DETECTION OF BIO ELEMENTS PRESENT IN HUMAN BIOLOGICAL TISSUE- TOOTH AND ITS USAGE FOR ELEMENT BIOMETRIC AUTHENTICATION

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ABSTRACT

Biometric authentication system uses some technique that measures the physical and biological characteristics of human to identify individuals and thus provide security to a system against fraud or intrusion. Common biometric authentication processes are vulnerable and possibility for imitation. Teeth are an important biological entity that plays a major role in forensic research to identify an individual whom cannot be identified visually. There are different algorithms used in biometric authentication. This paper proposes a unique method to recognize the human teeth by using a combination of Discrete Fourier Transform (DFT) and Discrete Cosine Transform (DCT) to extract significant features and an improved version of Binary Particle Swarm Optimization (BPSO) for feature selection is employed to search the feature vector space in order to obtain optimal feature subset to increase the performance rate. A combination of image pre-processing techniques like background removal, gamma intensity correction and Laplacian of Gaussian (LoG) filter are used to help in correct feature extraction. Using the shift invariance property of DFT, a circular feature extraction technique and the energy compaction property of DCT, a circular sector feature extraction method is presented. Experimental results on IvisionLab/dental-image standard database are shown which exhibit promising performance of the teeth recognition system.

Keywords: Teeth Recognition, Discrete Fourier Transform, Discrete Cosine Transform, Binary Particle Swarm Optimization, Biometric Authentiction.

1.0 INTRODUCTION

Biometric Authentication is the process of identifying an individual from their Biological, Physical and Gesture characteristics. Biometrics remains to be the strongest strategy for verifying personal identity and authenticity. Instead of relying on details that can be easily memorized, such as passwords or tokens, a person is being verified by his or her own unique physical features at present. The physical features are carried out everywhere and so stronger than passwords [1]. The Biological tissue Human Teeth contains various elements and trace elements. Trace elements are found in two types. They are available in stable form (in nature) and unstable form (radioactive) and these two kinds of elements enter into the human through food intake, air and water. These are transferred to various parts of the human via the digestive system, respiratory system, or dermal absorption [1].The variation of element concentration depends on many factors such as environmental conditions and mineral intake within the individual's diet [2]. Once they enter in to the human body, the bio elements or trace elements were stored in various parts of the physical body and they are consistent with their chemical properties. As an example, the element iodine is stored within the thyroid; the elements potassium, radium, thorium and potassium are stored within the bones; plutonium is accumulated in both the liver and bones [3]. The various stable elements play a vital and inevitable role in human organ, health and tissue function. The intake of several specific stable trace elements and absorption of some bio elements that has toxicity can cause some damage to the human beings. For example, the deficiency or excess of sodium can bring heart disease and the element, Magnesium**,** can cause damage to vessels and intestines of the human body. So the observation is needed to study the deficiency or excess of trace elements in biological fluids and tissues [3]. Biometrics refers to the use of physical characteristics of humans to identify individuals using technology to be used for authentication purposes. Personal identification using biometrics has gained significant importance in recent years. Using various physiological features of humans, namely face, fingerprints, iris and voice, personal identification has been made achievable.

The remainder of this research paper is roughly divided in 5 sections. Section “Background” defines in the section the main themes along the paper it also presents the imitation of existing biometric authentication methods. A solution approach to the stated Problems is presented in section “proposed method”. Research

methods and the obtained results are presented respectively in section “results and discussions”. The research results are concluded “Conclusion”

2.0 BACKGROUND STUDY

A technique for teeth recognition by characterization of key local features so the local sharp variations are used to represent the teeth in [4]. A teeth recognition system using morphological method for feature extraction is described in [5]. the sum of the dissimilarity residues obtained from tophat morphology operator is used to represent the tooth and uses SVM classifier. A feature extraction method using the Local Mean Decomposition (LMD) technique is used in [6]. It is a multi resolution decomposition technique and uses the deterministic features of the teeth. A Circular Hough Transform to reveal teeth boundaries and DCT as a feature extractor is used in [7]. Off gaze images are worked on by using Principal Component Analysis (PCA) which helps to solve the limitations of Gabor filters in [8].

