Research Article

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A Brief Review of Analysis, Diagnosis & Detection of Glaucoma Eye Disease in Human Beings

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Abstract— This document gives formatting instructions for authors preparing papers for publication in the Proceedings of an IEEE conference. The authors must follow the instructions given in the document for the papers to be published. You can use this document as both an instruction set and as a template into which you can type your own text.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. 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 cause 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'. In this paper, a brief review of the analysis, diagnosis & detection of Glaucoma Eye disease in human beings is being presented in a nutshell as a survey paper. In this paper, only a exhaustive literature survey of the recent works done by various authors across the globe till date is being presented w.r.t. the exciting & application oriented bio-medical field of glaucoma is being presented in a nutshell so that this paper serves as a ready reckoner for all the people who are going to work in this exciting field.

Keywords—Glaucoma, Matlab, Retina, CDR, IOP, Simulation, Results, Database, Algorithm, Hardware, Software, Implementation, Detection, Design, Flow-chart, Fuzzy, ANN, Neural Network, SLIC, LBP, HOG, Primary, Secondary, SVM, RNFL.

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. 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 cause 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'.

II. WORK DONE BY VARIOUS AUTHORS – LITERATURE REVIEW

Glaucoma represents harm to the eye (optic) nerve can prompt loss of vision or even ocular deficiency [1]. This disease is the principle source of irreversible visual impairment on the globe [2]. While anybody can get glaucoma, a few individuals are at more serious danger. Glaucoma is frequently called "the sneak criminal of sight" [3]. Glaucoma for the most part causes no indications at a very early stage in its progress, hence it must be analyzed by regular and normal eye examinations.

Intraocular weight increments above 21 mmHg when either an excess of liquid is delivered in the eye or the seepage or outpouring channels (trabecular meshwork) of the eye get to be blocked. This fluid is called Aqueous Humour [4]. The survey portrays the use of different image handling procedures for programmed discovery of glaucoma. The key image processing techniques to recognize eye sicknesses incorporate picture enlistment, picture combination, picture

division, highlight extraction, picture upgrade, morphology, design coordinating, picture arrangement, examination and factual estimations.

A number of researchers have worked on the diagnosis & detection of primary & secondary glaucoma in different types of fundus images using advanced image analysis techniques till date (both at the investigation level & at the hospital levels). To start with, 100's of research papers were collected from various sources, studied @ length & breadth and this paper gives a brief information about the review of the work done by various authors till date. In this paper, only a exhaustive literature survey [1] – [40] of the recent works done by various authors across the globe till date is being presented w.r.t. the exciting & application oriented bio-medical field of glaucoma is being presented in a nutshell so that this paper serves as a ready reckoner for all the people who are going to work in this exciting field.

In July 2012, H. Yu, E. S. Barriga, C. Agurto, S. Echegaray, M. S. Pattichis, W. Bauman, and P. Soliz, performed a work based on "Fast Localization and Segmentation of Optic Disk in Retinal Images Using Directional Matched Filtering and Level Sets". They exhibited a quick and completely programmed OD localization & division algorithm. Initially the OD area may be recognized utilizing template matching.

Likewise, the template is outlined to adjust on diverse image resolutions. Then vessel patterns on the OD are used to figure out the disc area. After that a fast, hybrid model is used for the division of the disc limit. The primary goal of this paper was to outline individual's eye shading picture with database of pictures comprising of typical individuals and additionally, pictures of individuals experiencing glaucoma.

In June 2013, Cheng, Liu, Xu, Yin, Wong, Tan performed a work, "Superpixel Classification Based Optic Disc and Optic Cup Segmentation for Glaucoma Screening" [1][2]. This work tags the optic disc and cup division utilizing superpixel order for glaucoma identification. In OD division, histograms and focal point facts are used to arrange each superpixel as disc or non-disc. In OC segmentation alongside those above specified methods, local data will be likewise utilized to support and boost the execution process. Those fragmented optic disc and cup are then used to figure out the cup to disc proportion for glaucoma screening.

