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Eye Movement based Biometric Identification

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Abstract
This paper presents the biometric identification system by using extracted features based on fixation and saccade points.Raw scan path signals in eye movement matrices are processed by velocity threshold-based fixation identification algorithm. I-VT is a velocity-based technique that isolates fixation and saccade indicates in light of their point speeds, that gives quick and strong examination of eye-movement information. A neural system utilized for grouping over information data retrieved from scan-path signals. So, we can state paper exhibits a novel biometric ID framework by a target assessment of different eye movement based biometric highlights and their capacity to precisely and absolutely recognize one of a kind people.

Keywords: Fixation,Saccade, Counterfeit Resistant, Scanpath Length.

Introduction

Biometrics system identifying an individual by his or her physiological or behavioral characteristics has capability to determine between authorized user and pretender. So Biometrics has been broadly utilized as a part of criminology applications, for example, criminal recognizable proof and jail security. It additionally has a solid potential to be generally received in regular citizen applications, for example, e-Banking, e-Commerce, and access control. There are various biometric technologies available such as fingerprint, iris, face, retinal, palm prints, hand geometry, voice, and signature etc. which are being utilized for biometric acknowledgment in later past.Nonetheless, some of these traits are less demanding to duplicate and causes a hole in distinguishing proof precision. Along these lines it is essential that biometric characteristics ought not to be anything but difficult to replicate. Eye movements attributes rely upon the mind movement and additional visual muscles properties that make it exceptionally fake safe and counterfeit resistant. Therefore, it isn't conceivable to precisely reproduce the eye movement of any person.The researches in eye movement as biometric trait is at extremely introductory stage and require more thoughtfulness regarding work with progress Computational insight procedures other than the customary measurable strategies or conventional statistical techniques used in [1], [2], [6] for recognition. In this paper, we utilize a neural system intraining and testing module. For feature extraction from the raw scan path signals,we embrace velocity threshold (I-VT) distinguishing proof calculations [3] for fixations and saccades recognizable proof.Saccades happen when eye pivots immediately amongst obsessions and fixation happens when eye is held in generally stable position on a protest [2].Schematic chart of the proposed philosophy is exhibited in fig.1 which includes three essential procedures: fixation and saccade classification from raw eye motion signals [4]; feature extraction from fixations / saccades groups and finally training and testing which employs neural network system.

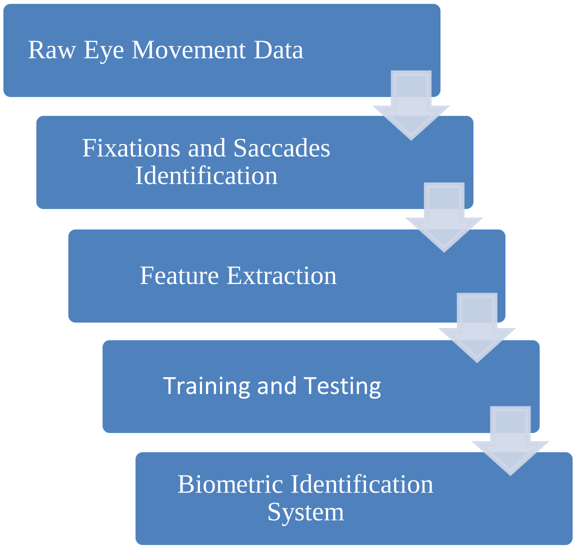

Figure1. Schematic diagram of proposed methodology

On the other hand, neural network (NN) is used for biometric identification. Neural system is a scientific model or computational model in view of biological neural system. It comprises of an interconnected group id artificial network and procedures data utilizing a connectionist way to deal with calculation or computation. The neural system may contain, input layer, output layer and at least one hidden layer.The neural system works by altering the weight values during training with a specific end goal to diminish the error between the genuine and desire output pattern.