2.1 Trace Elements in Tooth

The concentration, content and composition of trace elements are different in permanent tooth and sound deciduous. It depends upon the type of the teeth [9]. The presence of chemicals or trace elements in the human serum, whole blood and urine was analysed in previous studies. The drawback of using human urine, blood and serum is that the concentration of trace elements is stable for some days and may be for a week. After those periods, the concentration varies. So it has been proved that the biological entities like urine, serum and blood is used as transient Biometrics [10]. The trace elements concentration in biological tissues is stable for few months. So the selection of biological tissue Tooth for biometrics is the right choice among other biological entities. Previous studies include the concentration measurement of biological fluids like plasma, urine, whole blood, serum, breast milk, sweat and saliva and also in the biological tissues hair, nail, brain regions and tooth. They are often measured in the fields such as forensic identification, paleoecology, scientific archaeology and the other area of research [11]. The Element biometric analysis methods help us to figure out the geographical origin of human beings also. The Element biometric analysis assist in identifying the elements that are important for the function of the human body and important for the growth function of the human body, This also helps to the development of human body, metabolism, and endocrine function. The same also play a vital role in environment and pollution through detection of toxic heavy metals in tissues and fluids of human beings. These biological entities are considered for soft Biometrics [12].The concentration of trace and other elements in deciduous teeth are applied mainly in environmental field because the information on metals or chemicals, trace presence obtained from the environment during the development of tooth is not same as the person grows. So, the study is performed on the teeth regarding the age and gender related changes [12]. The study has also been performed on the different parts of the teeth and type of the tooth, such as the tooth part (root, crown, Cementum, pulp, and enamel and dentine). The dynamics in elemental content may be due to the several factors such as intake of the food, air, and water and also from the surrounding [12]. The pollution of environment may also cause diseases in humans and also heavy metals like cadmium, Pb can also affect the composition and concentration of human tooth. The mineral concentration and composition of human teeth also be destroyed by the applied fillings in permanent and primary teeth.

2.2 Comparison of Element Biometrics with other Biometrics

In the element biometrics the trace and other elements present in the human are easily collected and it is always present permanently inside the human such as the blood, serum and outside the human body such as hair, tooth and nail [13]. The element biometric is very accurate as it is not determined with more calculation and comparison of the observed value is used for determination of an individual. It does not need different kind of algorithm usage like other biometrics as element biometrics need classification and comparison only. This uses only numeric data and not an image. The scale or size of the database is very small compared to other database of present biometrics. This is very easy to use and can be accepted like other biometrics in future.

Table1: Comparison of all present biometric

	Security	**Accuracy**	**Permanence**	**Usability**	**costs**
Fingerprint Recognition	*	*	*	+	*
Facia- Recognition	*	*	*	+	-
Hand Geometry	+	*	*	*	+
Iris	+	+	+	-	+
Retin Identification	+	+	+	-	+

Table 2: Comparison of Samples or biological entities used for element biometrics

Samples	**Security**	**Permanence**	**Accuracy**	**Usability**	**Cost**
Tooth	+	+	*	+	Less
Blood	+	-	-	+	Less
Serum	-	-	+	-	Less
Urine	-	-	-	-	Less
Brain regions	+	+	+	+	Less

+ = High
- = Low
*** = Medium**

2.3 Limitations of present Biometric techniques

With Finger Print biometrics, the authentication cannot be done using finger prints if the fingers are too warm, dry, wet and oily etc. Permanent damages of finger or any cuts in the finger can make fingerprint recognition impossible [14]. With Iris biometrics, Eye diseases may cause this recognition a difficult one. For Example issues like black fungus disease spread makes the eye or iris recognition a complicated one. With face biometrics, the face recognition is difficult due to the factors such as hairstyle, make-up, facial hair etc. The scarf, glasses, hats etc., which is worn by the individual can cause improper identity.

Sometimes Drastic changes in skin colour and also weight dynamics, exposure to sun etc, are the factors for the failure of face recognition. With Hand geometry, the factors such as decreases or increases in weight, some cuts or any injuries, water retention and swelling etc., can make hand recognition a failure biometric system. Hands of some people cannot be identified if they have any diseases such as paralysis, arthritis. Sometimes the Image Acquisition devices are prone to error if the environments vary. Voice the cold and flu are such factors which make changes in the human voice. With DNA Biometrics, if Identical twins have the same DNA structure and sometimes this authentication also fail to recognise human. To overcome the above difficulties in the present biometrics a new biometric system is designed and it is called as element biometrics [15].