In November 2014, Salazar-Gonzalez, Kaba, Li, and Liu performed a work on "Segmentation of the Blood Vessels and Optic Disk in Retinal Images" [7]. They introduced blood vessels and optic disc division on retinal images by coordination the component for flux, MRF image rebuild and compensation variable under the graph chart technique. The methodology likewise includes difference enhancement, versatile histogram equalization, binary opening and distance transform for pre-processing of those DRIVE and STARE fundus image database.

Glaucoma is a chronic eye disease in which the optic nerve is progressively damaged. Advanced glaucoma leads to total irreversible blindness. Worldwide, it is the second leading cause of blindness, affecting 60 million people by 2010, and responsible for approximately 5.2 million cases of blindness [1]. Although glaucoma cannot be cured, early treatment can slow down progression of the disease. Hence, early detection is critical to prevent blindness.

Current methods to detect glaucoma include assessment of raised intraocular pressure (IOP), assessment of abnormal visual field and assessment of damaged optic nerve. However, IOP measurement is neither specific nor sensitive enough to be an effective screening tool and visual field testing requires special equipment only present in tertiary hospitals and special clinics.

In contrast, assessment of the optic nerve is more convenient and accurate. Optic nerve assessment can be done by ophthalmologists, or using specialized imaging technologies such as Heidelberg Retinal Tomography (HRT) [2], Optical Coherence Tomography (OCT) [3] and fundus imaging. However, the cost of obtaining 3D HRT and OCT images is still high due to the hardware cost and lack of trained professionals.

Automatic analysis of fundus images for glaucoma screening has been a popular research topic in recent years due to its speed, accuracy, objectivity and labour saving. In 2D fundus images, the vertical cup-to-disc ratio (CDR) is widely Many studies have been conducted to improve computer based decision support algorithms for early diagnosis of glaucoma by extracting optic disc and cup to calculate CDR ratio.

Fauzia Khan et al [2] used Morphological techniques to extract two major features for detection of glaucoma i.e. CDR, Area ratio of NRR in ISNT quadrants. The proposed method achieves an average accuracy of 94% having an average computational cost of 1.42 seconds. Kavitha et al [3] estimated the cup to disc ratio by extracting disc using component analysis method, manual threshold analysis and region of interest (ROI) based segmentation. For extraction of cup component analysis method was used.

A larger vertical CDR value corresponds to higher level of damage of the optic nerves, and hence indicating higher risk of glaucoma. A number of methods have been proposed to extract optic disc features and compute CDR from fundus images for glaucoma screening. Wong et al. proposed a method to segment the optic and optic cup using a variational level set method followed by ellipse fitting [4]. The enforcement of a shape model in the post-processing step can help in handling local minima.

One problem of this method is that other techniques are needed to handle the vessel occlusion problem. Yin et al. proposed a method based on the active shape model (ASM) [5]. A statistical model was first trained to contain shape and grayscale variations. The model is then applied to a new fundus image with blood vessels removed to search for the optic cup. The performance of this method is highly dependent on the initialization of the optic disc and cup. Cheng et al. proposed a super-pixel classification based method [6].

Super-pixels clustered based on colour, local texture, etc. are classified as disc/non-disc or cup/non-cup using features extracted from the super-pixels. Subsequently, a deformation step is used to fine tune the disc and cup boundaries. However, the method tends to under-estimate very large optic cups and over-estimate very small ones. Recently, Xu et al. [7] proposed a linear reconstruction based method. A set of ground truth is used to form the codebook and train an optimal linear reconstruction coefficient. In the reconstruction process, a cost/penalty term is introduced to the objective function to do the reconstruction with less but more related images in the codebook. This method is fast, robust and less sensitive to disc localization error in terms of glaucoma diagnosis.

Babu et al [4] has implemented Hill Climbing Algorithm for the extraction of optic disc whereas for optic Cup extraction Fuzzy C-Mean clustering. The algorithm was able to detect glaucoma with an accuracy of 90%. A.Murthi and M.Madheswaran [5] used a fused approach based on multimodalities including level set segmentation, convex hull and ellipse fitting boundary is proposed. Chih-Yin Ho et al [6] proposed an automatic detection system which contains two major phases: the first phase performs a series modules of digital fundus retinal image analysis including vessel detection, vessel inpainting, cup to disc ratio calculation, and neuro-retinal rim for ISNT rule; the second phase determines the abnormal status of retinal blood vessels from different aspect of view.

