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Iris Features Extraction and Recognition based on the Scale Invariant Feature Transform (SIFT)

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Abstract

Iris Biometric authentication is considered to be one of the most dependable biometric characteristics for identifying persons. In actuality, iris patterns have invariant, stable, and distinguishing properties for personal identification. Due to its excellent dependability in personal identification, iris recognition has received more attention. Current iris recognition methods give good results especially when NIR and specific capture conditions are used in collaboration with the user. On the other hand, values related to images captured using VW are affected by noise such as blurry images, eye skin, occlusion, and reflection, which negatively affects the overall performance of the recognition systems. In both NIR and visible spectrum iris images, this article presents an effective iris feature extraction strategy based on the scale-invariant feature transform algorithm (SIFT). The proposed method was tested on different databases such as CASIA v1 and ITTD v1, as NIR images, as well as UBIRIS v1 as visible-light color images. The proposed system gave good accuracy rates compared to existing systems, as it gave an accuracy rate of (96.2%) when using CASIA v1 and (96.4%) in ITTD v1, while the system accuracy dropped to (84.0 %) when using UBIRIS v1.

Keywords

Biometrics System, Difference of Gaussian (DoG), Feature Extraction, SIFT.

Introduction

Biometrics is the study of immutable, observable biological features that are used to verify and classify people(Pathak et al., 2020). A biometric based system is a pattern recognition methods that uses biometric for person's identifications. The fundamental aim of biometrics is to identify a person's identity based on "whom it is" and not on what it owns" (e.g., ID card) or what it remembers" (e.g., a password (Minaee et al., 2019) (Shah, 2006). Each human has a distinct, personally recognizable form, height, eye colour, voice, and others. Modern science used these variations to differentiate between people and in practically no mistake. The first approach is termed physiological identification, which is interested in the form of the body, such as the face, fingerprints, geometry of the hands, and the detection of iris. The second type is called behavioural, which has to do with a person's actions, such as signature and voice (Vyas et al., 2020) (Soliman et al., 2020). Iris Recognition technology is considered one of the most effective ways of protecting airports, government buildings, and research laboratories (Adamović et al., 2020). The iris is the ring portion between the black pupil and the white Sclera. In addition to helpful parts, such as the iris, the image of the iris also includes outside elements, such as noise like the eyelid, pupils, eyelashes, specular highlight. There are, in general, several characteristics that make an ideal biometric iris system, the first being that the features "no two iris are the same" even between the left and the right eye for the individual. The second is the consistency of the iris pattern(Agarwal et al., 2020b), which remains constant over the life of an individual with a data-rich physical structure. Iris identification systems have been one of the most active research subjects in biometric technology for the last few decades, as iris patterns have reliable and distinctive personal identity characteristics (Diaz et al., 2020) (Ali et al., 2007).Iris includes complex tissues that differ from person to person (Agarwal et al., 2020a) (Shah, 2006), as seen in fig 1.

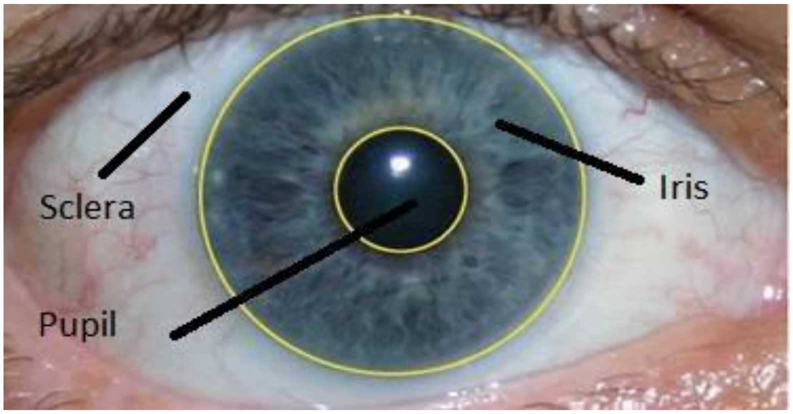


Figure 1 Human eye

Iris recognition, though a well-studied problem, has only been focused on iris images obtained in (NIR) wavelengths most common iris recognition techniques. However, no broader use of NIR sensors on mobile devices makes it harder for smartphone devices to use these approaches. Furthermore, NIR pictures do not present difficulties such as illumination and reflection. The emphasis was, therefore, on more real and difficult iris images captured in the visible wavelength (VW). One of the first attempts to estimate the efficiency of iris recognition on bright VW images was the brilliant iris challenge assessment (NICE) Sections I and II. The competitions have been tested on iris databases UBIRIS.v1 and UBIRIS.v2 (Vyas et al., 2020).

