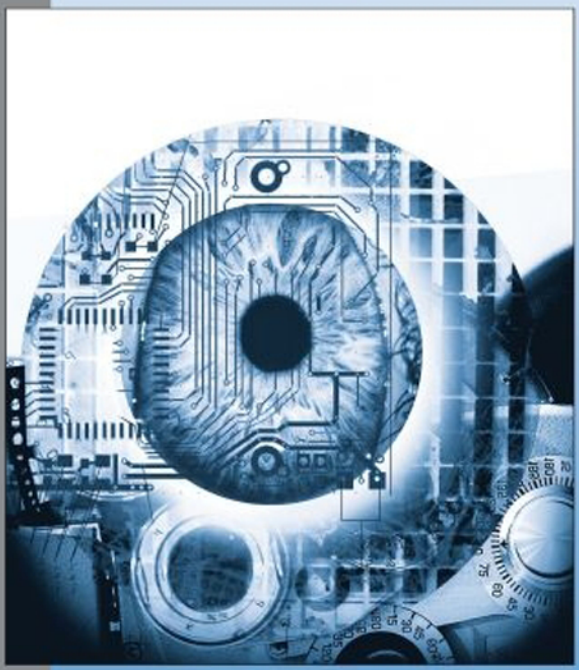
TECHNOLOGY AND INFORMATICS 143

Advances in Information Technology and Communication in Health



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Preface

In March 1986, a Canadian colloquium with an international flavor was convened to discuss the impact of information technology on community health. It was sponsored by the School of Health Information Science at the University of Victoria and the British Columbia Ministry of Health. Notable speakers were Salah Mandil, the Director of Information Systems Service at the World Health Organization, and Stan Dubas, the Deputy Minister of Health for British Columbia. This small, successful gathering was the predecessor of the Information Technology in Community Health (ITCH) conferences that followed in 1987, 1988, 1990, 1992, 1994, 1996, 1998 and 2000.

In 2007, after a brief hiatus, the conference was held again but this time it had expanded its scope. It was known as Information Technology and Communications in Health (ITCH) 2007; with the same acronym but with a different meaning as demanded by its international appeal and wider choice of subject areas. The conference in 2007 was an unmatched success and now, as 2009 approaches, we prepare for an even more eventful convention, which encourages experts to demonstrate and share their experiences and knowledge. The theme for the ITCH 2009 conference is "Revolutionizing Health Care with Informatics: From Research to Practice."

The Organizing Committee feels honoured to promote this event and, thereby, to contribute to the advancement of informatics in health and health care. Many people have volunteered their time and financial sponsorship; we sincerely thank them. We wish, however, to give specific recognition to those who are serving on the Steering Committee and the Scientific Program Committee.

James G. McDaniel, Editor
School of Health Information Science
University of Victoria,
Victoria, British Columbia, Canada
December 15, 2008

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A Morphological Approach for the Fovea Location in Color Fundus Images

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Abstract. This paper presents a novel method for the detection of the fovea center in color fundus images. The method was evaluated using a set of 89 images from the DIARETDB1 project, which contains images presenting normal and pathological situations. Using the Mean Absolute Distance (MAD) as a metric, we report 7.37±8.89 (mean ± standard deviation) detection performance for the fovea center which represents an improvement in comparison to other state-of-the-art methods in the literature.

Keywords. fovea detection, mathematical morphology, color fundus image

Introduction

There are few papers that address the fovea location issue. Sinthanayothin et al [1], use an artificial image of the fovea for to find the fovea's place in real retinal images. They consider the position of maximum correlation coefficient between a synthetic image (template) and the retinal image as the fovea's place. Li et al [2], use a modified active shape model and the Hough Transform on the main vessels arcade, to fit a parabola which has its center in the optic disk. Then, candidate regions for the fovea are defined at 2 DD (DD=Disk Diameter) away from this optic disk center, but along the main axis of this parabola. Tobin et al [3] also use a geometric model (also parabolic) of the vasculature tree to identify the fovea anatomy. As in the previously described paper, Tobin et al explore the geometric relationship between the optic nerve and the main vessels arcades to find the fovea locus. Besides, Goldbaum et al [4] use a constant distance (i.e. 4.5 mm) away from the optic disk to find the fovea center. In this way, we can classify all these methods of the literature for the fovea localization, in three categories: 1) those that use the variability of the gray values of the image to find the fovea, 2) those that explore the vessels (main vessels arcade or the fovea avascularity) and 3) those that use fixed parameters to identify the fovea region.