Yang et al [7] extracted the optic disc using HRT images for the assessment of glaucoma in an eye. They proposed Multi-scale region and boundary hybrid snake method to extract the optic disc. Li et al [8] proposed a modified active shape model (ASM) for shape detection of optic disc boundary. N.M.Tanet et al [9] proposed a probabilistic mixture model for optic cup segmentation.

It is assumed that the pixel intensities within the optic disc can be modeled to a mixture model. Expectation maximization (EM) is used to solve the optimization problem for Gaussian Mixture Model (GMM). The results from evaluations show an improvement of 8.1% in cup area overlap and 14.1% in relative area difference from the ARGALI cup segmentation. Yuji Hatanaka et al [10] proposed a method to measure the cup-to-disc ratio using a vertical profile on the optic disc.

III. CONCLUSIONS

A brief review of the related research work done in the field of glaucoma detection was presented in this review / survey paper. This survey paper serves as a ready reckoner for all the researchers who wants to pursue their career in the field of bio-medical image processing.

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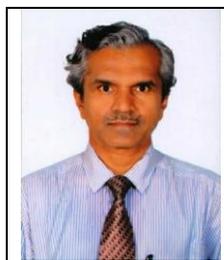
Dr. T.C. Manjunath was born in Bangalore, Karnataka, India on Monday, the 6th of Feb. 1967 & received the B.E. Degree (Bachelor of Engg. in Electrical Engg.) from R.V. College of Engg. (Bangalore Univ.) in the year 1989, M.E. degree in Automation, Control & Robotics from the prestigious 100 year old Govt.'s LD College of Engg., (Gujarat Univ., Ahmadabad) in the year 1992 and Ph.D. in Systems & Control Engineering from the prestigious Indian Institute of Technology Bombay (IIT Bombay) in the year 2007 respectively.

He has got a teaching (academic), research & administrative experience of nealry 32+ years in various engineering colleges all over the country (Karnataka, Gujarat, Maharashtra). He has worked in the levels of Lecturer-Asst. Prof. (18+ yrs), PG Coordinator, Prof-i/c HOD-Prof. & Head (>6+ yrs), Director-Research, i/c Principal & as Full time Principal (7 yrs) in various institutions where he has worked so far. Currently, he is working as Professor & Head of the Department of Electronics & Communication Engg. of the famous Dayananda Sagar Group's 'Dayananda Sagar College of Engineering' in Bengaluru, Karnataka, India since more than 2½ years. He has also worked as a Project Assistant and as a Research Engineer in the Systems and Control Engineering (IIT Bombay, India) and worked on vibration control of space launch vehicles in IITB during his research tenure.

He has published a large number of research papers in various National, International Journals and Conferences in India & abroad and published more than a dozen textbooks (20) with editions, notable among them being ('Introduction to robotics' - 1st edition, 'Fast Track to Robotics' - 4th Edn., 'Fundamentals of Robotics' in 2 volumes, Vol-1 and Vol-2 along with a CD which contains about 200 C / C++ programs for performing various simulations on robotics – 5th edition, 'Examination Security System - Design & Development of Examination Mechanism Using Electronic Box' from Germany costing around 49 Euros, 'Microcontroller & Applications Theory'-1st Edn, 'Basic Electronics'-1st Edn). He has also published a number of 'book chapters' in various edited books from renowned publishers. He has also published a research monograph in the International level from the Springer-Verlag publishers (Europe) based on his Ph.D. thesis topic titled, "Modeling, Control & Implementation of Smart Structures", Vol. 350, LNCIS, costing 126.35 Euros.

He is a member of more than 25 professional societies. Some of them are …. a member of IEEE for the past 15 years (currently Sr. Member), Sr. member of IIIE, SPIE student member (USA) and IOP (USA) student member for 4 years, life member of ISSS (India), life member of additive manufacturing society of India (LMAMSI), life member of the ISTE (India), life member of ISOI (India), life member of SSI (India), life member of the CSI (India), Life member of IMAPS, Sr. Member of IACST (Singapore) and life member cum fellow of the IETE (India), AMSI, Chartered Engineer from IE (I) and Fellow of Institute of Engineers (FIE).