There is a need to build a straightforward iris recognition method that needs no knowledge from the use. Iris recognition techniques are accurate calculations based on the distinctive characteristics of the iris. In addition, in NIR, as in visible wavelength iris images, the method developed should be equally efficient. Both these essential criteria arise from biometric surveillance systems when they are implemented in public viewing, requiring the combination of input data (from VW-based surveillance cameras) and NIR databases which are already processed. This paper thus leads to a simplified approach to iris extraction. We test our frameworks for the publicly accessible image dataset, such as CASIA v1, ITTD v1, and UBIRIS.V1, to analyze the suggested strategy's efficiency. The purpose of this study is to formulate and construct a statistical extraction method based on the Scale Invariant Feature Transform (SIFT) for extracting relevant iris texture characteristics from both NIR and VW iris images. To analyze system performance, the accuracy, false acceptance rate (FAR), false refusal rate (FRR), and genuine acceptance rate (GAR) are all used.

The following is an overview of the paper's structure. Section 2: Additional Works The suggested iris recognition system is described in detail in Section 3 and all of its phases are explained. The results are given in Section 4 and compared to existing technology. Finally, in Section 5, there are some conclusions.

Related Works

Various studies in this area of iris recognition systems based on NIR iris images have been carried out. A brief of various works that provide information on different methods of extraction by the system of iris recognition is discussed in this section.

Daugman was developed with phase features for the first commercial iris identification system. 2D-Gabor filters are used in this method to extract a feature vector, size 256 bytes, from the iris ROI model in the normalized iris image. Although the computational complexity is able to achieve a good recognition rate, it increases in time with Gabor (Liu et al., 2020).

The paper in (Sarhan, 2009) included extraction and identification of iris features based on a 2D discrete cosine transformation. A primary iris detection system mainly involves four phases, including a collection of images, image preprocessing, and extraction and matching of features. Iris localization has been achieved by the circular Hough transform. After the iris is located, iris-based images are normalized to turn the iris area into a fixed dimension by the Daugman rubber-sheet model. Feature modulation has been used to obtain the most discriminating characteristics of the iris and is achieved by 2D DCT.

Two Dimensions Discrete Wavelet Transform (2D DWT) was used in iris feature vector extraction, as seen in (Masood et al., 2007). In this article, the pupil and iris borders are defined using the histogram of an image of the iris using a location technique. To minimize machine time and to improve performance, two small portions of the iris are being used for polar transformation. Iris rotation is offset without iris code changes. The system is checked in the Iris University multimedia database, and results indicate that the approach proposed has a good performance.

Gabor filter is applied in two separate ways on iris images as demonstrated in (Minhas & Javed, 2009). To obtain iris features. Firstly Gabor filter is applied in one way to the whole image, and specific characteristics are extracted from the image. Second, it is used to gather local image information and combine it to establish global characteristics. The findings are compared using various filter banks with 15, 20, 25, 30, and 35 filters.

The author in (Devi et al., 2016) (M. Taha & Ahmed, 2021) concentrates primarily on the extraction of the texture of an image using GLCM technology. GLCM reflects a spatial relation between various intensity values based on a non-filter technology (Rashid et al., 2020). First, by combining the Circular Hough Transform (CHT) as circular object detector and the Canny as edge detector, the iris area is found. The texture characteristics are extracted from the standard image. Contrast value, difference, energy, and entropy are measured.

The work suggested in (Rashad et al., 2011) proposes a framework based upon local binary patterns, histogram features as a statistical approach to extraction, and a neural-network system based on the combined learning vector quantification classification to create a hybrid model that depends on both the f-and combined learning vector quantification classifications. The localization and segmentation techniques are provided with a combined

LVQ classification with different groups to determine minimum appropriate performances using the Canny Edge Detecting and CHT for the purpose of isolating an iris from the overall image and for noise detection.

