Automated Detection of Diabetic Retinopathy Using
Intuitionistic Fuzzy Digital Convex Envelope Segmentation
Algorithm

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Abstract- Diabetic retinopathy is an ailment of the retinal vessels, which progresses about in most of the diabetes mellitus patients with high blood sugar levels. A framework for automated detection of disorders of the retinal vessels is proposed and examined in this article. As intuitionistic fuzzy sets are being defined through membership and nonmembership functions, they play a vital role in digital image processing to detect the disorder part more clearly. Moreover, shape is a crucial one in numerous areas such as object identification, detection, geomorphology and biology characterization. The intuitionistic fuzzy digital convex envelope is used to measure and analyze the shape of the image of the affected part. The various stages concerned in the process are image acquisition, preprocessing and segmenting the disorder region by the new proposed intuitionistic fuzzy digital convex envelope algorithm. Foremost, this automatic segmentation method reduces the manual work errors and time consuming.

Keywords: Diabetic retinopathy, intuitionistic fuzzy digital (IFD) convex set, intuitionistic fuzzy digital (IFD) convex envelope, digital image processing, preprocessing, acquisition.

1. Introduction

Medical images are at the fundamental of medical science and they are the massive source of information that needs to be used. Medical image processing has been an interdisciplinary research arena fascinating expert from Computer sciences, physics, applied mathematics, statistics, biology, engineering and medicine. Computer-aided diagnostic processing becomes a vital part of clinical routine.

Afterward Zadeh’s initiation of fuzzy sets [1], numerous higher order extensions of fuzzy sets were anticipated by different researchers. Midst them Atanassov’s intuitionistic fuzzy sets[2] offer a modest, flexible and dense mathematical context to deal with with the uncertainties depicting real world structures. The intuitionistic fuzzy architecture has been effectively applied to various image processing problems. A novel image enhancement method using fuzzy morphological intuitionistic reconstruction function was proposed in [3]. An efficient intuitionistic fuzzy context for image processing is established in the
framework of contrast enhancement and edge detection in [4]. In [5], the thresholding technique was described with intuitionistic fuzzy sets and this tactic used intuitionistic index values by Atanassov to represent the hesitancy of the proficient in deciding which pixels belongs to the background and which belongs to the object.

In this article, a framework for automated detection of disorders of retinal vessels is proposed and examined. The various stages are concerned in proposed methods such as image acquisition, preprocessing and intuitionistic fuzzy based segmentation. Intuitionistic fuzzy sets are defined through membership and non membership functions which plays a vital role in digital image processing to detect the disorder part more clearly. This automatic method is reduced the manual work errors and time consuming. The image processing techniques are used to detect the disorders of the retinal vessels. The affected parts are detected and extracted by applying intuitionistic fuzzy set theory. This automatic method is reduced the manual work errors and time consuming.

2. Preliminaries
In this section, some definitions which play the vital role in this article are provided. Also, a brief introduction of the disease, Diabetic retinopathy is given.

2.1 Diabetic Retinopathy:
People with long standing Diabetes Mellitus can have a disorder of the retinal vessels, called Diabetic Retinopathy or Diabetic eye disease. This will damage the blood vessels in the retina and these blood vessels can swell and outflow or they can stopover the blood from passing through. In some cases, anomalous new blood vessels nurture on the retina. These disorders will tend to loss one’s vision.

The following are the two foremost phases of Diabetic retinopathy:
(i) Non-Proliferative Diabetic Retinopathy: In this phase, a minor deteriorating in the small blood vessels of the retina and the percentages of the vessels may swell and outflow liquid into the neighboring retinal tissue.
(ii) Proliferative Diabetic Retinopathy: It is a progressive form of Diabetic retinopathy. This ensues when anomalous new blood vessels and scar tissue form on the exterior of the retina.

Diabetic retinopathy underwrites 4.8% of the 37 million cases of loss of sight all through the world. A recent study in city population in South India estimates prevalence of Diabetic Mellitus in adult population as high as 28% and the frequency of Diabetic retinopathy in diabetics to 18%. Each year in the US, Diabetic retinopathy records for 12% of all new cases of loss of sight. It is also the primary reason of loss of sight of people aged 20 and 64 years.

2.2 Intuitionistic fuzzy digital subset:[6]
If \( A = \langle \mu_A, \nu_A \rangle \) is the intuitionistic fuzzy subset of the Euclidean plane \( E \). The IFD subset of the lattice points in \( E \) is defined by \( A_\alpha = \langle \mu_{A_\alpha}, \nu_{A_\alpha} \rangle \) with degree of membership \( \mu_{A_\alpha}(P) = \max\{\mu_A(R) \mid R \in P^+\} \) and degree of nonmembership \( \nu_{A_\alpha}(P) = \min\{\nu_A(R) \mid R \in P^+\} \), provided \( 0 \leq \mu_{A_\alpha}(P) + \nu_{A_\alpha}(P) \leq 1 \) for each \( P \in E \).

