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New Proposed Methodologies for Detection of Eye Diseases in Human Beings using HDL, Modelsim Matlab, Python & Tensor Flow w.r.t. the Bio-Medical Image Processing Point of View

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***Abstract*—**In this research paper, the proposed methodologies for glaucoma detection are presented using different hardware & software tools.

Keywords—*Glaucoma, Eye, Block-Diagram, Disease, Normal, Affected, Blocks, Pressure, Proposed, Comparision.*

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I. INTRODUCTION

Glaucoma is a complex disease in which damage to the optic nerve leads to progressive, irreversible vision loss. Glaucoma is the second leading cause of blindness. Glaucoma is usually described as a disease affecting peripheral vision [1].

So, it wouldn't have any effect on reading, the ultimate task of central vision, right? In fact, glaucoma does affect reading. Why? First, while glaucoma does affect peripheral vision, it also affects central vision as shown in the Fig. 1 [2].

Glaucoma patients with moderate or severe disease often describe looking through a fog which extends into their central vision. Because of this fogging, people with glaucoma recognize fewer letters in one glance. They must therefore look at text more times to make their way through a passage. The result is slower reading and particular difficulty with longer words [3]-[10].

Second, reading also brings in one's mid-peripheral vision. For example, we use our field of view when moving from the end of one line to the start of a new line of text, or when searching a page of information for the specific details we wish to learn about. Glaucoma patients have particular difficulty with these aspects of reading [11]-[20].

In this research paper, the proposed methodologies for glaucoma detection are presented in the form of a block-diagram for glaucoma detection. In the glaucoma case of disease detection, 4 approaches (contributions) were proposed, which are depicted below one after the other in the form of a block-diagram (DFD) along with its working [21]-[30].

Fig. 1 : Loss of vision due to Glaucoma

1. **#C1 :** Detection of glaucoma using watershed algorithm (Fig. 2).
2. **#C2 :** Detection of glaucoma using histogram of gradients & SVM (Fig. 3).
3. **#C3 :** Detection of glaucoma using genetic algorithm & SVM (Fig. 4).
4. **#C4 :** Detection of glaucoma using ANN / CNNs (Fig. 5.

The above mentioned approaches of *glaucoma* detection are well explained in a very highly abstracted manner with various blocks as follows one after the other [31]-[40].

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Contribution 1 : The input to the proposed algo is the images taken from the database (block-1). Then, the input image is pre-processed (block-2) & further the edges are detected (block-3). Segmentation process is carried out next to extract the cup & disc using the proposed & revised watershed algorithm (block-4). Features of the ROI (cup & disc) is extracted & classification process is carried out next (block-5). Finally, the results are computed using the cup to disc ratio (block-6), from which it can detected whether the patient is affected with glaucoma or not using the value of CDR (block-7). ……. Fig. 2 [41]-[43]

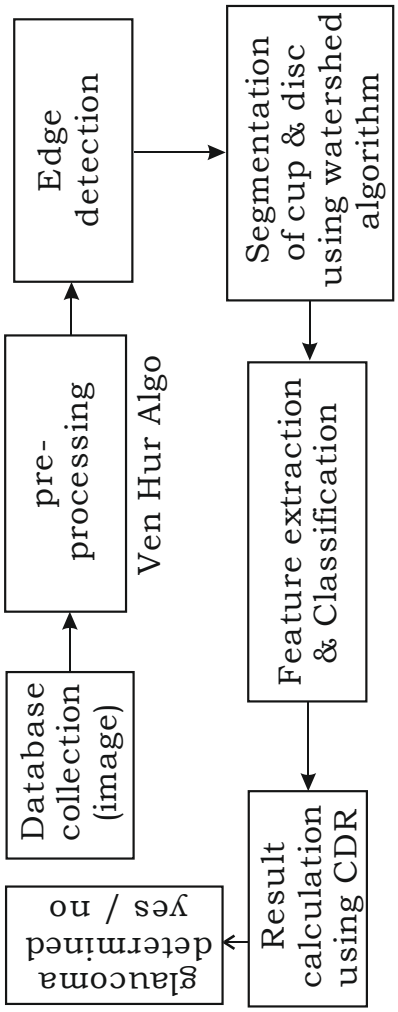

Fig. 2 : Block-diagram of glaucoma detection using watershed algorithm

Contribution 2 : The input to the proposed algo is the images taken from the database (block-1). Then, the input image is pre-processed using the Gabor filters (block-2) & further the edges are detected (block-3). Segmentation process is carried out next to extract the cup & disc using the histogram equalization method (block-4). Features of the ROI (cup & disc) is extracted & classification process is carried out next (block-5) using the HOG & SVM method respectively. Finally, the results are computed using the cup to disc ratio (block-6), from which it can detected whether the patient is affected with glaucoma or not using the value of CDR (block-7).. …. Fig. 3.

