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Hybrid Algorithm Developmental Strategies For Eye Disease Detection in Human Beings Using MLT Using Local Binary Pattern For The Extraction Of Features From Image Texture For Obtaining of Cup & Disc Ratio (CDR) For Moderate Case

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Abstract—In this research paper, we present the hybrid algorithm developmental strategies for eye disease detection in human beings using MLT using local multi-level binary pattern (LMBP) for the detection of disease using cup and disc ratio (CDR) for moderate disease along with its simulation results. This work explores hybrid algorithm development strategies aimed at improving the detection of chronic diseases in humans by leveraging machine learning techniques (MLT) and advanced image processing. Specifically, the approach utilizes the Local Binary Pattern (LBP) method for extracting detailed texture features from medical images, with a focus on identifying the cup and disc regions—crucial for assessing the Cup-to-Disc Ratio (CDR), an important biomarker in ophthalmology. By integrating LBP-based texture extraction with robust machine learning models, the proposed framework enhances the accuracy and reliability of chronic disease diagnostics, paving the way for more effective, automated screening processes in clinical settings. This fusion of feature extraction and data-driven analysis demonstrates significant promise in advancing early detection and management of various chronic conditions.

Keywords—Hybrid Algorithm, Chronic Disease Detection, Machine Learning Techniques (MLT), Local Binary Pattern (LBP), Feature Extraction, Image Texture Analysis, Cup and Disc Segmentation, Cup-to-Disc Ratio (CDR), Ophthalmology, Medical Image Processing, Automated Screening, Diagnostic Accuracy, Early Disease Detection, Computer-Aided Diagnosis, Biomedical Engineering.

I. INTRODUCTION

The human eye forms one of the vital organs of the body. The eye always plays a vital role in our daily life ; as without eyes, the whole world would be dark & performance of the daily routine works would be very difficult. In the sense, without sight, it would be very difficult for any person to do any activity (reading, writing, working, studying, etc...). There are various reasons for the loss of vision/sight in the human eyes. Hence, blindness has to be avoided in the human eyes as the most precious human organ is solely responsible for the vision. One of the causes for blindness & loss of vision in the eyes is due to different types of diseases that occurs in the eyes because of various factors. One such disease which is caused due to vision loss is the 'Glaucoma'.

'Glaucoma' is a silent killer thief of sight which is responsible for the loss of vision in the human eyes due to the increase of pressure, which damages the optic nerves leading to permanent blindness, i.e., loss of vision. This disease occurs from the new born to the age old ones. Even though this glaucoma disease is fully not curable, its growth & symptoms can be controlled. So, we have to detect the glaucoma disease at an early stage so that this detection process forms a proper intimation to the person, once the person comes to know that he/she is affected with the disease, further precautionary measure could be taken from the doctors & proper diagnosis could be done and the further loss of vision could be controlled.

There are a number of conventional methods for the detection of glaucoma, but many of them are quite expensive (many people cannot afford) as they are using the modern tools & requirement of skilled and

trained personnels for the diagnosis. Many types of glaucoma exists such as primary, secondary, neovascular, pigmentary, congenital, etc..... In the work considered, we have tried to cover up all the types of glaucomatic diseases. Many works have been proposed on glaucoma detection by various researchers till date. Majority of the researchers had worked on the base issues of the disease. Nearly 140 references are being cited in the thesis report, of course 1000s of papers were collected before finalizing the research topic.

II. MOTIVATION & PROBLEM STATEMENT

After studying the importance of eye, its disease, and rectification from various papers related to the glaucoma and understanding their drawbacks such as good accuracy, longer execution time, failure of some of the methodologies, not considering other parts of the eye, the issue of glaucoma detection was considered for the research. Methodologies were proposed, algorithm were developed for the rectification of the same through algorithm development in Matlab. In this context, a large number of research papers were collected from various sources in the chosen field, studied & the problem was being finally defined.

Likewise, because of the present activities (current responsibilities) taken up by the state & the national government in the field of the health sector and every person giving more importance to the eye, this had additionally motivated us to take up the work in the vision loss in human beings. This issue has made us to study the importance of vision loss & identify the problem w.r.t. the loss of vision due to the glaucoma ailment as w/o eye sight, there would be no life.

Therefore, in continuity & motivation obtained w.r.t. the ongoing research work, an in-depth survey was conducted and a number of algorithms was proposed (software implementation in Matlab) to detect the glaucoma disease by automatic means in the form of a GUI. Finally, the problem was defined stating as "Hybrid algorithm developmental strategies for eye disease detection in human beings using MLT using local multi-level binary pattern (LMBP) for the detection of disease using cup and disc ratio (CDR) for moderate disease", which was coined as the research problem statement.