Proposed Methodology

The raw Eye Movement Data from different channels deliveredto the Eye Movement Classification module whichrecognizes,filters, and unions the information focuses that portray the special fixations/saccades exhibit in each.Fixation and saccade groups are merged, identifying fixation-specific and saccade-specific features. The extracted features are supplied to the training and testing module and training & testing is done by neural network.

Fixations and Saccades Identification

I-VT is a speed-basedstrategy that isolates fixation and saccade indicates in view of their point speeds. The velocityprofiles of saccadic eye movements indicate basically two conveyances of speeds: low speeds for fixations, and high speeds for saccades.

I-VT (protocol, velocity threshold)

- Calculate point-to-point velocities for each point in the convention, every velocity (vel) is registered as the separation between the present point and the following (or past) point.
- $vel = \sqrt{((x2 - x1)^2 + (y2 - y1)^2)}$ (1)
- Calculate the threshold (th), th = $\sum$ vel / Total no of samples (s)
- If(vel<th)

Label each point as a fixation point.

Else

Saccade point.

- Collapse back to back obsession focuses into fixations groups, isolate saccade focuses.
- Translates every fixation group to a <x,y,t,d> fixation tuple utilizing the centroid1 of the focuses as x and y, the time of the first point as t, and d is the duration of the points. Return fixations.

Feature Extraction

After fixations and saccades identification, we haveselected 6eye movement measurementsas fixation count (FC), average fixationduration (AFD), average horizontal, vertical and vectorial saccade amplitude(AHSA, AVRSA and AVCSA) and scanpath Length[2] which are defined as following:

- **Fixation Count**: Number of detected fixations. It is a characteristic of the number of items prepared by the subject.

- **Average Fixation Duration**: It shows the measure of time a subject spends deciphering a protest [8]. It is measured as entirety of fixation spans over fixation check.
  Give FC= A chance to number of fixations, d is the fixation span
  What's more, S=Number of saccades at that point,

$$AFD = \frac{\sum_{i=1}^{FC} d_i}{FC} \qquad (2)$$

- **Average Vectorial Saccade Amplitude**: There is a prominent inclination for saccades to keep up comparative amplitudes amid perusing [7]. Average saccade amplitude is considered as biometric include under supposition that distinctions in abundance might be clear between subjects. It is measured as total of vectorial saccade amplitudes over the aggregate number of saccades as:

$$AVCSA = \frac{\sum_{i=1}^{S} \sqrt{x_i^{\ 2} + y_i^{\ 2}}}{S} \quad (3)$$

- **Average Horizontal Saccade Amplitude**: Normal abundance of the horizontal segment of saccadic movement.Level saccade amplitude was considered independently as these are progressively characteristic of between-word saccades.

- **Average Vertical Saccade Amplitude**: Normal abundance of the vertical part of saccadic movement.Vertical saccade adequacy was considered independently as these are more characteristic of between-line saccades.

- **Scanpath Length:** Scanpath length is demonstrative of the proficiency of visual search [8]. Scanpath length was measured as the whole of supreme separations between the vectorial centroid of fixation focuses, where the vectorial centroid was characterized as the Euclidean standard of the even and vertical centroid position, as indicated by the condition:

$$Scanpath\ Length = \sum_{i=2}^{n} \left| \sqrt{x_i^2 + y_i^2} - \sqrt{x_{i-1}^2 + y_{i-1}^2} \right| \quad (4)$$

Training and Testing

In this research paper, neural network (NN) is used for biometric identification. Neural system is a scientific model or computational model in view of natural neural system. Basically it consists of an interconnected group id artificial network and processes information using a connectionist approach to calculation or computation. Back propagation neural network is an orderly strategy for preparing multi-layer neural system. The BP neural network may contain, input layer, output layer and at least one hidden layer. The main task of neural network is to reduce the error between the genuine and desire output pattern by adjusting the weight values during training.

