Iris Tracking Based on Fuzzy–Ripplet Techniques

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Abstract
In this research, a Medical Imagery Fusion multimodality technique grounded on Ripplet Transformation (RT) is employed as the source of "local" time series data. RT is a modern Multi-scale Geometric Analysis feature that has the capability of not only portraying image edges actually but also rebuilding two-dimensional uniqueness. Initially, discrete RT (DRT) is employed to translate the input medical images. This enables the application of unique fusion protocols to the sub-bands of the rendered images. A fused image is then extracted after the fused coefficients are combined with an inverse DRT (IDRT). Through quantitative measures such as Mutual Information, Spatial Frequency and Entropy, the performance metrics of the proposed strategy is determined. This shows that the approach as compared to the Contour let Transformation (CNT) fusion schematic performs much efficiently.
Keywords:
fuzzy models; Contour let Transformation; Ripplet Transformation; Iris Tracking.

1. Introduction

Based on fuzzy logic, fuzzy systems are mathematical implementations employed to assess analog input. With regards to logical variables, this input is made up of continuous 0 and 1 values. These systems are recorded in the field of soft computational models known as universal approximations. In time series analysis, fuzzy systems are categorically employed to analyze data related to trends, change in variances among other patterns. By nature, it's hard to perform a universal approximation of data that presents composite "local behavior" [1]. The efficiency of fuzzy models only meliorates when pre-manipulated information associated with time series about trends and seasonal patterns are employed. In this research, the pre-manipulated information is collected through the fusion of medical images by the proposed transformation method, the RT.

During analysis, relative information about human organs and tissues is manifested from the different modalities of imaging in medicine. According to [2], each portray a respective application scope. For example, high-depth images with anatomic data are extracted from a Magnetic Resonance Angiography (MRA), Magnetic Resonance Imaging (MRI) and Ultrasonography (USG). On another point of view, low-depth images are extracted from functional imagery such as Position Emission Tomography and functional MRI. Fusing the images collected from these two representation modes (i.e. anatomical and functional imagery) together enhance the collection of diverse and efficient information. Furthermore, the fused image records an improved visual complexion suitable for human viewing [3]. It also heightens machine perception making it possible for further manipulation and analysis.

The Iris is the round contractile membrane of the eye, which is suspended between the lens and cornea and perforated by the pupil (Figure 1 shows the anatomy of human eye). Iris movement denotes the specific locating and tracking of the iris and its center, using features such as shape, color, and size. The iris tracking system can be drawn in four stages i.e. image acquisition, face detection, eye detection and eye tracking. The stage of image acquisition is the entry of image or data to the system that will be about capturing of video by camera. The outcome of image acquisition stage is RGB space image. After this stage face, detection stage is carried out. Face detection is performed using one current technique called, color feature. The RGB space having light intensity data, pixel color data and face brightness is varied for different people and atmospheres, and utilize this RGB space to identify the face color, which is not efficient and creates some issues. Subsequent to face detection, the stage of eye detection is completed by using eye color, which varies from other face parts. The vertical and horizontal projections are used for eye detection. The last stage is eye tracking, the applicable technique used for this stage is particle filter. The particle filter is the technique computational and numerical to attain the random processes probability density function [4].

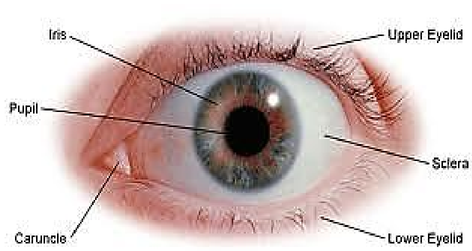

Fig. 1 The anatomy of the human eye.

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2. Elated Works

Over the years, various Image Fusion Techniques have been developed. However, they are constrained within three categories determined by the form after merging. These classes include feature level, decision level, and pixel or sensor level. Contrast reduction in images is recorded by the pixel-level image fusion methods [5]. On the other hand, techniques that entail Principal Component Analysis (PCA) Intensity-Hue-Saturation (IHS) and Brovey Transform record a higher contrast ratio but are affected by a spectral abjection.
Furthermore, [6] emphasizes that a Discrete Wavelet Transform (DWT) MRA tool has over the years been utilized for IF. However, the tool cannot convey spatial features efficiently but can otherwise maintain spectral data. Moreover, the isotropic wavelength transform does not record the correct multi-directionality and shift-invariance of images. It further fails to convey a desirable aspect of excellent anisotropic contours and edges within images [7]. This research paper looks into an MIF technique under the Multiscale Geometric Analysis tool, Ripplet Transform Type-I (RT). This method was suggested by [8] to handle the challenge presented by established transformation methods such as Wavelength Transform [9].
Fu andYang [10] introduced a high-performance eye-tracking algorithm, in which two eye templates, one for each eye, are manually extracted from the first video frame for system standardization. The facial region in a captured frame is detected, and a normalized 2-D cross-correlation performed to match the template with the image. Eye gaze direction is estimated by iris detection using both edge and Hough circle detection. The algorithm is used to implement a display control application; however, the calibration process is inflexible.