III. REVIEW OF LITERATURE

Various analysts, researchers, creators, scientists, engineers have taken an in-depth look at the determination, diagnosis & detection of glaucomatic diseases in various sorts of fundus pictures using hybrid imaging strategies till date (both at the investigation level & at the hospital or clinical levels). To start with, 1000's of research papers were collected/gathered from various sources, studied @ length & breadth and some review/survey papers were published. Consequently, a comprehensive review of the ongoing works done by different writers/researchers over the globe done till date was carried out in this exciting & application oriented bio-medical field of glaucoma detection in the form of an abridged literature survey, which was presented well in this paper [1]-[75].

In a bigger piece of the work done by a large number of researchers, analysts, engineers, scientists, authors and creators, there were a number of drawbacks, inconveniences, downsides, lacunas. Some of the above mentioned drawbacks which were existing in the works done by the earlier researchers were imbibed in the work considered by us and novel algos were developed in order to overcome some of the deficiencies of the existing algos and also to detect the normal & unhealthy glaucomatic image's full diameter of the cup & disc so that accurate results are obtained [1]-[75].

The research work was examined / validated by observing the results of the simulation done in the Matlab environment by developed .m codes incorporating all the concepts of medical imagining, thus substantiating the research problem undertaken in comparison with the works developed by the earlier authors w.r.t. the glaucoma field, in the sense to solve the desired objective (question) & arrive at the outcome (answer/solution) of the research work [1]-[75].

In this particular paragraph, a short audit/survey of the related info w.r.t. the detection of glaucoma is being presented. In this context, it has to be noted that the glaucoma is relating to the IOP of the aqueous liquid flowing in the eye channels & the parametric ratio w.r.t. the cup & disc, commonly known as the Cup-to-Disc-Ratio & abbreviated as CDR. In the human healthy eye, constraints like fluid present in the eye and which leaves through eyes drainage system should be in balanced way (inlet & outlet pressure should be the same) [1]-[75].

Improper functioning of drainage system in the eye or balance between two constraints doesn't functions properly ends with increased pressure of the aqueous fluid which causes a major injury/damage to optic nerve head, which results in the variation of the cup & disc's area. So, the primary feature is considering only the cup to disk ratio in the detection of glaucomatic disease. This glaucoma occurs in humans because of the increase in the intraocular pressure in the human eyes in which the cup and disc area increases, relating to the variation in the values of the CDR [1]-[75].

This CDR value for the healthy eye is within 0.1 - 0.4 range, whereas for the glaucomatic eye, the range varies from 0.4 - 1.0 (moderate & severe case). In the glaucomatic detection, the method of measuring the cup to disc ratio is being considered (even though there are quite a no. of methods) as the main parameter in the research. An hybrid algorithm developed using the concept of LBP (local binary pattern) is proposed in the research work, where the severity of the disease could be detected, viz., normal, moderate & severe. The input fundus images were taken from the standard database & from reputed hospitals in the country, which was serving as the input to the algorithm that are being developed for the glaucoma detection. For the computation of the CDR value, once the features (area, diameter) of the OD & the OC are obtained, the cup to disc ratio of the ROI considered in that particular fundus image is calculated using the relation given by

$$CDR = \frac{OC_{v\ dia}}{OD_{v\ dia}}$$

A set of 60 images was used as the input to the hybrid algorithm. Finally, it was observed that the proposed methodology when compared with the work done by other others was supposed to be the best method (more data points) for the same image, which could be seen from the simulation results. Note that this work is being tested both for healthy & un-healthy images present in the DB.

IV. OBJECTIVE / AIM OF THE RESEARCH WORK

The research that was taken up by myself under the guidance of my supervisor was aimed to develop sophisticated medical image processing algos for detecting the glaucoma disease in the case of normal & unhealthy human beings, which was our main desired objective using a hybrid algorithm consisting of many processes. The main objective of the research work is to develop a hybrid method by using some novel algorithms for the detection of glaucoma through estimation of CDR in different types of fundus images (healthy and unhealthy images) & we combine the following algorithms to develop a hybrid method for glaucoma detection, some of the objectives (main 6 objectives) that are going to be met are

- Use of local binary pattern for the extraction of feature that is image texture for extraction of cup and disc
- Use of local multilevel binary pattern for the better texture analysis
- Use of multilevel wavelet feature
- Use of principle component analysis
- Use of grey level occurrence matrix
- Use of k-NN classifier to finally classify the image as glaucomatic or not.