There are some biometrics methods such as face recognition, iris, retina, palm geometry, voice recognition, signature identification recognition and verification and gait analysis [15]. The present Biometric system such as

iris, retina, finger, Face as well as the gait, DNA, and Palm geometry are techniques which takes more storage and more processing time to compare the individual data and also use various complex Algorithms. Because of the current biometrics system contains images and those images require complex devices such as camera and scanner and it required more storage to store the images. It take complex algorithms to solve, requires more cost and many comparisons are to be done to process the individual data and to verify them [16].

2.4 Advantages of element Biometrics

Present biometrics available contains more databases and image based information. So the compression techniques have to be implemented. But elements based biometrics has less compression techniques needed. Trace-Element based authentication could be implemented with Artificial Intelligence techniques also. The concentration of trace elements is fully accurate compared to other biometric system [17] and more secure than existing biometric authentication system.

Existing biometrics methods are limited. They are storage space consuming, require huge devices, and costly. Biometric Systems must have the capability to authenticate individual person with (i) Great accuracy, (ii) in a user-friendly manner (iii) quickly, (iv) Dependency, (v) without invading privacy rights, (vi) cost effectively and (vii) without radical changes to the existing infrastructures are desired [18]. Several biometric techniques weren't accurate for specific categories of persons for example those have cuts in the finger. A biometric authentication system may be suitable for ladies, but not suitable for men or children, and may not be suitable for older people. The skin colour of people may also cause difference in images. Some technique work with lighter skin, but may not be suitable for darker skin. Other difficulties arise especially with face recognition are when the person apply dye or cuts the hair, change the size and shape of eyebrows or grows a beard [19]. The low quality of camera can cause error and accuracy relies on the devices while capturing images. The sunshine is different from one place to another place. The intensity of the nature and of ground noise is also an important factor. Another factor is the person's position may have changed. The element Biometrics can also be used in Database access, Criminal identification , Border crossing controls ,Prison security , ATM and other Financial Transactions , PC/LAN Login ,cloud storage etc.

3.0 PROPOSED SPECTRUM BASED FEATURE EXTRACTION AND PSO BASED FEATURE SELECTION ON TEETH IMAGES

Noise and unnecessary features cause major difficulty for proficient recognition in any recognition system. Trace-Elements based Biometric Authentication system contains only data such as the concentration of the elements, which are in the form of digital data which carry numeric values. Therefore, less comparisons operations are performed to authenticate individuals; thus, easy to be performed. This biometric system doesn’t contain any images, only data is used. There is no need for more storage and complex algorithms to solve. One of the main characteristics of an efficient recognition system is speed. Obtaining results in real time is a daunting challenge in recognition systems.