Restores the properties of the iris of the eye in different ways, most of which depend on imaging the eye using NIR, and a little depends on visible light due to noise. As a result, this study suggests that attributes in NIR and visible wavelength (VW) iris pictures be retrieved using the SIFT approach.

Proposed Methodology

Because of the stability and uniqueness of the iris of the eye, this system is one of the most reliable authentication systems as compared to other systems that rely on face, fingerprints, speech retina, etc. As shown in Figure 2, the most of iris recognition systems go through various steps: segmentation, iris normalization, feature extraction, and matching. In the features extraction stage, the characteristics of each person are retrieved and used for comparison with other people. It is a form of data reduction that delivers most information about the actual image of an iris. To make an easy and accurate comparison between templates, the feature coefficient is encoded when the feature is retrieved. The extraction of iris texture features from the databases CASIA v1, ITTD v1 as near infra-red images, and UBIRIS v1 as VW images is the subject of the research.

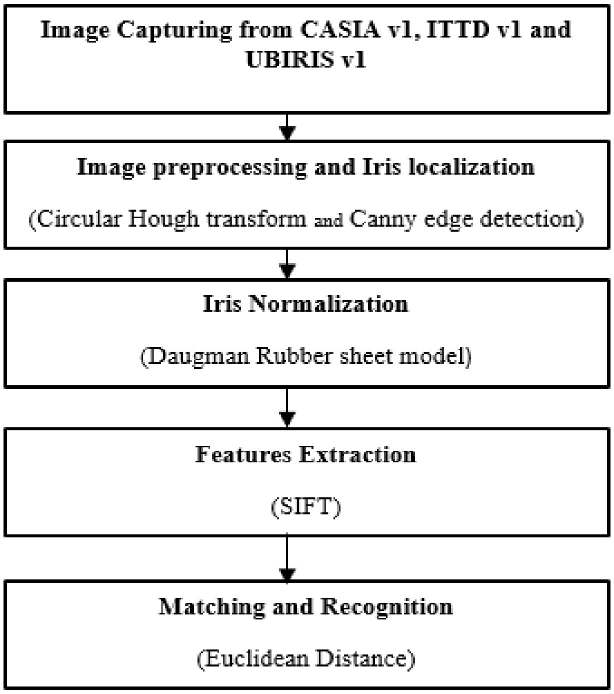


Figure 2 Proposed recognition systems

Image Acquisition

The initial stage entails gathering input images from a variety of sources. The total performance of the recognition system is influenced by the image quality. In this research, pictures from ITTD v1, UBIRIS v1 and CASIA v1 (Omran & Al-Shemmary, 2020) were used. CASIA v1 is made up of 756 iris scans from 108 people and 7 images from two independent sessions separated by at least one month. Both 8-bit grey images have a resolution of 320 to 280 pixels and are saved in bitmap format.

The iris images received from IIT Delhi students and staff make up the majority of the IITD v1 image database. From January to July 2007, the Biometrics Research Lab used JIRIS, JPC1000, and a digital CMOS camera to build this database. The photos that were collected were saved in bitmap format. Researchers can access 2,240 photographs from 224 distinct individuals in the database for free. There are 176 men and 48 women in the sample, all of whom are between the ages of 14 and 55. All of these shots were taken inside and have a resolution of 320 × 240 pixels (Ajay Kumar & Passi, 2008).

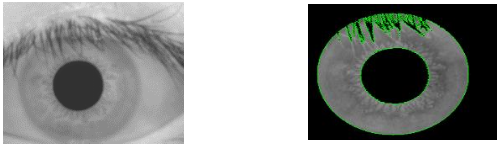
In September 2004, UBIRIS.v1 collected 1877 photographs from 241 person in two distinct sessions. Noise components related to contrast illumination, reflections, and in the initial image capture session, have been reduced. In the second session, the researchers changed the position of the pickup to add a natural luster. This allows for the appearance of heterogeneous pictures in response to reflections, contrast, light, and concentration issues (Proença & Alexandre, 2005). NIR imaging datasets ITTD v1 and CASIA v1 are available, while VW noisy image files UBIRIS v1 are available.

