 6 shows the system architecture of our web application. The back-end system is based on the Django Framework [13] for developing web applications with python. This facilitates for robust and simple managing of the different sections in the entire system. In a system where we need to work with a larger dataset, Django allows for the efficient managing and creating faster access to each of these items whilst managing the whole application with the database. Django uses a system called "Models" that are used to handle the database.

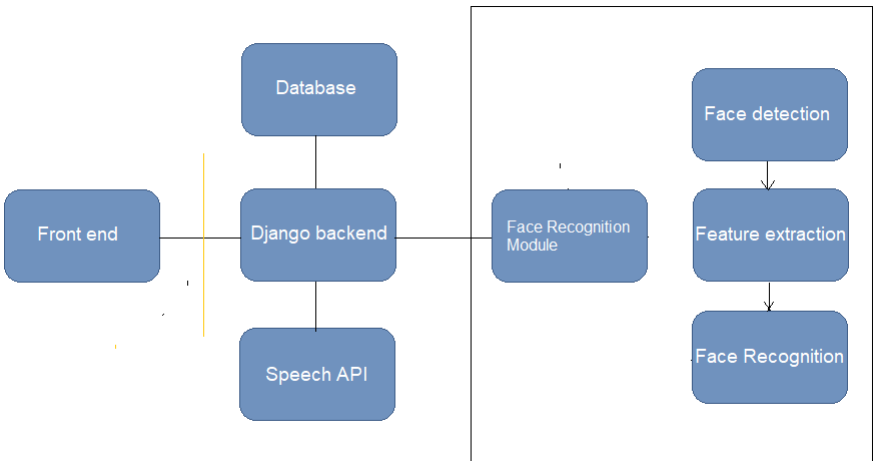

FIGURE 6: System Architecture.

"Models" is a single entity that defines all our information for a field related to a particular dataset. It consists of the important fields and behavioural aspects of our data that we have been storing and maps each of those to a single database table. Every python class is basically a model that has necessary subclasses and different attributes related to it. Combining the models gives a layout of the entire system connecting our database to the web application. With these Models, we can create new tables in the database, and therefore calling models as objects to add rows in the tables of the database.

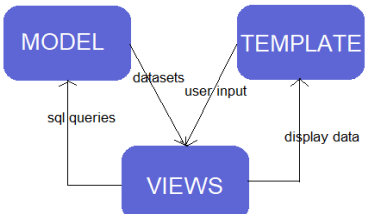

FIGURE 7: Django Framework.

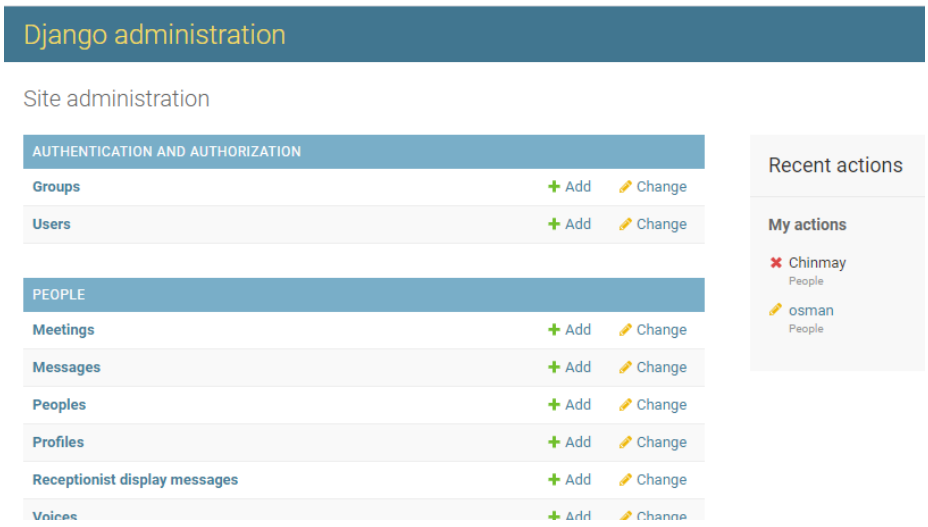

FIGURE 8: Admin page backend.

Views in this framework are the logic layers for business models. Hence it is well suited for our application that allows to process the input given by a user and sends back the necessary valid response. The system takes in the input and fetches the required data from the database and sends an output onto the screen. In our application, each page is a different view that has its own GUI to interact with the user such as adding his/her name, email id, and the necessary meeting details. These entities are all connected to allow for a dynamic managing of different sections of the system as shown in Figure 7.