Contribution 3 : The input to the proposed algo is the images taken from the database (block-1). Then, the input image is pre-processed & further the edges are segmented (block-2), smoothened & detected (block-3). Feature extraction is carried out next to extract the cup & disc using the genetic algorithm (block-4). The classification process is carried out next using the SVM method (block-5). Finally, the results are computed using the cup to disc ratio (block-6), from which it can detected whether the patient is affected with glaucoma or not using the value of CDR (block-7).. ……. Fig. 4 [44]-[48]

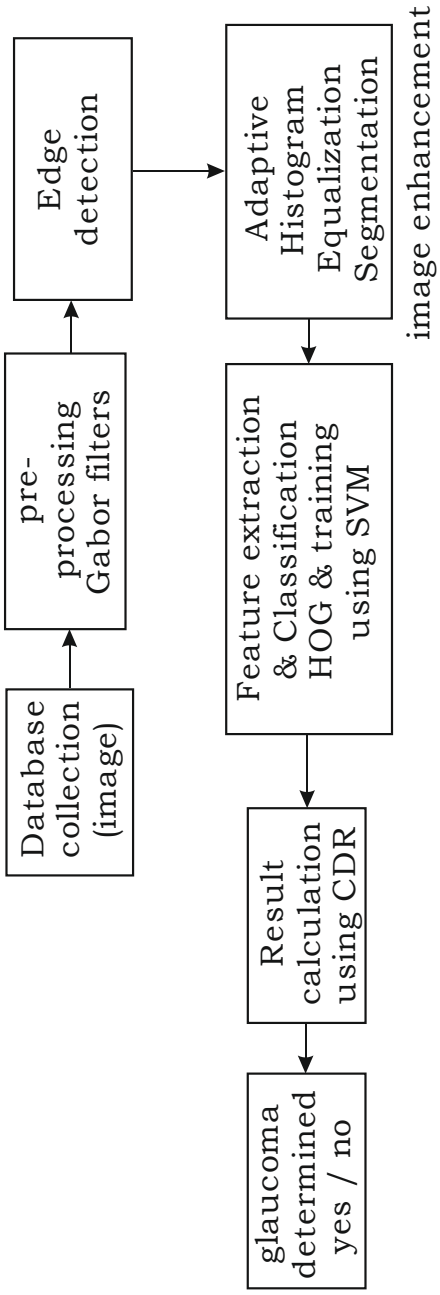

Fig. 3 : Block-diagram of glaucoma detection using HOG with SVM algorithm

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Contribution 4 : The input to the proposed algo is the images taken from the database (block-1). Then, the input image is pre-processed & further the edges are detected (block-2), segmentation & smoothening is done next (block-3). Feature extraction is carried out next to extract the cup & disc using the convolution neural networks (block-4). The classification & the training process is also carried out using the CNNs (block-5). Finally, the results are computed using which it can detected whether the patient is affected with glaucoma or not (block-6).. ……. Fig. 5 [49]-[50]

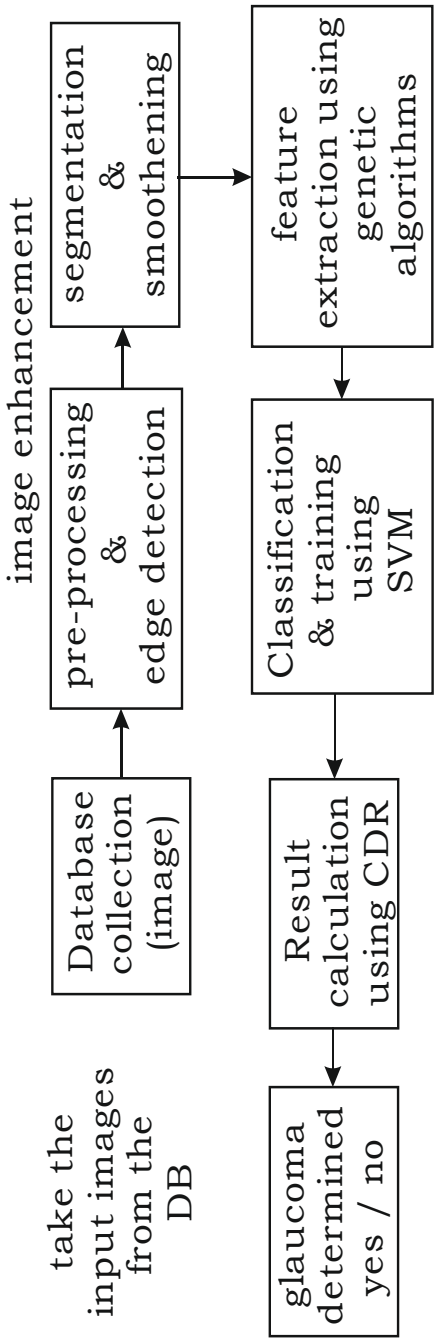

Fig. 4 : Block-diagram of glaucoma detection using genetic algorithm with SVM

II. Hardware & Software Tools Used For Research Work

In this section, we present the various tools that are used for the detection of glaucoma in our research work.