By combining all the above, we can get more accurate results. The concept of hybridization is as follows. For example, algorithm 1 has got some 80% advantages & 20% disadvantages and algorithm 2 has got 80% disadvantages & 20% advantages. If we club both the algorithms 1 & 2 and make a hybrid algorithm, then the hybrid algorithm will be having the 80% advantages of algorithm 1 and 20% advantages of algorithm 2 so that our hybrid algorithm will be 100% efficient. This is the main need for hybridization & this is done in order to increase the efficiency of the process.

In this paper, we solve the first objective, i.e., the use of local binary pattern (LBP) for the extraction of feature that is image texture for extraction of cup and disc, do the simulation & observe the results.

V. PROCESS METHODOLOGY

The above mentioned objective of our research work is achieved using the following steps.

- Images of both healthy and unhealthy of human eyes are collected.
- Large number of images (database collection) from various image database and hospitals.
- Using state of art techniques appropriate images is been prepared.
- Performing image pre-processing which includes image enhancement, increase in luminance of an image and segmentation.
- Region of interest is been identified and marked where the features are being extracted.
- Preparing and extracting of features vectors from the previous step.
- Diagnosis of eye glaucoma by comparing of data base feature vector and currently obtained feature vector is made.
- Detection of the disease is done with the comparision.

In short, to say, the main aim of our research work that is undertaken by me under the guidance of my supervisor is aimed to develop sophisticated medical image processing algorithms for the detection of

glaucoma in the case of normal & affected human beings, which is our main desired objective for the detection of the disease.

VI. OUTCOME OF THE RESEARCH WORK

The final result or the outcome or the end-result of the research topic will be aimed to develop couple fast & efficient algos for the automatic detection of glaucoma eye disease. The main outcome being, when the designed algorithm/s are run with the input given (fundus image-healthy or un-healthy), the automatic detection of glaucoma is done with minimum computational time in comparison with the work done by the other researchers till date taking into consideration many of the drawbacks of the fellow researchers, thus enhancing and improving the performance of the existing algorithms using hybrid combination of the proposed algorithms and also because of the hybridization concept, the algorithm will become more efficient.

VII. PROPOSED BLOCK DIAGRAM

The overall proposed block diagram w.r.t. the software implementation of the glaucoma detection proceeds is presented in shown in Fig. 1. Also, a brief exhaustive review of each and every block is being presented with its functionality & it has to be noted that the entire detection process is divided into 3 stages, viz., stage-I, stage-II & stage-III to arrive at the end product after stage-III, i.e., glaucoma detection.

Block-1 : The i/p to the algorithm proposed is the fundus pictures obtained from the database in which we have taken 60 image collection from various sources (we have created our own database).

Block-2 : From the fundus database, the inputted fundus image from the block – 1 is selected to determine whether it is affected with glaucoma or not affected.

Block-3 : Pre-processing of the fundus image is carried out next, where all the noises are removed and a noise free image is obtained.

Block-4 : Segmentation of the pre-processed image is carried out here in order to find the region of interest, i.e., the cup and the disc.

Block-5 : The Region of Interest, i.e., RoI which is the area of optical cup and area of optical disc will have to be extracted & are nothing but the RoI features, which is done using the hybrid concepts of LBP & LMBP algorithm, the output of which gives the entire features of the ROI.

Block-6 : At long last, the outcomes are processed utilizing the cup to the disc areas (which is the output of block - 5), using the hybrid combination of 3-level discrete wavelet transform and the principal component analysis.

Block-7 : The output of the block-6 is given as input to block 7, where the process is further refined using the concepts of gray level co-occurrence matrix in order to obtain the statistical texture features

Block-8 : Here, the ratio of the cup to disc is calculated using the formula

$$CDR = \frac{A_{cup}}{A_{disc}}$$

Block-9 : The output of block-8 is given as input to the k-NN classifier, where the inputted & processed image is classified into healthy ones (normal) or unhealthy ones (moderate / severe) ones depending upon the cup to disc ratio, if the ratio is < 0.4, it is classified as normal case, if it falls in between 0.4 & 0.6, it is classified as moderate & if it is > 0.6, it is treated as a severe case.

Block-10: Here, all the inputted images from the block-1 statistics are obtained where we can find how many are affected & how many are not affected.