Our approach explores the low intensity values of the fovea region on the green channel of the color retinal images. We use morphological operators on the green channel of the original color retinal image. Moreover, other anatomical information is used to select the fovea center position. Later, we compare our method with the

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approach used in Sinthanayothin et al and discuss the advantages and drawbacks of both methods.

1. Materials and Methods

1.1. Materials

Our proposed method was tested on a public database of retinal images called DIARETDB1 [5], which consists of 89 color fundus images of size 1500 x 1152 captured using a 50 degree field-of-view digital fundus camera. This database contains normal images (without diabetic lesions) and images with diabetic non-proliferative signs. Also, the images show great variability in terms of quality, i.e., illumination problems. In order to save computation time, we resized the images to 640 x 480 pixels.

1.2. Our Proposed Method

Our proposed method needs two parameters in order to find the fovea. These parameters are the diameter and the optic disk center point, which where found in this work using an approach based in the method proposed by Walter et al [6]. Basically, their method has two steps: the first step is the optic disk locus detection and the second is the identification of its boundaries. Figure 1 (a), illustrates the output of Walter et al for an image of the DIARETDB1 database. Thus, having an acceptable optic disk boundary, its diameter and its center point can be calculated as shown in Figure 1 (a), where the disk diameter (DD) is equal to 68.9143 pixels.

First, we select only a region of interest (ROI) of the segmented image shown in Figure 1 (a). This ROI has a size of 160 x 160 pixels and its center point is located at 2.6 DD pixels away from the optic disk center point. It is important to notice that the ROI center point is aligned to the optic disk center point, or in other words, they are on the same image row as illustrated in Figure 1 (b). We consider that the fovea center is inside of this ROI and in this way only this ROI will be used to detect it. This is a robust approach because there is an anatomical relationship between the fovea and the optic disk, i.e., the fovea can be located at a minimum distance of twice the optic disk diameter [1,2,4]. Then, in order to detect the fovea center on this ROI image, we use morphological image processing techniques.

If we consider two input images where f is a marker image and g is the mask image, and where δ denotes a morphological dilation and ε represents the elementary morphological erosion, we can denote the geodesic dilatation (with $f \leq g$) and the geodesic erosion (with $f \geq g$) by Eqs. (1) and (2), respectively.

$$\delta_g^{(n)}(f) = \delta_g^{(1)}[\delta_g^{(n-1)}(f)], \quad \text{where } \delta_g^{(1)}(f) = \delta^{(1)}(f) \wedge g \tag{1}$$

$$\varepsilon_g^{(n)}(f) = \varepsilon_g^{(1)}[\varepsilon_g^{(n-1)}(f)], \quad \text{where } \varepsilon_g^{(1)}(f) = \varepsilon^{(1)}(f) \vee g \tag{2}$$

where n represents successive geodesic dilations or erosions of f with respect to g and $\wedge$ and $\vee$ are point-wise operators for minimum and maximum. If the geodesic dilation

or erosion is performed successive times until stability, it results in the morphological reconstruction by dilation and the reconstruction by erosion transformations respectively. Eqs. (3) and (4) illustrate these transformations.

$$R_g(f) = \delta_g^{(i)}, \text{ where } \delta_g^{(i)}(f) = \delta_g^{(i+1)}(f) \tag{3}$$

$$R_g^*(f) = \varepsilon_g^{(i)}, \text{ where } \varepsilon_g^{(i)}(f) = \varepsilon_g^{(i+1)}(f) \tag{4}$$

In addition, from the reconstruction by dilation, we can define the regional minimum of an image, *f*. The regional minimum, RMIN, is a grayscale image where the regions RMIN ≤ *f* is delimited. If a pixel value of *f*, namely *f(x,y)*, is smaller or equal to its neighboring pixels, it is kept at its original value otherwise it is assigned to zero. In other words, each pixel of *f* surrounded by pixels brighter than itself is a regional minimum. The RMIN image can be found according to Eq. (5).