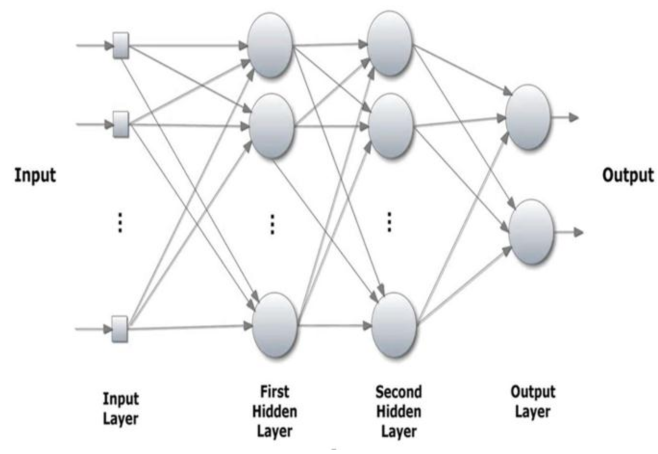

Figure2. Multi-layer Neural Network

Firstly, the input and target samples of the neural network are obtained. After that, the matrix is converted into a 6×1 column vector that is treated as the input of the neural network (Fig. 2). The input layer of the neural network has 6 neurons. Learning technique accepts that each info vector is combined with an objective vector representing to the desired output; together they are known as a learning pair. For the output layer, if 32 learning pairs are required, the output layer neurons are 32. Output is restored in a 32×1 column vector. For the number of hidden layer neurons, we refer to the empirical formula Eq. (5). We set the number of hidden layer neurons to 40.

The k-th output of neural network is determined by the formula.

$$P_k = f\left(\sum_{i=1}^{h2} v_{it} \,.\, f\left(\sum_{k=1}^{h1} U_{kt} \,.\, f\left(\sum_{j=1}^{m} W_{jt} X_j\right)\right)\right) \quad (5)$$

In Eq. (5), $X_1, X_2, \ldots, X_j$ are grayscale values of input array that characterizes the Features information, $P_1, P_{2,\ldots\ldots,} P_k$ are output patterns that characterize the eye movements. Where V_{it} weights between the hidden layers and output layers of system,weights between the hidden layers are U_{kt}, W_{jt} are weights between the information and hidden layers, *f* is the activation function that is utilized as in neurons. *m* is the quantity of information signals, *h1* and *h2* are the quantity of neurons in hidden layers, the number of output neurons is n (*k=1,..,n*). The back propagation learning techniqueis connected for preparing of neural system [5]. The prepared system is then utilized for eye movements testing. For testing, include vectors of unknown eye movement measurements are encouraged into the neural system. A pattern is identified by corresponding member of cluster forwhich maximum value of threshold is obtained. Along these lines, eye movement measurements are characterized by neural system.

Experimental Setup & Software

We have utilized EMBD V1.0 [2] in which raw scan path signals are accommodated 32 subjects (26 guys/6 females), ages 18 – 40 with a normal age of 23 (SD = 5.4). 29 of the subjects performed 4 recordings each, and 3 of the subjects performed 2 recordings each. Each account contains almost 64,000 scanpath signals. For 29 subjects, we select 2 accounts for training and rest 2 for testing; while for 3 subjects, single recording is utilized for preparing and rest single is for testing.

We have used MATLAB software, and experiments are performed on Intel Core 2 Duo CPU, i.e. 2.00GHz PC with 2 GB RAM.

Results and Analysis

I-VT is clear to execute, runs proficiently, and can without much of a stretch keep running continuously. Fixation recognizable proof takes as information an eye-movement convention containing a succession of <x,y> information focuses. It at that point changes the convention to an arrangement of <x,y,t,d> fixation tuples, where x and y show the fixation location, t demonstrates the beginning time at which the fixation happened, and d shows the span of the fixation. At last, I-VT makes an interpretation of every fixation group to a <x,y,t,d> fixation vector.