HDL : This is used for the detection of glaucoma w.r.t. contribution 1. Hardware description language (HDL) is a specialized computer language used to program electronic and digital logic circuits. The structure, operation and design of the circuits are programmable using HDL. HDL includes a textual description language consisting of operators, expressions, statements, inputs and outputs. Instead of generating a computer executable file, the HDL compilers provide a gate map. The gate map obtained is then downloaded to the programming device to check the operations of the desired circuit. The language helps to describe any digital circuit in the form of structural, behavioral and gate level and it is found to be an excellent programming language for FPGAs and CPLDs.

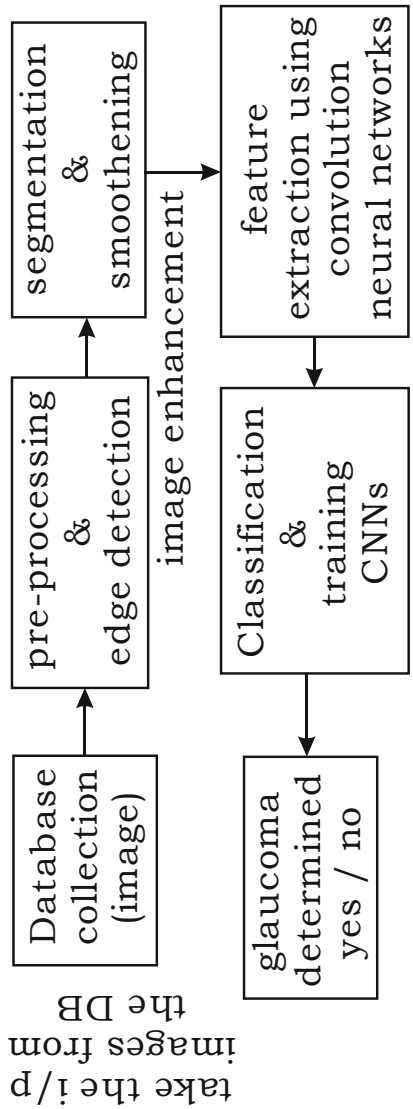

Fig. 5 : Block-diagram of glaucoma detection using convolution neural networks

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The three common HDLs are Verilog, VHDL, and SystemC. Of these, SystemC is the newest. The HDLs will allow fast design & better verification. In most of the industries, Verilog and VHDL are common. Verilog, one of the main Hardware Description Language standardized as IEEE 1364 is used for designing all types of circuits. It consists of modules and the language allows Behavioral, Dataflow and Structural Description. VHDL (Very High Speed Integrated Circuit Hardware Description Language) is standardized by IEEE1164. The design is composed of entities consisting of multiple architectures. SystemC is a language that consist a set of C++classes and macros. It allows electronic system level and transaction modelling.

The software tool that is used for the research work is Matlab & various tool boxes such as image processing tool box, signal processing 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.

ModelSim : This is used for the detection of glaucoma w.r.t. contribution 1 & this modelsim is a multi-language HDL simulation environment by Mentor Graphics, for simulation of hardware description languages such as VHDL, Verilog and SystemC, and includes a built-in C debugger. ModelSim can be used independently, or in conjunction with Intel Quartus Prime, Xilinx ISE or Xilinx Vivado. Simulation is performed using the graphical user interface (GUI), or automatically using scripts. In addition to supporting standard HDLs, ModelSim increases design quality and debug productivity. ModelSim's award-winning Single Kernel Simulator (SKS) technology enables transparent mixing of VHDL and Verilog in one design. Its architecture allows platform-independent compile with the outstanding performance of native compiled code. This language is used for glaucoma detection in C1. HDL Coder provides a workflow advisor that automates the programming of Xilinx® and Intel® FPGAs. You can control HDL architecture and implementation, highlight critical paths, and generate hardware resource utilization estimates. HDL Coder provides traceability between your Simulink model and the generated Verilog and VHDL code, enabling code verification for high-integrity applications adhering to DO-254 and other standards.