Image Preprocessing and Iris Localization

The next stage is preprocessing after the eye picture has been taken or received (M. A. Taha, 2017). To improve the tool's capacity to identify traits and artefacts, images are pre-processed. Preprocessing, such as extending intensity, histogram equalization, and noise reduction, can be as simple as adjusting intensity. A high-resolution camera is used to photograph the iris. The original image must be preprocessed to remove extraneous objects such as the eyelash, pupil, and so on. To remove picture noise, pre-processing images is a vital step in various applications.

One of the most crucial aspects of the iris recognition process is iris location. The iris's outer and inner borders can be found. Sclera, iris, and pupil are the three parts of the eye. Sclera is a white, iris-like substance. The pupil is located in the iris and varies in size depending on the light intensity. Because iris stores texture data, it should be addressed. There is an approach to identify the eye with a set of phases in (Othman, 2016) that can provide good results when combined with Circular Hough Transformation (CHT) (Kazakov, 2014). The iris field is detected using the circular Hugh Transform, which is limited to a manually specified interval based on the dataset. The eyelids are isolated using Hough Transforms (Aminuddin et al., 2017) and the Canny Edge detection line (Devi et al., 2016). As shown in Figure 3, the eyelids and any reflections are excluded by the threshold.

(a) ITTD.v1 (b) ITTD



(c) CASIA.v1 (d) CASIA

(e) UBIRIS.v1 (f) UBIRIS cropped Iris

Figure 3 ITTD v1, CASIA v1, and UBIRIS v1 Database Original and Cropped Iris

Iris Normalization

The object's coordinates are converted from Polar to Cartesian coordinates during normalization. If the iris region has been located, it converts to fixed dimensions' aria. The fixed size of the iris image aids the extraction procedure in comparing the two iris images (Othman, 2016) (Abhineet Kumar and colleagues, 2016). Dimensional discrepancies may emerge as a result of pupil dilatation caused by shifting illumination levels. Camera rotation, changing picture distance, eye rotation, and head tilt, on the other hand, can cause dimensional incoherence within an eye socket. This indicates that the normalizing technique is required to produce two photos with the same iris in different situations. However, there are other algorithms available; the Daugman Rubber Sheet Model is used in this study (Abhineet Kumar et al., 2016). The rubber sheet approach, shown in Fig 4, remaps coordinates within the iris region to a pair of polar coordinates (r, θ), where r is on the interval [0, 1] and angle [0,2 π].

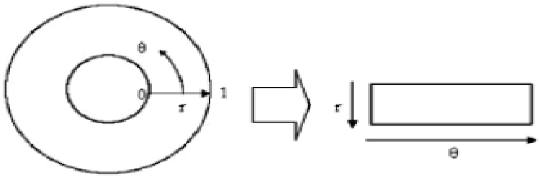


Figure 4 Daugman rubber sheet model

Iris Features Extraction by SIFT

Lowe (Low, 2004) introduced the Scale Invariant Feature Transform (SIFT). The image is converted into a collection of local feature vectors by the SIFT technique. These feature vectors should be separate and invariant to picture scaling, rotation, and translation.

The local extrema of Difference of Gaussians (DOG pyramid) as given by Eq (3) are used to determine the feature locations in the first stage. The input image is iteratively convolved using a Gaussian kernel to implement the DOG pyramid Eq (2). As long as down-sampling is possible, this technique is repeated. An octave is a group of images that are all the same size. Eq (1) combines all octaves to form the Gaussian pyramid, which is represented by the 3D function L(x, y, σ) (Karami et al., 2017):

$$\mathrm{L}(\mathrm{x},\mathrm{y},\sigma) = \mathrm{G}(\mathrm{x},\mathrm{y},\sigma) * \mathrm{I}(\mathrm{x},\mathrm{y}) \qquad (1)$$

$$\mathrm{G}(\mathrm{x},\mathrm{y},\sigma) = \frac{1}{2\pi\sigma^2} e^{-(x^2-y^2)/2} \qquad (2)$$

$$\mathrm{D}(\mathrm{x},\mathrm{y},\sigma) = \left(\mathrm{G}(\mathrm{x},\mathrm{y},\sigma) - \mathrm{G}(\mathrm{x},\mathrm{y},\sigma)\right) * \mathrm{I}(\mathrm{x},\mathrm{y})$$
$$= \mathrm{L}(\mathrm{x},\mathrm{y},\mathrm{K}\sigma) - \mathrm{L}(\mathrm{x},\mathrm{y},\sigma) \qquad (3)$$

The DOG function's local extrema (maxima and minima) are determined through evaluating every pixel with its 26 magnitude neighbors, as shown in Figure 5.