He has given a number of guest lectures / expert talks and seminars in many institutions across the length & breadth of the country and participated in more than 3 dozen CEP / DEP courses, seminars, workshops, symposiums,

besides conducting a few courses in the institutions where he worked. He was awarded with the "Best research scholar award in engineering discipline" for the academic year 2006-07 for the entire institute from the Research Scholars Forum (RSF) from Indian Institute of Technology Bombay (IITB). This award was presented in recognition of the significant contribution to the research (amongst all the researchers in all disciplines) in IIT Bombay. Also, he was conferred with the best paper awards in a number of conferences. He was also conferred with the prestigious Rajiv Gandhi Education Excellence Award, Global Education Achiever of India award, Rashtriya Vidya Gaurav Gold Medal Award & International educational excellence award (in recognition of sterling merit excellence performance and outstanding contribution for the progress of the nation & world-wide) from New Delhi in the year 2013 w.r.t. his achievements in the field of education, academics, administration & research.

He was also instrumental in getting a no. of Research centres (along with M.Tech. programmes & new UG programmes in the colleges where he has worked so far as the administrative head. He was also responsible for getting AICTE grants under MODROB scheme for the development of the Robotics & Mechatronics Labs in one of the colleges where he worked. Apart from which, he has brought a number of grant-in-aid for the conduction of various events like workshops, conferences, seminars, projects, events, etc., wherever he has worked [from VTU, DST, IETE, CSI, IEEE, IE(I), DRDO, ISRO, VGST, KSCST, Vodafone, Uninor, etc.] from different sources.

He has visited Singapore, Russia, United States of America and Australia for the presentation of his research papers in various international conferences abroad. His biography was published in 23rd edition of Marquis's Who's Who in the World in the 2006 issue. He has also guided more than 2 dozen projects (B.E. / B.Tech. / M.E. / M.Tech.) in various engineering colleges where he has worked, apart from guiding a couple of research scholars who are doing Ph.D. in various universities under his guidance (3 have already come out). Many of his guided projects, interviews, the events what he had conducted have appeared in various state & national level newspapers and magazines (more than 100 times). He has also reviewed many research papers for the various national & international journals & conferences in India & abroad (more than 100 times).

He has also organized a number of state & national level sports tournaments like yogasana, chess, cricket, volleyball, etc. He is also an editorial board / advisory board / reviewer member and is on the panel of many of the national & international Journals. He has also served on the advisory / steering / organizing committee member of a number of national & international conferences. He has given many keynote / invited talks / plenary lecturers in various national & international conferences and chaired many sessions, was judge, special invitee, guest of honor & was chief guest on various occasions.

He has also conducted / organized / convened / coordinated more than 220+ courses / workshops / STTP's / FDP's / Technical paper fests, Student level competitions & Symposiums, etc., in various engineering colleges where he worked so far. He has also taken many administrative initiatives in the college where he has worked as HOD, Principal & also where he is currently working as Prof. & Head, besides conducting all the semester university exams successfully as chief superintendent, deputy chief superintendent, squad member, etc. Some of the special administrative achievements as HOD, Principal & Head of the Institution are ….

He improved the results of the various branches in East West Inst. of Tech. / New Horizon College of Engg. / Atria Inst. of Tech. / BTL Inst. of Tech. / HKBK College of Engg. / Dr. Ambedkar Inst. of Tech. / Nandi Inst. of Tech. & Mgmt. Sciences / Dayananda Sagar College of Engg. He gave more importance to the development of in-house projects for the final years & initiated the Project Open-Day, where all the final year students used to exhibit their project works. He has also motivated many of the faculties to take up take up consultancy works & did it efficiently, so that the college got some good income (revenue generation scheme), besides sending large no. of students towards the internships in various industries. He made the faculties to take up research (Ph.D) work or do M.Tech. by compelling them constantly to purse for higher studies.