$$RMIN(f) = R_f^*(f+1) - f, \tag{5}$$

Next, applying the regional minima and the geodesic morphological reconstruction by dilation on the green channel, f_g, of the original ROI image, we remove the bright areas that are potentially associated with all diabetic lesions. The regional minima of f_g are computed and then a reconstruction by dilation of f_g is performed using the previously calculated regional minima as a marker image. The central idea is to identify the foreground and background of the f_g image. We assume as foreground the brighter structures, e.g., exudates, and as background all the remaining structures, for example, vessels and hemorrhage. Eq. (6) shows this process:

$$f_{g1} = R_{fg}(RMIN(f_g)), \tag{6}$$

where the new image, f_{g1}, contains no signs of bright lesions, i.e., exudates. Figure 1 (b) is illustrates the green channel of the original ROI image that contains a diabetic lesion (indicated by the white arrow). Figure 1 (c) depicts the resultant image, f_{g1}, where there are no signs of diabetic lesions. However, in the f_{g1} image, there are still many other undesirable features like little dark dots, which can be a natural pigment of the eye or even a microhemorrhage, and thin vessels (capillaries). Thus, in order to remove these features and to achieve homogeneous areas we use the ν *-minima* filter [7,8] on the f_{g1} image. The ν-*minima* filter removes all connected components, i.e., the image basins, which have a volume below ν. Basically, the volume of each level component of an input signal (image) is defined according to the area attribute for each level component in this image. The area of a determined level component plus all the connected areas above it results in the volume of this level component [9]. The algorithm and the mathematical formalization of this filter are beyond the scope of this paper because they are extensive. However, the entire volume graph computed for all level components can be found in [7,8,9]. Then, the ν-*minima*

filter removes all basins in which volume is lower then ν. We use a constant value for ν, i.e., 1000, and the resultant image, f_{g2}, is shown in Figure 1 (d).

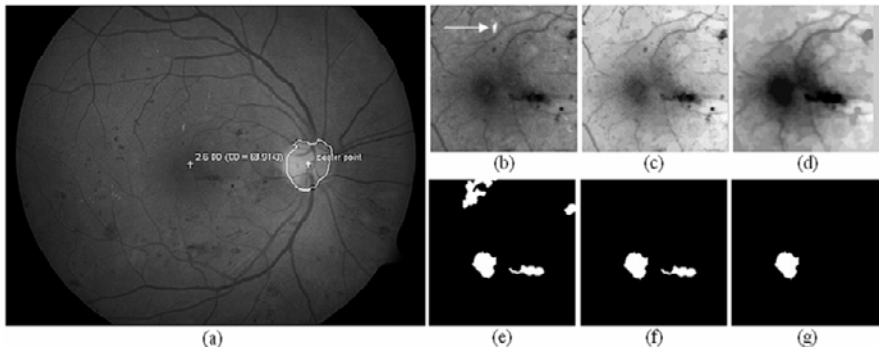

Figure 1. Steps for fovea location using our approach: (a) Optic disk center point and diameter detected through the method proposed by Walter et al. (b) Original ROI image. (c) fg1 image without signs of bright lesions. (d) fg2 image without small basins. (e) Fovea candidate regions (fg3 image). (f) Only candidate regions below the optic disk center point remain. (g) Selected region for the fovea.

In order to identify only the fovea region candidates, we perform the RMIN operator on the f_{g2} image as shown by Eq. (7).

$$f_{g3} = R_{fg_2}(RMIN(f_{g_2})), \tag{7}$$

The image f_{g3} is a binary image where the foreground figure depicts all possible fovea regions as illustrated in Figure 1 (e). Thus, we have to apply some criteria to exclude all non-fovea regions. First, all regions above the ROI center are removed because anatomically the fovea center is always below the optic disk center [10], which is aligned with the ROI center as shown in Figure 1 (a). Figure 1 (f) illustrates the resulting image of this previous process. Finally, the centroid of the remaining region of darkest intensity is chosen as the fovea center position. Figure (1) (g) shows the final candidate region chosen as the fovea region. Finally, the centroid point of this final candidate region is selected as the fovea center point.