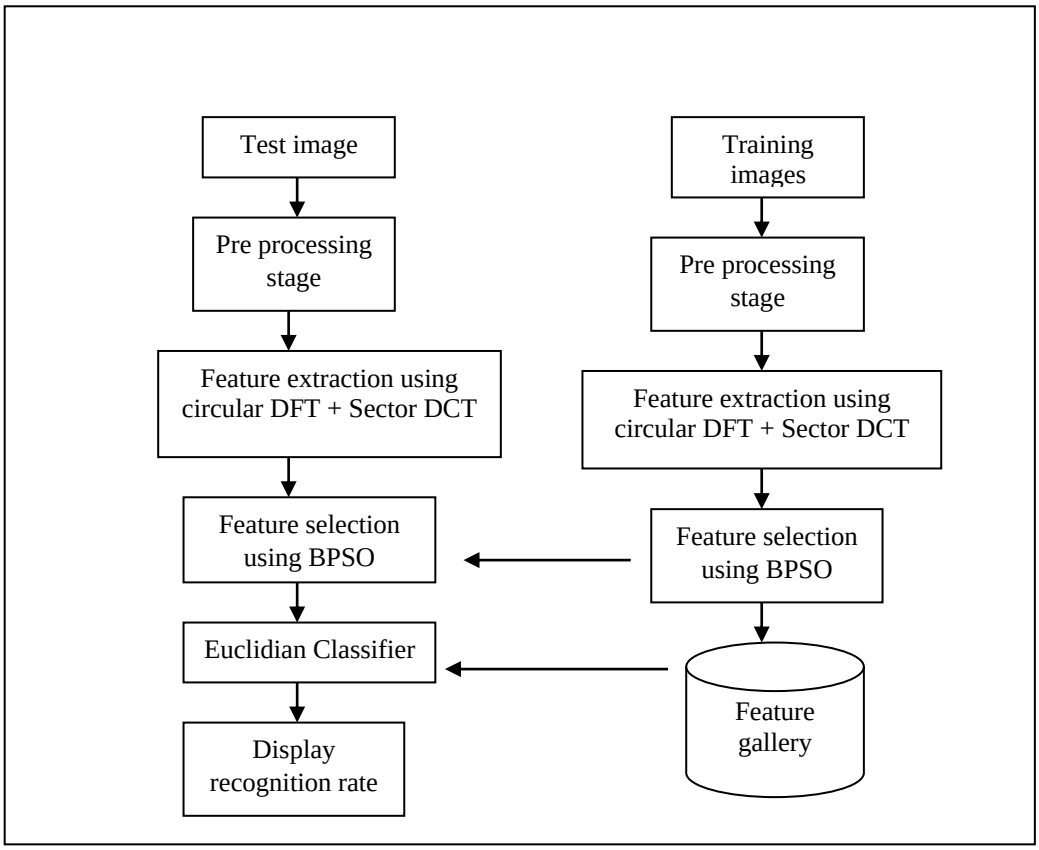

Fig. 1: Spectrum based Feature extraction and PSO based feature selection block diagram

3.1 Image Preprocessing

Image acquisition [20] commonly leads to distortion, poor contrast, and noise in the image. Pre-processing aims at eliminating these imperfections in the image. The following steps are used for this purpose:

a) Background Removal: This pre-processing method involves elimination of the unwanted background and preserving only the foreground necessary for the recognition process. The steps are as follows:

i. The RGB image is converted to gray scale image.
ii. Histogram equalization is applied to the gray image as it helps in distributing the intensities over a wide range thus increasing the contrast of the image.
iii. The image is further enhanced to highlight its edges by sharpening using unsharp masking method.
iv. The unsharp masked image is added to the original gray image as given in (1).

$$img = c1 * img1 + c2 * img2 \quad (1)$$

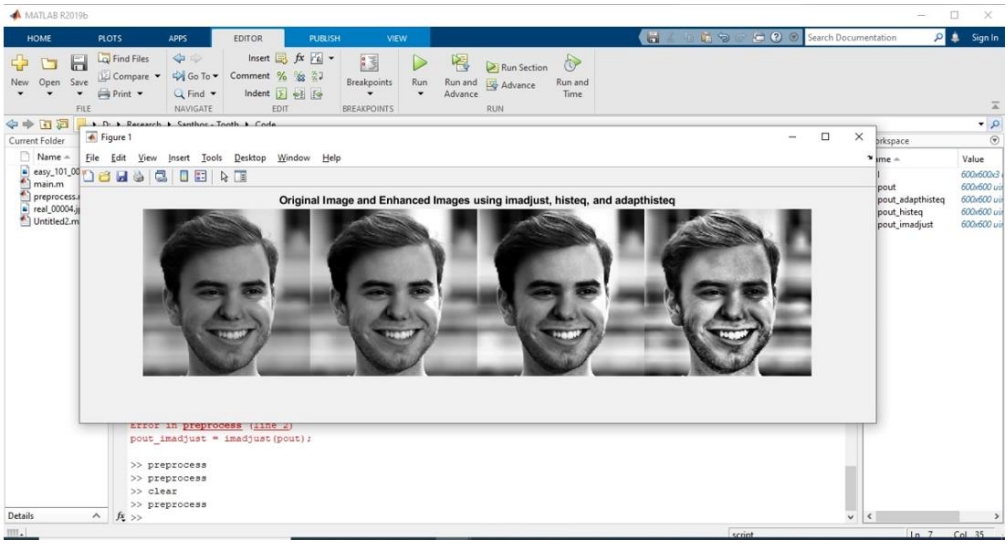

Fig.2: Original image with processed image

b) Gamma Intensity Correction (GIC): Gamma Intensity Correction (GIC) is a nonlinear mapping used either to increase the brightness of the image ($\gamma>1$) or to decrease it ($\gamma<1$), hence compensating for the nonlinear response of the capture device. It is a powerful tool when used accordingly [18].

GIC represented as,

$$f(I(x, y)) = I(x, y)\ 1/\Upsilon \quad (2)$$

where X, y are the image variables.

c) Laplacian of Gaussian (LoG): For enhanced recognition, edges of the image are obtained using LoG filter. The LoG filter first applies the Gaussian filter to blur the image in order to remove noise [19]. The Laplacian of the blurred image is computed. Finally it scans for zero crossings, which denote the edges, thus emphasizing the edges. The flowchart illustrating the pre-processing steps is shown in the following Fig. 3.