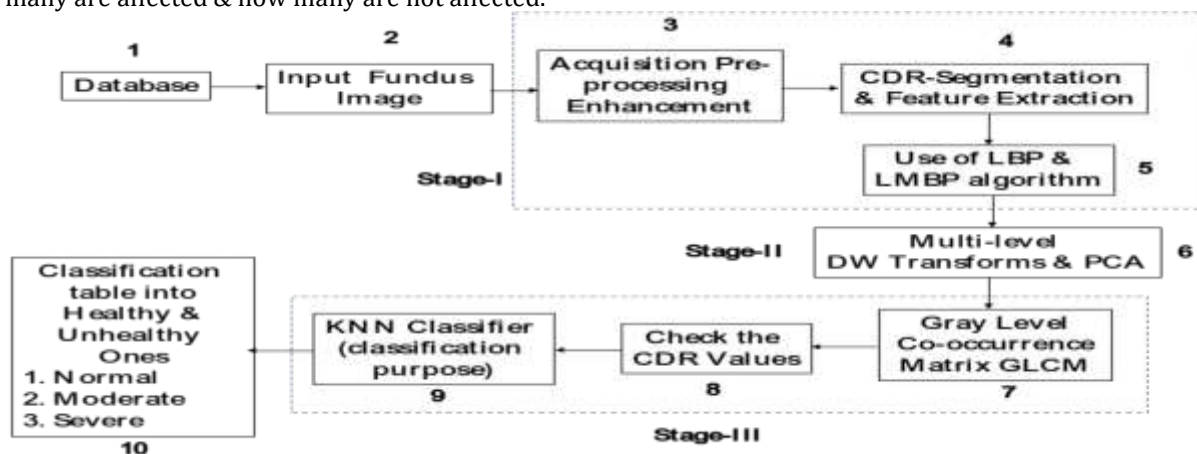


Fig. 1. Proposed block-diagram of the hybrid representation of glaucoma detection for solving the use of local binary pattern for the extraction of feature that is image texture for extraction of cup and disc

VIII. SOFTWARE USED

Matlab is the tool that is used for the software implementation process in our research along with various tool boxes such as IP tool box, DSP tool box, etc... Coding (programs) are developed as .m files, the developed codes are run after giving the fundus image as the input and the results are observed from which the glaucoma detection can be traced, i.e., whether the patient is affected with glaucoma or not.

IX. DATABASE COLLECTION

In order to build the algo., the 1st fundamental step is to acquire the databases of the images from a standard available datasets (may be from on-line or from hospitals). Thus, 60 fundus pictures (obtained from the fundus camera & stored in the database) were accumulated from different on-line datasets out of which, few pics were from the (HRF) - High Resolution Fundus image DB (www.optic-disc.org) also, remaining images were obtained from on-line database called as 'DROINS' and the left over from the IIT-Drishti website and a folder was made called as 'fundus DB', which was used as the input images to all the hybrid algorithm that was developed in this thesis. Few high resolution pictures were taken from the on-line database DRIONS, which consisted of a large number of fundus pictures obtained from the fundus camera. Few images were taken from hospitals.

X. SIMULATION RESULTS

A program (.m code) along with subroutines & function calls is developed using the Matlab tool & the developed main program is run for different fundus images as the input & the results are observed for the first case of glaucoma, viz., normal case (case-1), for the set-1 image. To start with fundus images, viz., image_1.jpeg, image_2.jpeg & image_3.jpeg from the set 1 are given as inputs to the created hybrid algorithm one after other & the simulations results are observed as normal, moderate & severe. Once the OC & OD area is extracted using the process of segmentation, then the cup-disc ratio is calculated from the Matlab code using an equation.

Essentially, the investigation is completed for the remaining 51 pictures (27 sets) which are available in the considered database & finally, the quantitative results (numerical values) are tabulated. From this observation, it can be inferred that out of 60 images taken from the database, 12 were normal, 23 were moderate & the rest 25 were severe case of glaucoma, thus resulting in $48/60 = 94\%$ glaucoma affectedness. In this synopsis, only one set of results is presented, say set-1 consisting of 3 images & the remaining are now shown here for the sake of convenience.

The main application of this research work is to create an awareness in the rural sector, say, a medical team goes to a village where 60 villagers are there to find out the healthy & unhealthy condition of the eyes and all of them are subjected to test & out them (moderate -23 + severe -25), 48 people were affected with the disease. This is just a information given to those 30 people that they are affected with the disease & they have to go for further treatment or follow up in order to avoid further loss of vision.

