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Computer assisted detection, prognosis and management of Diabetic Retinopathy

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Abstract

Detection, prognosis and management of diabetic retinopathy (DR) by computer based algorithm database have great potential to enhance the quality and availability of healthcare. Comparable in performance to human specialist doctors, examples of these databases are STARE (structured analysis of the retina), DRIVE (digital retinal images for vessel extraction), ARIA, Image Ret, Messidor, REVIEW (retinal vessel image set for estimation of widths), ROC (receiver operating characteristic) microaneurysm set and VICAVR database. Patient data is collected in the form of digital image analogues. Processing includes filtration, image enhancement, identification of defective regions and their extraction. Extracted data is recognized, classified and used to diagnose the DR along with suggestive therapy.

Key words: diabetic retinopathy, algorithm, fundus images, prognosis

Full length article **Corresponding Author*, e-mail: fatmauaf@yahoo.com

1. Introduction

A spontaneous relationship exists between science and health. Medical research highlights disease mechanism and offers potential treatment options, regardless of remedial efficiency or execution. As a result, futile treatments become part of routine practice and medicine has become an opinion instead of confirmed scientific field. End users, the patients receive least favorable care. A technology that can manage knowledge can excel all prevalent medical procedures providing optimal clinical value. The most advanced type is computer- based exploitation of clinical data that exhibits utmost advantageous impact. Strategically this puts a responsibility on computer scientists to review clinical workflow, ascertain amazing potentials of artificial intelligence and allied fields assemble all tools to benefit health care while ensuring information management and privacy [1].

Clinical features of diabetic retinopathy (DR), a microvascular complication of diabetes mellitus includes exudes, hemorrhages, microaneurysm and texture. Numerous algorithms are used for the extraction of these features from digital fundus images. Highly developed computer models have improved fundus image based classification almost analogous to that described by an ophthalmologist [2]. Thereby, merger and analysis of conventional and advanced diabetes management measures can be supportive to patient and doctors. Recently, scientists have focused on developing and applying computer assimilation models to forecast disease outcome and treatment [3].

Examples of DR fundus image databases are STARE (structured analysis of the retina), DRIVE (digital retinal images for vessel extraction), ARIA, Image Ret, Messidor, REVIEW (retinal vessel image set for estimation of widths), ROC (receiver operating characteristic) microaneurysm set and VICAVR database [4].

2. Detection of diabetic retinopathy

Destruction of retinal microvasculature can lead to blindness in diabetic retinopathy. Interpretation of delicate morphological changes in retina by manual inspection is tiresome. Theoretically, ophthalmologists are doing better work. However, they have to read hundreds to thousands of images daily, most with no abnormality at all and decision variability among human experts necessitates a well-developed system with minimum number of errors. Additionally, imaging process, results production and communication to the patients can take days to weeks. By utilizing computer-assisted systems, early, easy and more accurate detection of DR is possible that can be shared with the patient immediately within a short period of time.

A computer assisted diagnostic model may deliver better insight and facilitates effective decision and care [5]. Large medical image data sets with high dimensionality require substantial amount of computation time for data creation and data processing (Fig.1).

Roychowdhury [6] presented an innovative method for detection of DR. Specific fundus image based characteristics and grading approaches were used for classification to extract optimal features. By using boosted decision tree and decision forest classifiers in the Microsoft Azure Machine Learning Studio platform, DR accuracies are calculated. Similarly, Gulshan et al [7] evaluated retinal fundus images from diabetic patients with DR to diagnose this ocular complication by incorporating highly sensitive deep learning algorithms.

Previously, Dupas et al. [8] evaluated automated fundus photograph analysis algorithms for the detection and grading of DR. They reported 83.9% and 72.7% sensitivity and specificity of the algorithm for DR. It was suggested that computer assisted diagnosis is more reliable and lesser time consuming as compared to manual investigations.

3. Disease staging

Disease progression is observed for treatment selection. Investigating the disease spread over a wide region in DR is preferred (Fig.2). Recently, Takahashi et al. [9] suggested an artificial intelligence method not only for staging the DR but also for recommending treatment decisions.

Choi et al. [10] applied MatConvNet, deep learning neural network to detect numerous retinal diseases with fundus images present in STructured Analysis of the REtina (STARE) database. Data sets of nine retinal diseases were used. A random forest transfer learning based on VGG-19 architecture was used to optimize results. However, due to small data sets deep learning techniques were unsuccessful as large number of patients suffering from multiple ocular diseases visit clinics. Leontidis et al. [11] offered outlines for precise and vigorous mining and exploration of ocular images with variable geometries. It emphasized on divergences during successive years of progress from diabetic with no DR to diabetic with DR. Vascular features differ widely and can be used as a marker to determine disease progress. When variability in major temporal arcade with time was studied by Oloumi et al. [12], user-guided modelling and generalized Hough transformations were used. It was concluded that these methodologies enhance structural features investigations, identification and treatment of DR.

Blood vessels segmentation analysis has widely been used for detection of numerous pathological conditions such as high blood pressure, diabetes, atherosclerosis and heart disease. Saleh and Eswaran [13] evaluated the performance of a novel algorithm regarding blood vessels segmentation in retina. With fast image processing, extraction and image segmentation properties, it was applied to 40 images collected from DRIVE database. Accuracy rate of 96.5% was yielded by proposed algorithm.

4. Management

Multidisciplinary research for DR management narrowing the barriers between medicine and computer science is the need of the day (Fig.3). Diabetes management landscape has been changed radically by inclusion of other scientific applications [3].

During a retrospective follow-up study of patients with diabetes mellitus attending a diabetes center, Soto-Pedre et al. [14] anonymized demographic and clinical data of diabetic patients to assess the risk for DR by a prediction model. Receiver operating characteristics analysis and calibration graph was used to analyze diagnostic potential and model fit. Results showed that model had a good fit and personalized screening practice should be adopted in future.