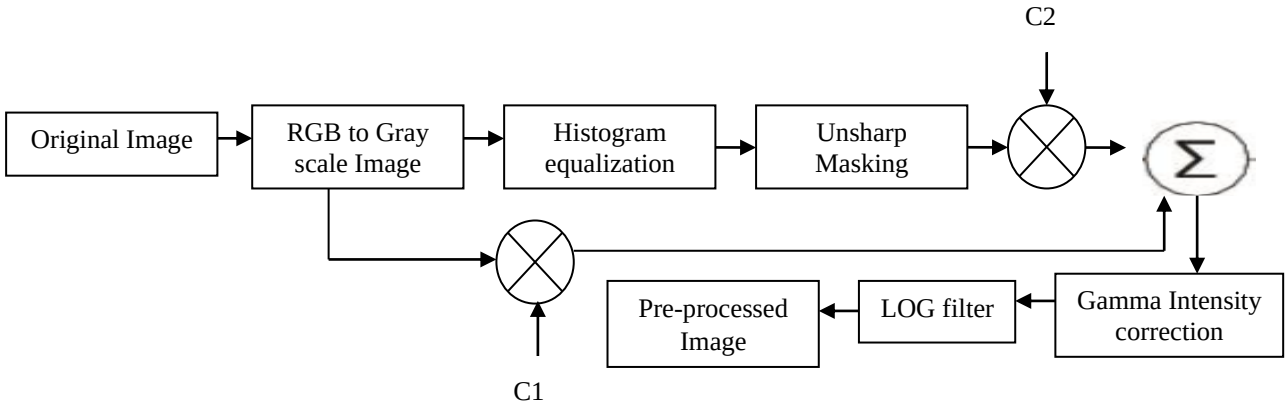

Fig. 3: Pre processing flowchart

3.2 Spectrum based teeth Feature Extraction

Feature extraction is carried out using a combination of DFT (Discrete Fourier Transform) and DCT (Discrete Cosine Transform). DFT switch the image from a local domain into a frequency domain and the essential information is moved to the center. Now only the vital features are utilized by taking the central circular portion. Upon application of DCT the critical low frequency information is concentrated in the top left hand corner out of

which only part of a circular sector is passed on to the next step. Discrete Fourier Transform is a transform which decomposes an image into its sine and cosine components and converts it from spatial domain to frequency domain given by (3) for an image of size M × N. These frequency components are complex consisting of real and imaginary terms. Therefore, we will consider only the magnitude for further processing.

$$F(u,v) = 1/MN \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y)e \quad (3)$$

Where F(u,v) is the image in frequency domain and f(x,y) is the image in spatial domain.

The low frequency components are located in the four corners of the spectrum which hold all the important features and are sufficient to represent the teeth image. One of the main characteristic of DFT is the shift invariant property. Hence, we can benefit from this property by shifting the low frequency components from the corners to the center of the spectrum. Using the equation of a circle x2 + y2 = r2 a circular mask is created to extract the important features. The radius of the circle r is chosen such that the necessary features of the image are encompassed within the circle. Consequently, the features within the circle are extracted as illustrated in,

$$F(u,v) = a(u)a(v) \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y) \cos\left[¶ \frac{(2x+1)u}{2M}\right] \cos\left[¶ \frac{(2y+1)v}{2N}\right. \quad (4)$$

Where

$$a(u) = \begin{cases} 1/M\ ,\ u = 0 \\ \sqrt{2}/M,\ u = 1,2,\ldots,M-1 \end{cases} \quad (5)$$

and

$$a(V) = \begin{cases} 1/N,\ V = 0 \\ \sqrt{2}/N,\ V = 1,2,\ldots,N-1 \end{cases} \quad (6)$$

When DCT is applied to an image all the low frequency components are concentrated on the top left hand corner of the DCT spectrum.

3.3 Feature Selection using Proposed Position based Binary Particle Swarm Optimization (PBPSO)

In conventional BPSO the velocity of the particle is used as a probability function based on which the position of the particle is updated either to 1 or 0. Hence the velocity is to be normalized to lie between (0, 1), for which a sigmoidal function is used. Here the current position of the particle is rendered useless which affects the continuous nature of particle swarm optimization. The above drawback is overcome in the proposed extension of BPSO namely the Position based Binary Particle Swarm Optimization (PBPSO) where, the current position of the particle is used in place of velocity in the sigmoidal function.