TABLE1. EXAMPLE OF A FIXATION GROUP

Time Stamp	X_d	Y_d	Vel
7.0000	17.4294	11.1516	0.0021
8.0000	17.4334	11.1519	0.0042
9.0000	17.4345	11.1521	0.0080
10.0000	17.4332	11.1611	0.0026
11.0000	17.4360	11.1611	0.0054

TABLE 2. FIXATION VECTORS SAMPLE

x	y	t	d
-90	-90	4553	34
-4.8949	1.9248	4589	0
-2.4018	12.3791	4609	187
-3.7607	12.5177	4798	1
-5.6653	12.6704	4801	618

TABLE 3.EXTRACTED FEATURES USINGI-VT

Metrics	Value
Fixation Count	285
Average Fixation Duration	24.397286228070172
Average Vectorial Saccade Amplitude	2.208451374599384e+02
Average Horizontal Saccade Amplitude	2.538728070175439e+02
Average Vertical Saccade Amplitude	3.963147462184874
Scanpath Length	1.095609973556465e+05

The execution of the framework is measured regarding testing exactness which is characterized as:

Testing precision = 100 × (number of right matches/add up to number of tests in test set)(6)

TABLE 4. COMPARATIVE ANALYSIS OF BIOMETRIC IDENTIFICATION

Dataset	Testset	Threshold	Accuracy (%)
32	64	0.1	54.6
32	64	0.2	56.7
32	64	0.4	60
32	64	0.7	63.8
32	64	0.9	67

We observed that best results are obtained at different values of threshold. In tests it is additionally watched that best precision could be acquired when threshold value is expanded. A greatest 67% exactness has been acquired by consolidating I-VT with NN that exhibits the Capability of eye movement scanpath signals as biometric highlights.

The False Reject Rate (FRR) measures the likelihood that a person who has selected into the framework isn't distinguished by the framework. It is otherwise called Type-I mistake.

FRR can be figured as:

$$FRR(n) = \frac{Number of rejected verification attempts}{Total number of verification attemps}$$

or

$$1/N \sum_{n=1}^{N} FRR(n) \qquad (7)$$

The False Acceptance Rate (FAR) measures the likelihood that a person who may have or have not enlisted into the framework is distinguished as another person. It is otherwise called a Type-II mistake.

FAR can be figured as:

$$FAR(n) = \frac{Number of successful imposter attempts}{Total number of imposter attemps}$$

or

$$1/N \sum_{n=1}^{N} FAR(n) (8)$$

Where N is the aggregate number of enrollments.

From trial comes about it is found that the biometric identification using I-VT has a FRR of 33.2 % and FAR of 32.8 %. Since FAR and FRR are about equivalent, in this way equal error rate (EER) is also 33% for I-VT.

Conclusion

This paper has exhibited the potential relevance of the eye movement scan path signals for biometric investigation. We have presented neural network based eye movement examination which takes into account the blend of different measurements to create more steady/precise distinguishing proof. The algorithm performed four major steps: The first one is analysis of raw eye movement data, The second one is fixation and saccade identification using I-VT algorithm, The third one is feature extraction by using fixation and saccade points and The last one is biometric identification by training and testing of features using neural network.Furthermore, we watched that I-VT is straight forward to actualize, runs productively, can without much of a stretch keep running progressively and give high precision/accuracy.

In the present paper, we have connected straightforward velocity threshold. It is likely that future research will explore elective characterization calculations/threshold to recognize more viable arrangements. In future work, one can utilize learning and visual pursuit qualities of human mind and can include more eye movement measurements for distinguishing proof purposes.

Preprocessing is an important advance in eye movement-based biometrics, and is basic to the change of the constant eye movement motion into discrete units of consideration. There is a wide scope of arrangement calculations that might be connected to recognize fixations and saccades inside the recording, each with one of a kind advantages. Also, the threshold credited to these calculations may substantially affect the exactness of characterization. In the present paper, we have used basic velocity-based algorithm. All things considered, future research will explore elective order calculations/threshold to distinguish more viable arrangements.

There are various regions in which the precision ofthese measurements might be enhanced, including: changes in accordance with the manner in which examination is performed, content related investigation, and the suggestions towards high level brain activity.

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