2. Experimental Results

We tested our approach and the method proposed by Sinthanayothin et al on the 89 images in the DIARETDB1 database. We used the Mean Absolute Distance (MAD) [11] to measure the accuracy of both methods. The method described by Sinthanayothin et al uses a 40 x 40 intensity template image and a real intensity image to obtain the candidate regions for the fovea. This template is an artificial gray-scale image that mimics a real fovea region and is obtained using a Gaussian distribution with a fixed standard deviation [1]. The real intensity image refers to the intensity-hue-saturation color model obtained from the original color fundus image. Then, only the

darkest region located in an acceptable distance away from the optic disk, i.e., 2.5 DD, is selected. Finally the centroid of this region is selected as the fovea center point.

Our method and that of Sinthanayothin et al depend on acceptable optic disk boundary identification. Nevertheless, the approach of Walter et al used in this research to segment the optic disk, failed for some images. Consequently, we compared the two methods using only those 51 images where the optic disk segmentation was considered acceptable. We used the Mean Absolute Distance (MAD) to analyse our results and to validate our technique. For each image, the MAD was calculated for each method - the fovea center was manually labelled by an experienced ophthalmologist and also identified automatically.

The fovea center is identified as a white point on the original green channel image, which means that the pixel representing the fovea center locus is assigned a maximum grayscale value of 255. Then the MAD, based on the Euclidean distance, is used to estimate the average discrepancy between the points identified by the manual and automatic methods. A MAD value of zero indicates that the manually identified fovea center point and the automatically identified center point are in the exact locus or the same pixel. For example, the MAD obtained for the image 2 was 3.1622 pixels using our approach and 89.0449 pixels using that of Sinthanayothin et al. Therefore, for this second image we achieved better segmentation because we were nearer to the ground truth fovea center.

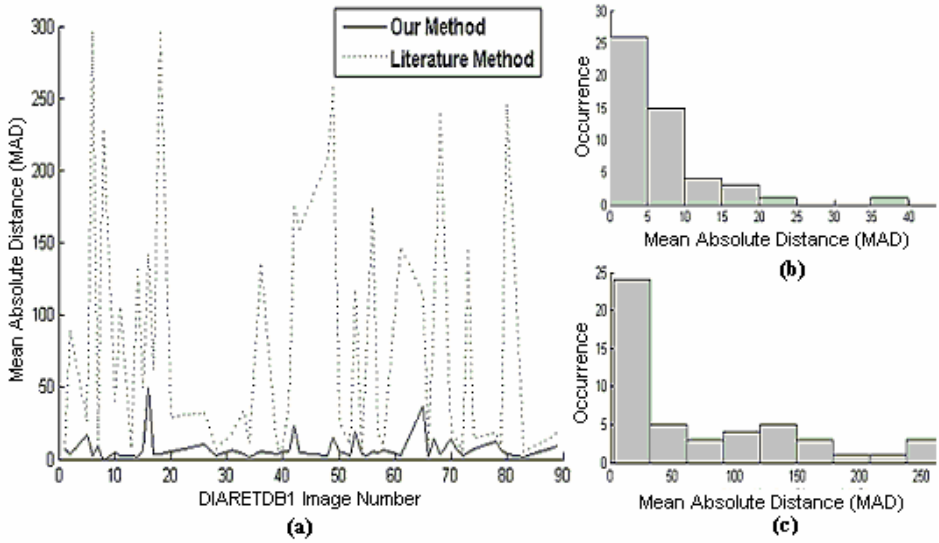

Figure 2. Comparative results between our approach and the approach of Sinthanayothin et al: (a) The Mean Absolute Distance (MAD) between these two approaches. The MAD of the solid and dotted lines was calculated using the ground truth images as reference. (b) The MAD histogram of our method. (c) MAD histogram of the Sinthanayothin et al method showing dispersion greater than our method.

Our approach gives a database average MAD of 7.37 ± 8.89 (mean $\pm$ standard deviation) and that of Sinthanayothin et al, 81.61 ± 87.09. Figure 2 (a) shows the MAD values for each image achieved with our method. It is easy to observe that our method

in general has lower MAD values than that of Sinthanayothin et al; in fact, the MAD for image 8 approaches zero. Figures 2 (b) and (c) show respectively the MAD histograms resulting from our method and that of Sinthanayothin et al.