However, Scanlon et al. [15] used survival modelling to determine whether personalized screening intervals are cost-effective in DR patients. They used a probabilistic decision hidden (unobserved) Markov model with a misgrading matrix along with two personalized risk stratification models: two screening episodes (SEs) (low, medium or high risk) or one SE with clinical information (low, medium-low, medium-high or high risk). Annual screening was not economical and great uncertainty prevailed in estimated costs.

Comparison of performance – Computer-aided systems versus eye specialists

An ophthalmologist checks most of the medical records available on DR for each patient. To optimize the diagnosis process, a panel of at least three experts must give advice. Abramoff et al. [4] used image samples of 500 patients, had them read by three ophthalmologists and compared their opinion with initial system reading to assess sensitivity and specificity. Performance of algorithms was slightly lower in terms of sensitivity and specificity of doctors.

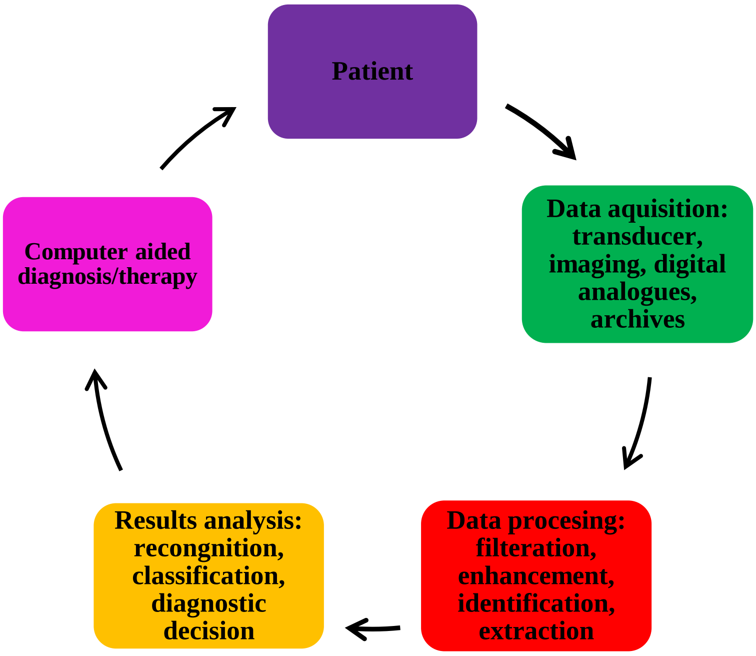

Fig.1 Steps involved in computer assisted diagnosis of DR

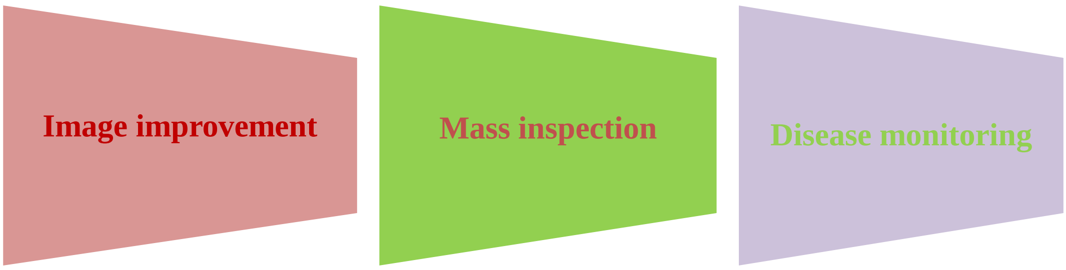

Fig.2 Role of computer assisted image processing

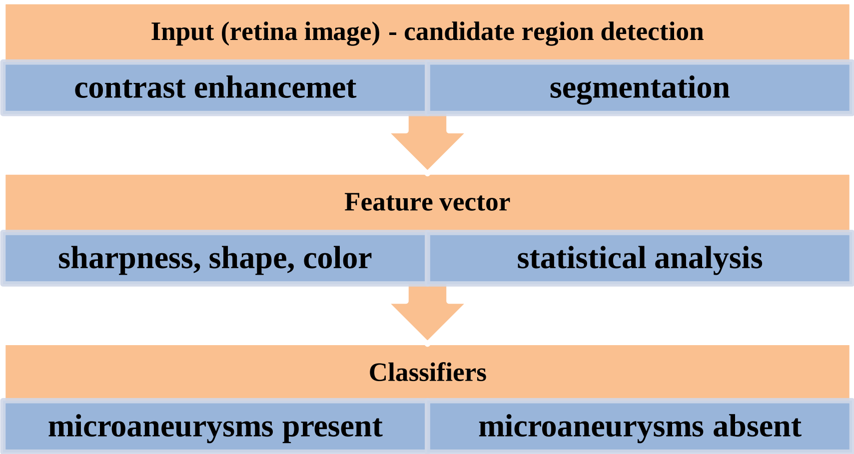

Fig.3 Flow diagram for proposed system

5. Future directions

More research is warranted on the following aspects of computer-aided DR detection and management:

1. Performance validation of algorithms on large high quality datasets obtained from diverse ethnic groups.
2. Assessment of variable interpretations in case of images taken from different angles by multiple camera types.

3. Merger of algorithms and evaluation of their performance.
4. Effect of individual and combined algorithms on demographic and clinical parameters.
5. Development of economical hardware for automated detection of DR.

6. Conclusion

It is anticipated that the use of automated algorithm based systems for diagnosis; disease staging and management of DR have matured rapidly. These approaches provide swift, better quality, economical and efficient treatments.

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