We have written the backend system in python programming language due to its ease of use and compatibility with the Django framework. Python has built-in libraries that we have used for our face recognition feature, as well as the voice automation. The libraries will be discussed in the subsequent sections. Figure 8 shows how admin side is managed with the help of Django to keep track of all the users and sections in the system.

The voice recognition module has been implemented with python's built-in library based on gTTS that is "Google's text to speech" library that allows us to interface with "Google Translating text to speech" and gives us a vocal speech output. For database management, we have used SQLite which is a widely used highly reliable and self-contained database engine that is well suited to work with the Django Framework.

4. IMPLEMENTATION

In this system, we have used different python libraries with implementation of OpenCV that uses deep neural network that allows us to exploit the face recognition module. We have used the Convolutional Neural Networks (CNN) to extract the key and essential components of images that have been taken as the input without any pre-processing of the raw images. CNN also has the potential to recognize patterns that have different geometrical variations such as rotations in the image, scaling, noise, etc.

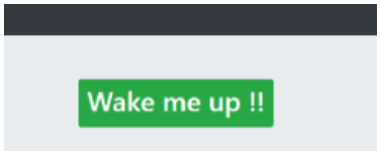

FIGURE 9: Initializing Face Recognition button.

Convolutional Neural Networks reduce the training performance of the traditionally used Back propagation (BP) algorithm [14] by reducing the number of learning parameters in that process to avoid any required pre-processing. The network relationship in CNNs are spatial that allows for the minimizing the pre-processing. Figure 9 is the homepage that initializes the face recognition algorithm on clicking the 'wake me up' button.

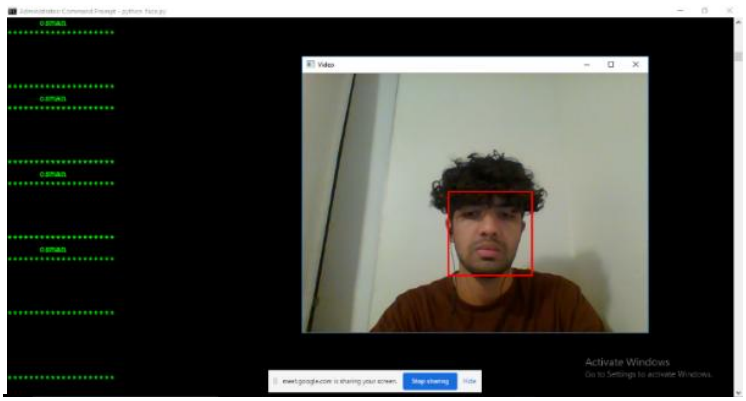

FIGURE 10: Face Recognition with python.

In addition, the main reason for implementation of CNNs is to capture 3D image recognition in all angles and directions, whereas traditional systems using HOG (Histogram of Oriented Gradients) [15] or Regularized Linear Discriminant Analysis (R-LDAs) [16][17] rely mostly on frontal face detection. To make our system more user friendly, we have used the libraries in python that allows for reading and capturing of faces laid in all axis, doing the translations and the rotations as shown in Figure 10.

```
class AddPeople:
    def add(self):
        #os.chdir("..\FaceRecognition\people")
        people_path = os.path.join(BASEDIR,'people','FaceRecognition','people')
        os.chdir(people_path)
        #print('base',os.getcwd())
        people_list = os.listdir()
        #print('list', people_list)
        known_face_encodings = []

        known_face_names = []

        print('Started encoding',os.getcwd())

        for i in people_list:

            img = face_recognition.load_image_file(i)

            encoded_array = face_recognition.face_encodings(img)[0]
            # print('shape',encoded_array.shape)
            encoded_list = encoded_array.tolist()
            known_face_encodings.append(encoded_array)
            name = (i.split('.'))[0]
            known_face_names.append(name)
```

FIGURE 11: Encoding Faces.

Figure 11 shows a block of code where we have performed the face encoding of some people for whom we were able to deploy the system to. We can use CNNs through OpenCV to train the system to generate 128 measurements for each of the faces. Then for all the people with different measurements, the neural network learns to generate 128 measurements for each person. Next, we run our face images through our pre-trained network to get the 128 measurements for each face and we can generate a string or array for each face that contains the encoded list. Therefore, at the end, each face (or person) has its unique string with its encoded array.