Particle Swarm Optimization (PSO) continuously updates a particle's position and velocity relative to the previous position and velocity until the global optimum is attained or the number of iterations is completed. Each particle in the swarm keeps a track of its best solution achieved known as the personal best, p_{best} . Also, a global best g_{best} , which is the best solution obtained by the particles is maintained. Each particle moves with a velocity and direction given by the following equations,

$$V_i^{t+1} = {}_{\varphi} * V_i^t + c1 * rand_1 * (P_{best} - X_i^t) + c2 * rand_2 * (g_{best} - X_i^t) \quad (7)$$

$$X^{t+1}{}_i = X_i^t + V^{t+1}{}_i \quad (8)$$

In Eq. 7, c_1 and c_2 are the cognitive and social parameter that lies in the range [0, 2], $rand_1$ and $rand_2$ are two random numbers, with uniform distribution U(0,1) and i=(1,2,.....,N), where N is the size of swarm.

Also, ω is the damping factor that keeps the velocity within the desirable limits so that the new position does not vary largely from the current position. An extended version of PSO is the Binary Particle Swarm Optimization (BPSO) [13] created to operate in binary problem spaces in which the position of each particle either takes the value '1'or '0', thus indicating whether a feature is selected or not. The equation for updating the position is shown in (9) while the velocity equation remains the same.

if

$$rand_3 < 1/\ 1+e^{-V\ t+1}{}_i \quad (9)$$

$$\text{then, } X^{t+1}{}_i = 1; \text{ else } X^{t+1}{}_i = 0 \quad (10)$$

In conventional BPSO, as seen from equation 9, the position update is dependent only on the velocity and not on the Current position. Hence making the current position futile as it does not affect the convergence process. Since the current position is vital to ensure a more accurate and faster convergence rate, it is evident that to improve the performance of the conventional BPSO we have to use the current position information in the position update formula. Therefore, to overcome the above problem we propose a method which is a combination of canonical PSO and BPSO known as Position based Binary Particle Swarm Optimization (PBPSO). The algorithm is as follows:

Step 1: Initialize cognitive, social and inertial factors (i.e. c1, c2 and ω). Also initialize position X t of the particles within the search space.
Step 2: Evaluate the performance of every particle, using the fitness function, using its current position X t
Step 3: Obtain the personal best position pbest of every particle by comparing the performance of each particle to its best performance and update the pbest .
Step 4: Similarly update the global best gbest by comparing the performance of every particle to the global best particle.
Step 5: Now update the velocity.
Step 6: Combining original PSO and BPSO, the position update is given by,

if
$rand_3 < 1/\text{-test}^{\ t+1}{}_i$

$\text{then, } X^{t+1}{}_i = 1; \text{ else } X^{t+1}{}_i = 0$

where $test^{t+1}{}_i = test^{t+1}{}_i + V^t{}_i$

Step 7: Repeat from step 2 till convergence is achieved or number of iterations are over.

3.4 Euclidean Distance Classifier

The Euclidean distance is defined as the straight line distance between two points in Euclidean space. The features of the training image contained in the feature gallery are compared with the feature subsets of the test images obtained from PBPSO. While making these comparisons, if the distance between the training and test images is the least then a best match is achieved. The Euclidean distance D is given by,

$$D = \sqrt{\sum^{M}{}_{i=i} (f_i - t_i)^{\ 2}} \quad (11)$$

Where f_i is the features of the image in the gallery, t_i is the selected features of the test image.

4.0 RESULTS AND DISCUSSIONS

The experimentation on teeth recognition was performed on IvisionLab/dental-image standard database [21]. The original size of the images is 240 × 320 and resized to 80 × 60 for the purpose of experimentation. The results were obtained from an intel i5 CPU @ 2.40 Ghz and 8 GB RAM and performed on MATLAB 2021a [16]. The results of the teeth recognition process for different training to testing image ratios for this database are tabulated as shown in Tables 3. The results from Table 3 are represented as plots shown in Fig 4.