MATLAB® : This is used for the detection of glaucoma w.r.t. contribution 2 & 3 and this Matlab. is a programming platform designed specifically for engineers and scientists. The heart of MATLAB is the MATLAB language, a matrix-based language allowing the most natural expression of computational mathematics. The language, apps and built-in math functions enable the user to quickly explore multiple approaches to arrive at a solution. MATLAB lets you take your ideas from research to production by deploying to enterprise applications and embedded devices as well as integrating with Simulink® and Model-Based Design.

Image Processing Toolbox™ provides a comprehensive set of reference-standard algorithms and workflow apps for image processing, analysis, visualization, and algorithm development. You can perform image segmentation, image enhancement, noise reduction, geometric transformations, image registration, and 3D image processing. Matlab is used for C2 & C3.

Python : is an interpreted high-level programming language for general-purpose programming. Created by Guido van Rossum and first released in 1991, Python has a design philosophy that emphasizes code readability, notably using significant whitespace. It provides constructs that enable clear programming on both small and large scales. Python features a dynamic type system and automatic memory management. It supports multiple programming paradigms, including object-oriented, imperative, functional and procedural and has a large and comprehensive standard library. This language is used for CNNs in glaucoma detection. This is used for the detection of glaucoma w.r.t. contribution 4.

TensorFlow : is an open source software library for numerical computation using data-flow graphs. It was originally developed by the Google Brain Team within Google's Machine Intelligence research organization for machine learning and deep neural networks research, but the system is general enough to be applicable in a wide variety of other domains as well. It reached version 1.0 in February 2017, and has continued rapid development, with 21,000+ commits thus far, many from outside contributors. This article introduces TensorFlow, its open source community and ecosystem, and highlights some interesting TensorFlow open sourced models. This language is used for CNNs in glaucoma detection in C4.

III. CONCLUSIONS

In this section, we present the brief outcome, i.e., the conclusions about the research work done in this exciting field of biomedical engineering, i.e., the disease detection in the eyes using novel concepts. We also presented the various tools that were being used for performing the simulations in the research work.

Research was carried out on the development of bio-medical image processing algorithms for the automatic detection of glaucoma. To start with, an extensive research was carried out on the chosen research topic. During this period, reference books and conference papers covering the fundamental theoretical concepts which would be a background for the research work were collected & studied. Hundreds of related research papers were collected from

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various sources such as …. internet, library, several IITs, NITs, IISc., Deemed Universities, Different college libraries, DSCE library, Research Center of VTU-Belgaum, Different engineering college libraries, VTU Belgaum Library, from friends, earlier researchers who have done similar work, etc…. This literature review was carried for a period of more than 6 months and finally summarized to get a conceptual view and was also being published as a review paper in a reputed IEEE conference.

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. A brief review of the work related to the research work undertaken w.r.t. the detection of glaucoma was presented in the form of an abridged literature survey along with an introductory information related to the research work & in the chapter on literature survey. The objectives of the research work was also explored and arrived at the definition of the problem that had to be tackled with and solved.

A total of 4 contributory works were carried out during the course of the research work till date in the field of glaucoma detection. 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. A total of 60 images was taken and a database was created, which was used for the simulation and training purposes. Four works were proposed for the detection of the glaucoma using watershed algorithm, histogram of gradients, genetic algorithms & using convolution neural networks.

Codes were developed for all the 4 contributory works, the program was run & the results were observed for various cases healthy-normal (non-glaucomatic), unhealthy-moderate, severe (glaucomatic). It has to be noted in this context that CDR concept was used for the glaucoma detection. It can be concluded that for all the 4 cases, a total of 60 images were considered from the database for the simulation purposes and the comparision of the performance characteristics is shown in the table 1.

In the first case, HDL codes were developed in the Xilinx environment w.r.t. the FPGA and good results were obtained. In the second case, histogram of gradients was used for glaucoma detection with the classification done using support vector method, which gave promising results. In the third case, genetic algorithm was used for the detection along with the classification done using support vector method, again which yielded good results. Finally, the convolution neural networks was with the support of the back propagation algorithm for the disease detection, which gave good results. Finally, all the 4 methodologies were compared for their best performance.

It was found that the convolution neural network was the best as it has given 100 % results, this was because of the proper training concepts involved in the detection & hence the objective of the research title "Design & Development of Algorithms for eye disease detection using Artificial Neural Networks" was thus met in toto. The works were also compared with the work done by others in order to establish the supremacy / effectivity of the methodology proposed by us.

Type of Images	No. of Images	Correct diagnosis	Water Shed Algo	HOG SVM	Genetic SVM	CNN
Normal Eye	30	30	29-96.67 %	29 96.67%	28-93.33 %	**100 %**
Glaucoma Eye	30	30	30-100%	29 96.67%	29-96.67 %	**100 %**
Total	60	60	59-98.33%	58 96.67%	57-95 %	**100 %**

Table 1 : Comparative performance characteristics all the 4 proposed works

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