3. Conclusions

We have presented a new method to locate the fovea center point. The performance of the proposed method is more robust than that described in the literature because lesions, i.e. exudates and microhemorrhages, surrounding the fovea region are eliminated. Our method is not negatively influenced by these lesions and the probability of finding false positive points is minor. Our method explores a new anatomic feature that eliminates candidate regions above the optical disk to find the best region of the fovea center point. However, it tends to fail in the presence of large hemorrhages because these may be darker than the fovea region as well as being located below the optic disk center.

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Integrating Evidence-Based Interventions into Client Care Plans

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Abstract. Within the mental health care system, there is an opportunity to improve patient safety and the overall quality of care by integrating clinical practice guidelines with the care planning process through the use of information technology. Electronic assessment tools such as the Resident Assessment Inventory – Mental Health (RAI-MH) are widely used to identify the health care needs and outcomes of clients. In this knowledge translation initiative, an electronic care planning tool was enhanced to include evidence-based clinical interventions from schizophrenia guidelines. This paper describes the development of a mental health decision support prototype, a field test by clinicians, and user experiences with the application.

Keywords. evidence-based practice, human computer interaction, health information technology, knowledge translation

Introduction

Health care professionals are called upon to create client care plans based on their assessment of clients' needs and their familiarity with appropriate interventions. This requires, among other resources, understanding of current best practices. The uptake of evidence into clinical practice is a complex area, one that formed the basis for the PARIHS conceptual framework, "Promoting Action on Research Implementation in Health Services"[1]. Doran and Sidani [2] used the PARIHS framework as a basis and created an intervention framework for outcomes-focused knowledge translation that links the theory about evidence-based practice, outcomes research, and quality improvement. In the Doran and Sidani framework, the choice of interventions is directly linked to the uptake of evidence in point of care planning. In turn this is related to the sources and quality of available evidence, patient preferences, the case context, and facilitation or coaching by advanced practice colleagues. They hypothesize that direct access to evidence-based resources at the point of care will increase nurses' utilization of interventions that are consistent with evidence-based resources and will ultimately result in improved patient outcomes [2]. In the current study, multidisciplinary health care team members were presented with electronic care plans,

client-specific practice guidelines and evidence about various treatments for clients who are living with schizophrenia.

The concept of actively involving clinicians in the implementation of clinical guidelines and of integrating guidelines into the decision making process are consistent with evidence-based recommendations of many researchers [3,4]. When research evidence and decision support are integrated at the time and place of decision-making, interventions are more likely to be successful [5] ultimately resulting in improved client outcomes.

1. Purpose

The purpose of this study was to evaluate the usability and effectiveness of a knowledge translation prototype system aimed at enhancing communication between health care professionals and improving patient-centred, evidence-based inpatient care for individuals diagnosed with schizophrenia. This paper focuses on the process of creating a knowledge-based system to enhance the quality of care plans, and the use of the system by multi-disciplinary health care teams during care planning meetings.

2. Setting

The study was conducted on inpatient units at a tertiary care mental health facility in Ontario. The participating units were part of the schizophrenia program. A total of 87 health care professionals (70 nurses, four psychiatrists, and 13 other health care professionals such as social workers and therapists) participated in the study.

3. Method

Research staff reviewed the literature and identified approximately ten international clinical guidelines for the treatment of schizophrenia, the majority of which were developed by psychiatric associations. We utilized Gaebel's [6] systematic review of the guidelines which used the AGREE tool (Appraisal of Guidelines Research and Evaluation) [7], a structured set of criteria developed by an international collaboration of researchers and policy makers from Europe, UK, Canada, Australia and New Zealand. The AGREE tool consists of 23 items in six domains, each representing different dimensions of quality. The six domains are scope and purpose, stakeholder involvement in guideline development, rigour of development, clarity and presentation, applicability, and editorial independence. Gaebel's review was augmented by including a more recent version of one of the guidelines.

An expert panel of 15 local mental health clinicians and decision-support specialists met to review published schizophrenia guidelines. It was agreed that the initial focus would exclude pharmacological guidelines due to their complexity and the short timeframe for the project. Rather than simply relying on the quality of the guidelines in order to decide among multiple resources, the expert panel included additional facility-specific criteria and customized the decision-support system to make it more appropriate for the institution at which the project was taking place. Guidelines