We have tabulated the values of the CDR and the classification of all the 60 images that were present in the fundus database as moderate severe or the normal glaucoma and the proposed works are compared with the work done by others, which is showing more number of data points & thus our work is supposed more profound and accurate compared to the work done by others as shown in the Fig. No. 2.

XI. MATLAB OUTPUTS

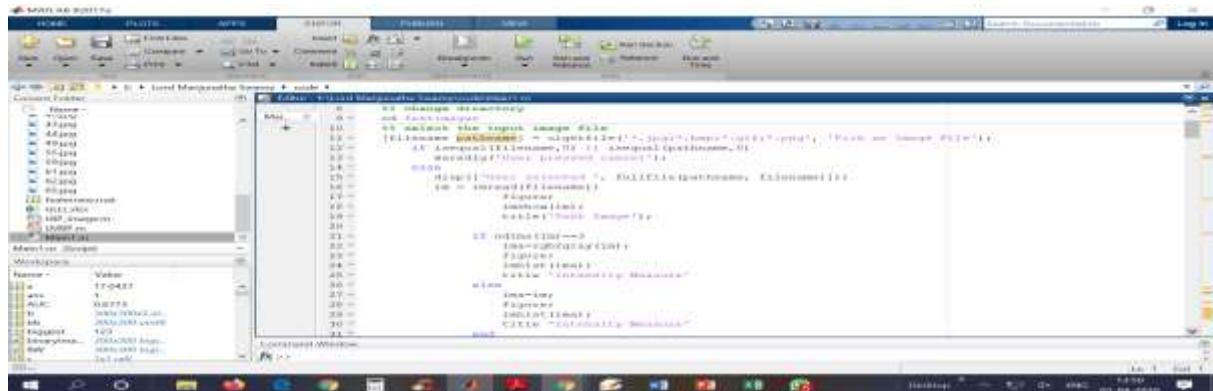


Fig. 2. Matlab file showing the hybrid algorithm

XII. PROCESSES FOR SET – 1 & CASE – 1 : IMAGE_1

The following processes are to be carried out for one set of image from the database.