3. Methods

3.1 Ripplet Transform Type-I (RT)

Among the Curve let Transform (CVT) types, Ripplet Transform Type-I is a higher dimensional abstraction with the capability of conveying images and 2D signals into dissimilar scales and directions. A parabolic scaling law is employed by CVT to acquire anisotropic directionality. Concerning micro local analysis, 2D singularities along C2 are guaranteed with anisotropic nature of CVT. RT offers a strong modern frame that entails a thin representation of imagery that records discontinuities around C^d curves [11]. RT extrapolates CVT by including two different parameters, degree d, and support c. These parameters address the need for an optimal scaling law for all kinds of boundaries even when the parabolic scaling law is not adequate [12]. These parameters record the values c = 1 and d = 2. It is thus possible to represent singularities that exist along arbitrary shaped RT curves through the anisotropic capability [13]

3.2 Continuous Ripplet Transform (CRT)

The Continuous Ripplet Transform is expressed as the interior product of a 2D integrable function and the ripplet as illustrated below.
2D Integrable Function = $f(\vec{x})$ and Ripplet = $\rho_{a\vec{b}\theta}(\vec{x})$

$$R(a\vec{b}\theta) = \langle f, \rho_{a\vec{b}\theta}\rangle = \int f(\vec{x}) \overline{=\ \rho_{a\vec{b}\theta}(\vec{x})}\, d(\vec{x})$$

According to [5], where the ripplet coefficients are $R(a\vec{b}\theta)$ and the conjugate operator is $\overline{(.)}$. Equation 1's ripplet function is denoted as:

$$\rho_{a\vec{b}\theta}(\vec{x}) = \rho_{a\vec{0}0}\left(R_\theta(\vec{x}-\vec{b})\right), R_\theta = \begin{bmatrix} cos\theta & sin\theta \\ -sin\theta & cos\theta \end{bmatrix}$$

When the Ripplet element function is $\rho_{a\vec{0}0}(\vec{x})$, R_θ is defined as the rotation matrix while $\vec{b}$ and $\vec{x}$ are 2-Dimensional vectors. These vector variables denote the rotation and position parameters respectively [12]. Within the frequency domain, the following equation represents the ripplet function:

$$\hat{\rho}_a(r,\omega) = \frac{1}{\sqrt{c}} a^{\frac{1+d}{2d}} W(a.r) V(\frac{a^{\frac{1}{d}}}{c.a}.\omega)$$

$\hat{\rho}_a(r,\omega)$ is the FT of $\rho_{a\vec{0}0}(\vec{x})$ in the polar coordinate system, while a is the parameter defining scale. $W(r)$ Represents the 'radial-window' component while $W(\omega)$ represents the 'angular window'. Both windows maintain a compact support on $\left[\frac{1}{2},2\right]$ and $[-1,1]$ respectively. Furthermore, they fulfill the following admissibility requirements:

$$\int_{1/2}^{2} W^2(r)\frac{dr}{r} = 1$$

$$\int_{-1}^{2} V^2(t)dt = 1$$

4. Experimental

We applied the proposed method, and have used the algorithm with the generalized probability distributions, and with different parameters, leading to different results.Figure2shows iris tracking using theβ-distribution function, with 2000 particles on some frames. Figure 3 show the position of the centroid of the particles in each frame. . Figure 4 shows the tracked iris, using a Gaussian distribution function with 2000 particles on some frames.

Figure 5 shows the position of the centroid of the particles at each frame.

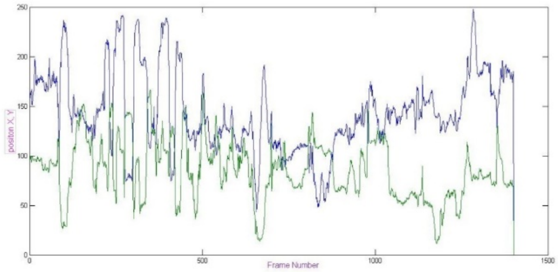


Fig. 3 Chart showing the position of the centroid of the particles at each frame, using β-distribution function (a = 1 and gamma = 3).