As an administrative head, he made the faculties to publish paper in either national / international journals & conferences at least one in an academic year. He started the student chapters in all the branches such as IETE, IEEE, ISTE, IEI, CSI, SAE, ISSS, ISOI & also conducted a number of events under their banners. He brought in power decentralization in the institute by developing the habit of making coordinator-ships for various works, getting the work done by monitoring and following it up successively. He was also involved in TEQIP-2 & 3 process in Dr. AIT along with the development of many of the autonomy and world bank works.

He was also a BOS member & BOE member in the university. He conducted a number of exams from public sectors & private sectors such as GATE exams, CET / COMED-K, KPSC, TCS, Police Exams, Inst. of Civil Engineer exams & conducted a number of state & national level examinations like Defense, PG entrance exams, Medical, KPTL in the college so that the college could get some revenue (under the banner of revenue generation scheme). He started the weekly monitoring of the staff & students. He developed the counseling of student data booklets & that of the faculty work-diary, besides the monthly newsletter & the research bulletin.

All the laboratory manuals were developed in-house, printed & given to the students (both in the hard as well as in the soft copy). He used to conduct the academic & governing council meetings regularly along with the HOD's meetings & staff meetings time to time. He had looked after the NBA process in Fr. CRCE, Atria IT, HKBKCE, Dr. AIT & in DSCE. He conducted the prestigious 7th IETE ICONRFW & the 28th Karnataka State CSI Student Convention. He introduced the scheme of best lecturer award / best HOD award / best non-teaching award / service awards concept / Principal cup / Departmental cup, etc. in the colleges where he worked as administrative head.

He created a record placement of more than 2000 students in Atria Inst. of Tech. / HKBKCE / BTLIT / Dr. AIT / NITMS / DSCE with the help of the placement department. He helped the management to fill up many of the student admissions in the first year of UG (B.E.) & in PG (M.Tech.) course. He created a number of hobby-clubs, EDC cells, Innovation & Incubation centres, centre of excellences in the institute for the staffs & students to work towards development of prototypes, models, and projects. He started the faculty seminar series in the institute so that every faculty gives a lecture of 45 mins with 15 mins discussion at least once in a month.

He introduced the concept of coaching class/tutorial classes for weak students & remedial class concept for failed students, slow learners, which yielded successful results apart from the training of top 10 students for getting ranks. He made students to get university ranks in BTL & HKBKCE in the UG & in PG streams. He started the on-line courses, MOOCS, NTPEL Courses, certificate oriented courses of 2/3 months & 6 months for various types of people, especially on weekends. He made students to participate in competitions outside the college & win a number of prizes, brought laurels to the institution. He helped the students to get some financial assistance using sponsors for the cultural events.

He brought a project grant of nearly Rs. 4 crore till date in the various organizations where he has worked so far with help of faculties under various funded projects scheme such as DST, ISRO, DRDO, VGST, AICTE, MHRD, etc.… He developed the Innovation & Entrepreneurship Development Cell in HKBKCE & did a number of programs under its belt. He was responsible for some of the UG students of HKBKCE to make them establish a start-up company in the college itself by name 'pentaPsystems'. He made more than one dozen MOU's with reputed firms & sectors with the college and utilized all the advantages of the signed MOUs with the companies.

He streamlined many of the process in the office level & that of the departmental level by developing new formats for the smooth conduction of various processes along with excellent documentation. He underwent the one week NUS-Leadership training programme in Singapore, sponsored by TEQIP-II SPFU MHRD GOK DTE & Govt. of India in the year Sept. 2015. He developed the culture of making up of small / mini hobby projects by the students along with the development of a number of alternate assessment tools. He developed the system documentation of entire departments & that of the college.

He also has got very good experience in the autonomous curriculum of the VTU course in the wake of make up exams, fast track exams, CIE, SEE, Curriculum Design, etc… as he has worked for more than 2 years in the autonomous colleges. Under industry-institute interaction, he conducted a number of industry oriented courses like CADD course, ANSYS course, PCB Designing course, Quadcopter course, IOT Course, Oracle course, Infosys campus connect courses (18 batches rolled out in HKBKCE), Software testing, etc. His special areas of interest are Control systems, DSP, AI, IP, Robotics, Signals & systems, Smart Intelligent Structures, Basic Electrical Engg., Basic Electronics, Network Analysis, Vibration control, Instrumentation, Circuits & Networks, Matlab, etc.…..