The Processes for Set – 1 & Case – 2 : image_3

Set – 1 : image_2

Case 2 : Simulation results showing the moderate glaucoma



Fig. 3.: Test sample

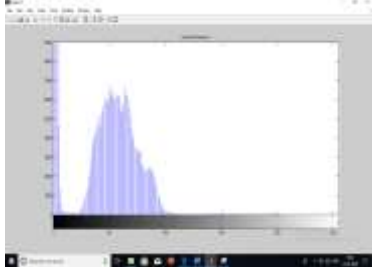


Fig. 4.: Histogram output

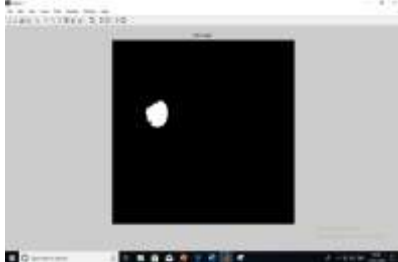


Fig. 5.: Disc image

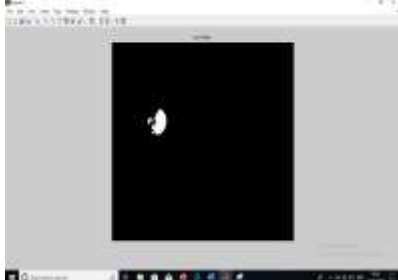


Fig. 6.: Cup image



Fig. 7.: The boundary of the disc

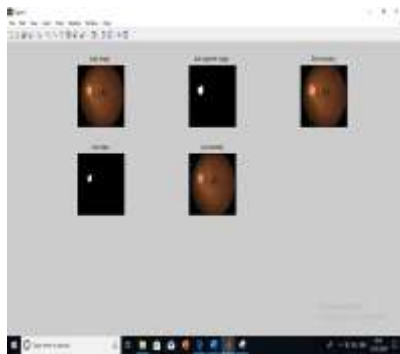


Fig. 8. : Extracted features

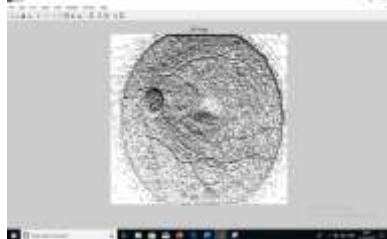


Fig. 9. : The LBP image



Fig. 10. : The LMBP image



Fig. 11. : First level wavelet

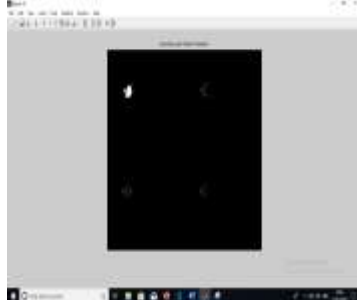


Fig. 12. : Second level wavelet

Fig. 13. : Third level wavelet

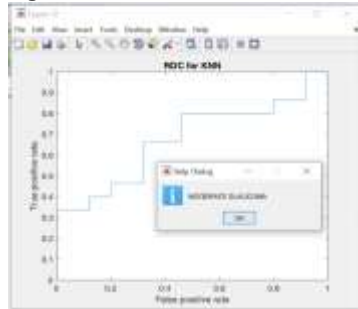


Fig. 14. : OC of true positives and false positives



Fig. 15. : Command window output - Command window output for moderate glaucoma (showing det = 2)
Here, the cup to disc ratio is 0.571792, so it is the case of the moderate glaucoma and also the det is found to be 2.

From the Fig. 14 & 15, we can come to a conclusion that the image inputted is moderate case of glaucoma disease.

XIII. RESULTS & DISCUSSIONS

In this section, we present the concise result (outcome or the end-result), i.e., the simulation results w.r.t. the software implementation of the glaucoma detection work done. Research was carried out on the development of bio medical image processing algorithms w.r.t. the diagnosis & detection of the glaucomatic disease in human beings. To start with, an extensive background research was carried out on the chosen research topic. A number of reference text books, conference & journal research papers which covered the basic & fundamental concepts relating to the theoretical aspects, practical aspects, hospital aspects and w.r.t. the implementation point of view were collected and a brief study was carried out.

This was carried out from various sources from library, NITs, IITs, NCET, RRCE, Different deemed universities, Different college libraries, Various R & D centres of VTU across the state, hospitals, earlier researchers, friend circles, who had done similar research works. This literature review was carried for a period of more than 6 months and finally summarized to get a conceptual view. This was followed by the taking of the written test, interview, taking of the course work subjects & clearing with good grade (marks). After collecting lot of research materials on the chosen topic and defining the problem, the problem solving methodologies of the chosen problem/s was formulated, simulations were carried out, obtained the results and the proposed works being published in reputed conferences & journals with high impact factors. Exhaustive audit of the research findings which was relating to the work taken up by me w.r.t. the field of the detection of glaucoma in the human beings using hybrid algorithms was explained in an abridged form of the literature review along with an introductory information related to the research work in the introductory chapter.

The research problem which was defined as the research problem statement, "Development of novel & hybrid algorithms in medical imaging for the detection of glaucoma disease in human beings" was successfully tackled upon with & solved thus meeting the set objectives which were obtained as the outcomes.

An aggregate of 1 contributory works (LMBP) were taken up & completed over the duration of the full time research work undertaken in this exciting field of glaucoma detection in this research paper. All the images that were considered as the input for the simulation purposes were taken from the standard databases available on the internet and from the hospitals.

XIV. CONCLUSIONS

To conclude, a concise survey of the research related to the task pointed out in this research work was delineated in the past segments as presentations. The target of the venture work was likewise investigated by developing a hybrid algorithm and implementing in the Matlab tool. Algorithms like LBP (Local binary

pattern), were used to form a hybrid method so the disadvantages of one method can be overcome by the other in order to get accurate results. The simulation results presented in the related section shows the effectiveness of the proposed method.

The application of this research work carried out is the research work can be implemented in the public places and as it is very affordable it can be made available to all the sections of the society. It can be accessible to all the public so that it can be used as a precautionary and the person detected with glaucoma can approach the medical help at the starting stages itself as the disease is symptomless in the beginning. And it would be great help to the rural areas where the people will be unaware of the disease and as they would have the good medical facility to get regular check-ups. Glaucoma can be detected early so that the loss of vision can be prevented.

XV. SCOPE FOR FUTURE WORKS

In some of the future works, the future work can be incorporated with artificial intelligence to classify other abnormalities of the eye as well. It can also be designed to generate a report by itself with full information of the patient so that it can be used for telemedicine purpose. Considering hybridization method has a great accuracy as compared to the individual algorithms used. Computers already using artificial intelligence (AI) have equalled dermatologists in diagnosing skin cancer and nearly matched retina specialists in recognizing diabetic retinopathy from fundus images.

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