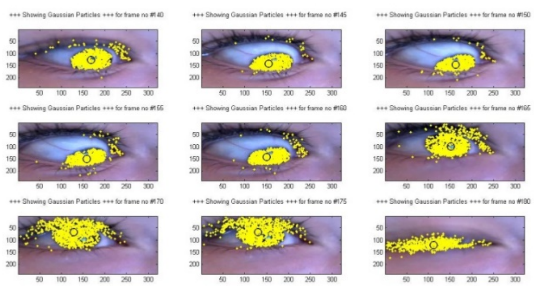


Fig. 4 Graphic showing the particles drawn on iris using a Continuous Ripplet Transform.

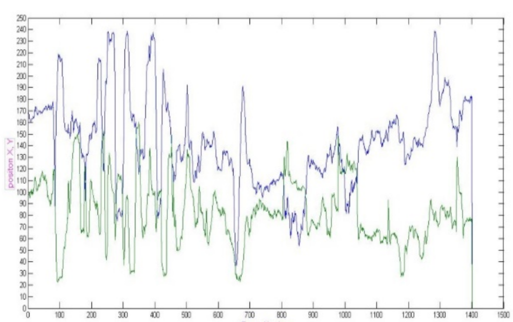
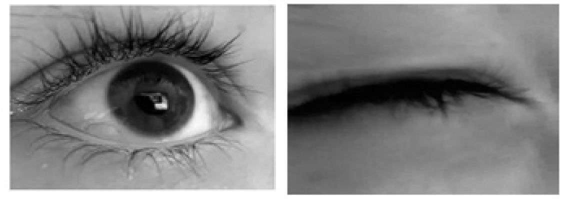


Fig. 5 Chart showing the position of the particle centroid in each frame, using a Gaussian distribution function (a=1 and gamma =0.5).

We resampled the parameters that are computed from log-likelihood by calculating the cumulative distribution; the resampled the cumulative distribution that matched the cumulative distribution for the open and closed eye color histograms for frames 1–1447. Figure 6 show the histogram for iris tracking through an open and closed eye.



a. Open eye b. Closed eye

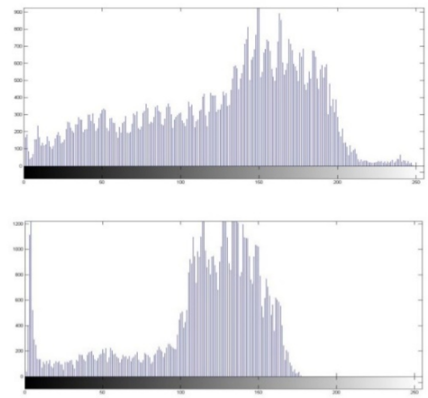


Fig. 6 Top: examples of closed and open eyes. Middle/bottom: Charts showing histograms for the closed (middle) and open (bottom) eye in frames from 1 to 1447.

Most iris tracking methods, rarely investigate the required CPU time. However, real-time applications require investigation and optimization of performance requirements. In addition, most studies do not address the measurement of computation time. Using the proposed method, we were able to trace for a shorter length of time, compared to published methods [14], and the computation time of the approach is also faster. Table 1 clearly shows that computation time is reduced to about 3.22 ms

Table 1: Compares the described iris tracking methods with the proposed method.

Method	**Detection Accuracy %**	**CPU time ms**
Raudonis*et. al.*,[15]	100%	N/A
Kuo*et.al.*,[16]	90%	N/A
Yuan &Kebin [17]	N/A	N/A
Lui&Lui[18]	94.1%	N/A
Khairosfaizal&Noraini[19]	86%	N/A
Hotrakool*et.al.*,[14]	100%	12.92
Proposed method	100%	3.22

5. Conclusion

In this paper, we have proposed a new approach for tracking the iris, based on Fuzzy - ripplet methods. The research focuses on Fuzzy - ripplet methods for time series analysis. It goes through the analysis of various transformation methods based on the Ripplet Transform Type. This is done through the fusion of a number of medical images to determine the better method. Various algorithms are then defined to enhance the quality of the acquired results. A performance metrics section is then recorded portraying the overall results of each and every method. This helps determine the best and most recommendable ripplet transformation method to employ while collecting medical time series data. In this regard, the low frequency original subbands are fused while relying on the max selection rule. The results show that the suggested method leads to more useful data on the fused image which tends to have an improved resolution and minimal difference with the original image. In addition, we can improve many applications that introduce in [20-23].

In this paper, we have proposed a new approach for tracking the iris, based on Fuzzy - ripplet methods. In this method, a sample set of the tracked iris is constructed at the beginning of the tracking process. Then, we have predicted the prior representation and position of the tracked iris, depending on minimization of the parameters of the proposed generalized probabilistic distribution. The computation of the likelihood of generalized particle filters for each distribution function is then estimated. Our approach had provided reliable results with a low error rate, and low levels of computation. This technique aimed to improve the speed of the eye-tracking algorithm so that can be used for real-time applications. The results show that the proposed method is robust and works smoothly in real time.

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