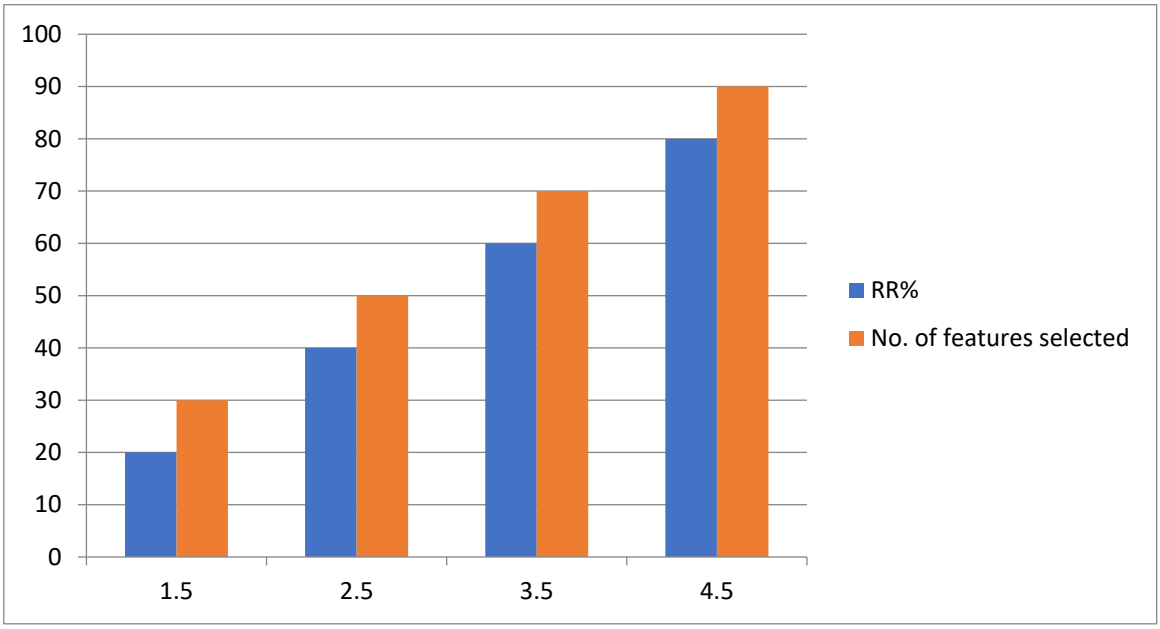

Fig. 4: Plot of Experimental Results for Varying Training to Testing Ratio

Table 3: Experimental results

S.No.	Method	Ratio	Recognition Rate (RR) %	Training time (µs)	Testing time (µs)	Average number of features selected
1	DFT	1:4	20.18	202.10	113.89	117
2	DCT	1:4	47.25	213.66	112.52	103
3	DFT + DCT	1:4	57.86	214.71	113.86	105
4	Pre-processing + DFT + DCT + BPSO	1:4	83.72	230.03	135.41	108
5	Pre-processing + DFT + DCT + BPSO	1:4	86.15	490.34	294.0	147

Table 4: Comparison with existing methods

S.No	Method	Avg. Recognition Rate % (1:4)
1	Preprocessing + Triangular DCT + BPSO [3]	75.44
2	LOG + IMCE + DsrhDFT + BPSO [4]	86.56
3	Proposed Method	91.49

Experimentation on database by using DFT+DCT technique has significantly improved the recognition rate by 10% when compared to using DCT alone and a greater increase compared to DFT alone. A further increase in recognition rate is achieved by using the proposed pre-processing method along with DFT+DCT. An increase of more than 10%

is observed. The last section of Table 4 show increase of almost 2% in the recognition rate with the use of proposed BPSO when compared to BPSO. The proposed method average recognition rate is improved with the ration 1:4 compared with two existing methods.

5.0 CONCLUSION

A new approach for tooth recognition system is proposed in this research paper which uses a combination of circular DFT and circular sector DCT for feature extraction and an enhanced version of BPSO for feature selection. The unique combination of DFT along with DCT has played a prominent role in increasing the recognition rate and hence increases the accuracy of the recognition system. The feature selection method proposed in this paper, namely PBPSO, helps in better feature selection compared to the conventional BPSO and thus leads to an increase in the recognition rate. It also helps in reduction of features gallery size as well as decrease in computation time. Elimination of undesirable features, noise, variation in illumination and low contrast is achieved using the combination of pre-processing steps mentioned resulting in a recognition rate of 86.15% for the selected database for training to testing ratio of 1:4. The findings and results of this study would be helpful for creating a biometric knowledgebase and also it will be useful in future biometrics if any new device will be found with the calculation capability of trace elements concentration in a human tooth of a living person's teeth.

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