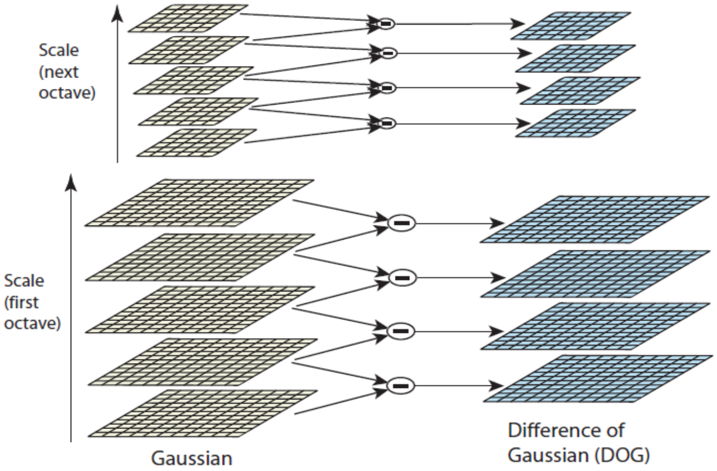


Figure 5 Local extreme detection in DoG scale space (Low, 2004)

The local extrema (maxima or minima) of the DOG function are discovered by comparing each pixel to its 26 scale-space neighbors, as shown in fig5. Because they lack a scale above and below, the beginning and end images in each octave are eliminated from the search for extrema. The discovery of scale-space extrema produces a large number of keypoint candidates, some of which are unstable and useless (Mishra & Panda, 2016).

The next step is to do a comprehensive fit to the adjacent data in order to determine the Principal curvatures are accurately located, scaled, and proportioned(Gandhi & Kulkarni, 2014).This information is useful for points with low Contrast or for estimating the position of each candidate keypoint using interpolation of surrounding data. With the candidate keypoint as the origin, the interpolation is performed using the quadratic Taylor expansion of the Difference-of-Gaussian scale-space function, D(x, y, σ) as seen in Eq (4) below (Hashim & Al-Khalidy, 2021):

$$D(x) = D + \frac{\delta D^T}{\delta x} X + \frac{1}{2} x^T \, \frac{\delta^2 D}{\delta x^2} X \qquad (4)$$

At the candidate keypoint, D and its derivatives are evaluated, and x=(x, y, σ) represents the offset from this point.

Then, based on the local image gradient directions, each keypoint is assigned one or more orientations. Because the keypoint description can be represented relative to this orientation, invariance to picture rotation can be obtained. The Gaussian-smoothed picture L (x, y,σ) at the keypoint scale σ is first taken to verify that all computations are scale-invariant. As shown in Eq(5)(6) below, the gradient magnitude, m(x, y), and orientation, Θ(x, y), are precomputed using pixel differences for an image sample L(x, y) at scale σ (Karami et al., 2017).

$$m(x, y) = \sqrt{(L(x+1, y) - L(x-1, y))^2 + (L(x, y+1) - L(x, y-1))} \qquad (5)$$

$$\theta(x, y) + \tan^{-1}\left(\frac{L(x,y+1) - L(x,y-1)}{L(x+1,y) - L(x-1,y)}\right) \qquad (6)$$

Matching and Recognition

The template created during the feature extraction procedure requires a suitable matching metric for the two iris templates as similarity measurement. Similarity measures used should give similar or identical values when comparing among templates belonging to the same person and different values when comparing templates belonging to different persons taking into account the value of Threshold. The corresponding choice is made using the Euclidean distance (ED). It is the most often used measurement. The square root of the sum of the vector difference squares is used to calculate Euclidean distance. The ED is calculated by comparing the test iris vector (VT) to the specified vector (VC) in Eq (7).