2.3 Intuitionistic fuzzy digital convex set:[7]
An IFD set \( A_\alpha = \langle \mu_{A_\alpha}, \nu_{A_\alpha} \rangle \) of the lattice points in the Euclidean plane \( E \) is called as an IFD convex set if for any two points \( P, Q \in A_\alpha \) and \( \alpha \in [0,1] \),
\[
\alpha \mu_{A^c}(P) + (1 - \alpha)\mu_{A^c}(Q) \geq \min(\mu_{A^c}(P), \mu_{A^c}(Q))
\]
and
\[
\alpha \nu_{A^c}(P) + (1 - \alpha)\nu_{A^c}(Q) \leq \max(\nu_{A^c}(P), \nu_{A^c}(Q)).
\]

\textbf{Notation:}
\[C(E)\] denotes the set of all IFD convex sets in \(E\).

2.4 Intuitionistic Fuzzy Digital Convex Envelope: [6]
If \(A_{\alpha} = \{\mu_{A_{\alpha}}, \nu_{A_{\alpha}}\}\) is an IFD subset of the lattice points in the Euclidean plane \(E\), then the IFD convex envelope of \(A_{\alpha}\) is \(A_{\alpha}^e = \{\mu_{A_{\alpha}}, \nu_{A_{\alpha}}\}\) whose membership and non membership functions are as follows,
\[
\mu_{A_{\alpha}}(P) = \inf\{\mu_{B_{\alpha}}(P) : \mu_{B_{\alpha}}(P) \geq \mu_{A_{\alpha}}(P) \text{ where } B_{\alpha} \in \mathcal{C}(E)\}
\]
and
\[
\nu_{A_{\alpha}}(P) = \sup\{\nu_{B_{\alpha}}(P) : \nu_{B_{\alpha}}(P) \leq \nu_{A_{\alpha}}(P) \text{ where } B_{\alpha} \in \mathcal{C}(E)\},
\]
provided \(0 \leq \mu_{A_{\alpha}}(P) + \nu_{A_{\alpha}}(P) \leq 1\) and \(P \in E\).

3. Methodology
In this proposed work, the concept of intuitionistic fuzzy digital convex envelope was applied to segment the affected region from the images. The aim of this work was achieved from the base of the intuitionistic fuzzy digital convex set together with the Euclidean distance based of membership and non membership values. These values are measured from the intuitionistic fuzzy digital image region. The region was extracted clearly by using this proposed algorithm.

Eye disorder image datasets were acquired through medical lab. Intuitionistic fuzzy digital convex envelope concept was applied in the image to detect the disorder part clearly. There are three main steps in this proposed work and they are as follows.
A) Image preprocessing
A digital image is basically a numerical representation of an object. After the image was acquired, the true color image \(f(x,y)\) is converted to hue, saturation and value. These values are extracted from 0 to 1. Then they normalized to \([0 \text{ to } 255]\).

B) Image Segmentation
Segmentation sections an image into is component regions or objects. The level of feature to which the subdivision is supported rest on the problem being resolved. The segmentation should stopover when the objects or regions of curiosity in an application have been spotted. Segmentation of nontrivial images is one of the greatest tough tasks in image processing. In this proposed work, the non membership and membership values of intuitionistic fuzzy digital convex envelope is applied to segment the disorder region more accurately compared to the existing method of fuzzy edge based segmentation.

The binary mask of all foreground objects in the input image, can be detected through the intuitionistic fuzzy digital convex envelope. The foreground defected object was detected via proposed method.

C) Measuring Image Region
After the segmentation process, each disorder region on the segmented image is measured by using the pixel values. Then calculate the standard deviation of each region in defected area through centroid, pixel values of the image and boundary box which are aided to detect the defected region.
The values of the standard deviation of the segmented regions lies between intuitionistic fuzzy convex envelope based segmentation and fuzzy edge based segmentation. The prevailing method of fuzzy edge based segmentation technique is not truthfully partitioning the disorder regions and the standard deviation region values are too low compared to the proposed algorithm.

4. Experimental Result
The proposed algorithm is developed by using matlab 2009b. Figure 3 illustrates the following.
(a) an original eye disorder image was acquired.
(b) applied the membership and non membership values of the intuitionistic fuzzy digital convex envelope to detect the disorder region
(c) computed the standard deviation between the disorder regions
(d) from the existing fuzzy edge based segmentation technique, some of the disorder regions are neglected
(e) segmented the regions by using fuzzy edge.

Figure 3: Intuitionistic fuzzy digital convex envelope based convex envelope and fuzzy edge based segmentation process

5. Conclusion
Automatic detection of the eye disease is assisted to reduce the time-consuming process. In this proposed work, intuitionistic fuzzy digital convex envelope based segmentation detected the disorders accurately.
compared to fuzzy edge based detection. Fuzzy based segmentation excludes the disorder regions. After segmentation process, measured the standard deviation values from the region of the segmented image. The standard deviation values are defined for the segmented areas by using the proposed method. It segmented the region properly with truthful information.

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