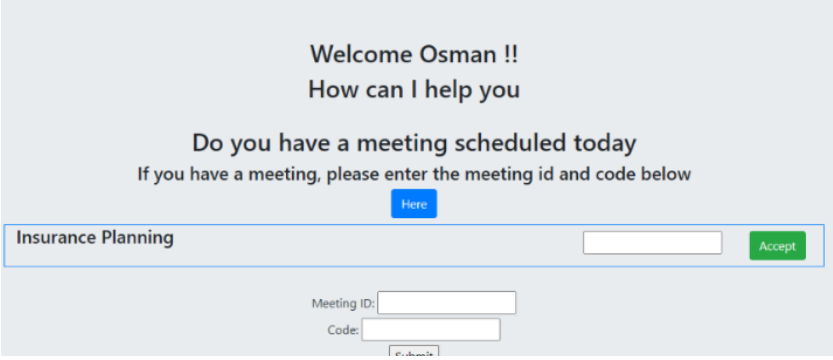

FIGURE 12: View Page after Authentication.

4.1 Receptionist Task

The main task of the smart receptionist in our system is to accept incoming users, record their faces and ask for their names and email address.

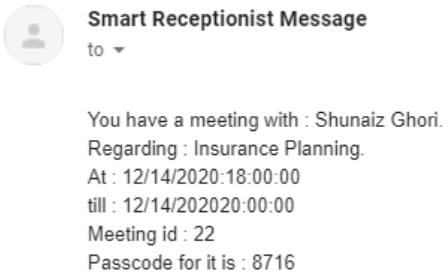

FIGURE 13: One-time Code sent via email to User.

When a user logs in for the second time, the system identfies the image of the user by comparing the existing data in the database. The system search the individual and checks if the user has any meeting (Figure 12).

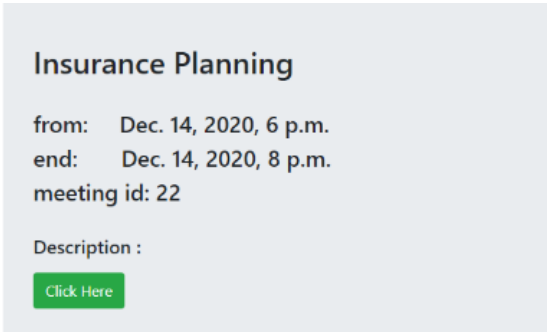

Figure 14: Voice Input for Meeting ID and Code

Next, the receptionist generates a one time code after the manager schedules a meeting. The code is sent to the user's email address (See Figure 13) that he/she had entered. The message includes details of the meeting including the time and the description of the meeting. The user will use the code in that email and enter it in the system as shown in Figure 14 in order to aunthenticate himself for that specific meeting.

FIGURE 15: Alert to Manager.

FIGURE 16: Testing.

The receptionist then tells the user to proceed for the meeting, after the manager approves the alert (Figure 15) that was sent to user when the suer had arrived. This is the basic task of the receptionist that we have implemented in this system. Many other functionalities can be added later as the future work.

4.2 Results

We have deployed the application to about 40 different individuals who were able to log into the system after feeding in their facial data, and storing their name and email address into the database. We have allowed them to enter their first image with a regular face. Later, we have tested the accuracy of the system by having them face the camera wearing sunglasses, or hats as we seen in Figure 16. The system was able to detect the faces of those individuals. Each facial data was unique and did not overlap with any of the other data.

For each of the individuals, we were able to record their faces in different lighting and backgrounds and the system was able to recognize and authenticate that individual as well as welcoming the person with his/her name. The model has an accuracy of 99.38% for the face recognition module.

5. CONCLUSION

The smart receptionist system allows for an efficient, robust and dynamic use of the face recognition and voice interaction modules as well as providing an easy GUI that would allow users to come in and authenticate themselves and schedule meetings.

The smart receptionist system can be further enhanced by adding advanced facial recognition to avoid existing security issues. Furthermore, voice automation can be improved by creating a more dynamic interaction between the user and the receptionist to have a proper conversation between the two. It is also possible to assign more tasks to the receptionist. Receptionists in the existing system, are capable of scheduling meetings, and few other minor jobs. The front-end of our application is built on HTML, CSS and Bootstrap, and future work would include refining it to a more dynamic application with buttons and drop-down menus depending on the added tasks of the receptionist. Further, we have used the webcam in laptop HP EliteBook, and future implementations would be extended over to use Raspberry Pi, or other IoT devices.

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