$$\boldsymbol{ED} = \sqrt{\sum(\boldsymbol{VT} - \boldsymbol{VC})^{\ 2}} \ (7)$$

Results and Discussion

False Acceptability Rate (FAR), False Refusal Rate (FRR), and Genuine Accepted Rate (GAR) were utilized to measure the efficiency of our method (GAR). FAR stands for falsely accepted impostor attempts, whereas (FRR) stands for genuine attempts that were incorrectly refused. The genuine acceptance rate (GAR) is a ratio of real users who are approved by the system; it is expressed as (100-FRR) in percent and is also referred as accuracy rate. In this article, experiments were conducted in three databases: IITD v1, UBIRIS v1, and CASIA v1. For a total of 100 people, the system examined eyes images. Each person has seven photographs, one for testing and another for training. The number of iris photos successfully differentiated in both datasets is shown in Table 1.

Table 1 Result analysis of different databases

Database	**FAR**	**FRR**	**Recognition Rate**	**Time**
CASIA v1	0.0	4.08	96.2	0.418 ms
ITTD	0.0	4.06	96.4	0.320 ms
UBIRIS v1	0.0	16.0	84.0	0.496 ms

Table No. 1 clearly shows us that the results extracted from the images in the database of CASIA v1, IITD v1 are better than UBIRIS v1 because the images taken from IITD v1, CASIA v1were taken using NIR and within a fixed distance, which is reflected in the clarity of the image and the lack of noise, in contrast to the images taken from UBIRIS v1, It clearly shows us the effect of noise on the quality of the information extracted from the image, which negatively affects the efficiency of the system. The results clearly show us that the time spent in CASIA v1, IITD v1 and UBIRIS v1 changes with the change in the image size, as large-sized images take more processing time, such as UBIRIS v1, in Contrast to small-sized images such as IITD v1.

Comparison with Existing Algorithms

Iris identification system performance analysis is dependent on FRR, FAR, GAR and the number of coefficients required to fit iris templates. The proposed approach was compared with other existing iris recognition system extraction algorithms. Table 2 shows how different algorithms compare in terms of detection rate and technique.

Table 2 The recognition rates of various algorithms

Authors	**Methods**	**Recognition rate**
J. Daugman (Daugman 2009)	Gabor filter	100%
Shervin Minaee_, Amirali Abdolrashidi (Minaee and Abdolrashidi 2019)	CNN	95.5%
Basma Ammour, Larbi Boubchir (Ammour et al. 2020)	2D Log Gabor filter	99.16%
Muthana H. Hamd and Samah K. Ahmed (H. Hamd and K. Ahmed 2018)	Principal component Analysis PCA	96%
Venkateshwarrao Pasam, Vijaya Madhavi Vuppu, etc. (Vuppu et al. 2019)	GLCM	93.33%
Proposed methods	SIFT	96.2%

Table 2 reveals that the Daugman technique exceeds all other current algorithms in terms of recognition rates. It delivers a 100 percent recognition rate. However, Daugman's technique is typically slower than any other contemporary technique. It compared two iris templates using many bits. SIFT has a good discrimination efficiency and is rotation invariant. Time taken by the proposed system increased as the number of extracted keypoints increased.

Conclusion

Iris identification is a growing field with important applications in a variety of fields. The iris has a distinct physical structure that is dense with data, making it one of the most reliable methods of identifying a person.

In this work, SIFT technique is chosen because it is robust against variations in scale and rotation. In addition to this, uniform features constitute a large percentage of dominant (or discriminant) features, which the SIFT method extracts from images. On CASIA, ITTD, and UBIRIS data sets, the proposed approach was checked and validated with the accuracy of respectively 96.2, 96.4, and 84.0%. These findings from the technology offered are better than those from some other methods in terms of the accuracy of recognition. Different iris properties can be investigated further in the future, which can help enhance system precision and be tested on other datasets under a variety of constraints and settings to improve system activity in real-time applications. This article was sourced from a public iris dataset. To see how it works with non-cooperative databases, it must be utilized with them. Shifting iris and distant iris are two further issues.

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