Biometric Authentication of a Person Using Mouse Gesture Dynamics: An Innovative Approach

Parashuram Baraki and V. Ramaswamy

Abstract A unique method for biometric authentication is through the mouse gesture of an individual, though this technique, the movement of mouse as a pointing device is assessed, two types of authentication are recognized, static and continual. The most prominently utilized system is continual. Static authentication has been slow to develop, whereas continual systems have rapidly evolved. To solidify effectiveness of authentication, we have introduced a new model which is robust. In this approach, user draws a gesture using mouse. These gestures are collected and evaluation through a cover markov model classifier, a remarkable consistency in mouse gesture systems, in regards to False Rejection Ratio and False Acceptance Ratio in comparison to conventional systems. From the results, one can observe that there is improvement in terms of precision and authentication in comparison with conventional systems. The report concludes, as we believe the first time in history, that a mouse gesture system successfully recognized its purpose accurately.

Keywords Component behavioural biometric · Mouse dynamics
Mouse dynamics analysis framework · Data acquisition · Data preprocessing

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1 Introduction

The primary point of developing biometric system is to convey precise and effective authentication. During the past two decades the rapid development in online banking, online trading etc. has lead to increase in the number of hacking theft incidents etc. enormous. Mouse gesture dynamics is considered to be a new behavioural biometric example, and this approach has gained considerable prominence recently. A person's featured regarding mouse usage as assessed as part of dynamics deals with extracting the features related to the Mouse dynamics. Evaluating these movements will help in the authentication of a valid user. Mouse dynamics biometric technology is gaining importance given its capability of monitoring consistently a computer's usage. This text recognizes the user's attributes or fluctuations when a user utilizes the mouse. This leads to the creation of mouse gestures. Whenever user enters into a session, his credentials are checked and the user is authenticated. Mouse gesture is drawn by considering data points with coordinate values. They primary characteristics of biometric identification are behavioural attributes and physiological attributes. Physiological attributes incorporate finger prints, hang prints, DNA recognition, voice, etc. Behavioural attributes incorporate a person's behaviour, encompassing two phases: registration phase and authentication phase. During the first phase, mouse gestures will be conducted over the computer screen by the user multiple times. The movement is registered and subsequently assessed through relevant systems. Later on, this collected data is utilized for authentication of the user. During the authentication phase, individuals will require to perform identical mouse gestures as they were performed in the registration phase.

Recognizing the mouse patterns of an individual is associated with biometric recognition. These systems utilize covert Markov model for interpretation. It is unessential for a person to remember the specific patterns they create, rather the systems utilize the biometric recognition of the user. Syurki has suggested utilization of a signature, drawn by users as part of the recognition procedure, whereas the suggestion of Revetter utilizes mouse locking for static recognition. The constituents of suggested approach incorporate users showing their recognizable patterns during the computer's login. Each performed gesture is assessed for recognition. Conventional gesture recognition platforms utilize input device, such as the style; however, this research will utilize mouse as the primary input. Figure 1 depicts drawn gestures from individuals at computer login through time with 14 data points.

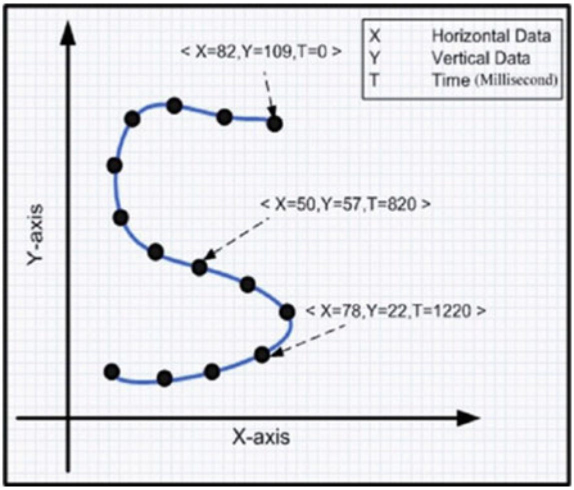

Fig. 1 Gesture involving $n = 14$ data points

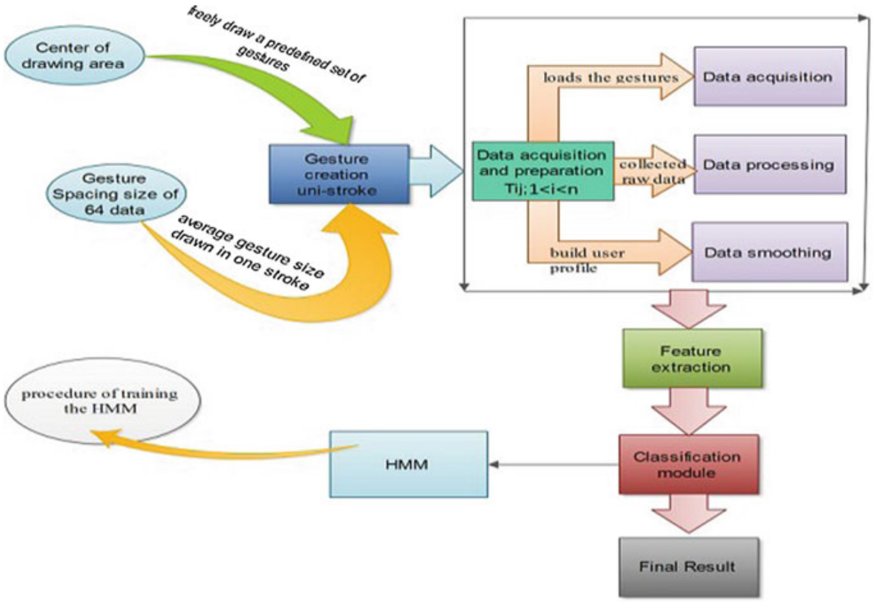

Fig. 2 Flow diagram for capture and analysis of mouse gestures

2 System Design

Figure 2 depicts authentic flow diagram of collection and evaluation of gestures. This method incorporates individuals to perform multiple gestures in repetition. Given that the new data stemmed from these gestures is a match with the saved sample, which had been collected during registration phase.

Information obtained through the drawing vicinity (gesture drawn in Fig. 1) incorporates horizontal coordinate (x-axis) and vertical coordinate (y-axis) and spanned period in milliseconds for every individual pixel. Data points are sequenced for gesture or pattern replication, with each point being signified through a triplet $\langle x, y, t \rangle$ indicating X-coordinate, Y-coordinate and elapsed time, respectively. Jth duplication of a gesture G is signified as a sequence $G_j = \{\langle x_{1j} + y_{1j} + t_{1j} \rangle, \langle x_{2j} + y_{2j} + t_{2j} \rangle, \langle x_{nj} + y_{nj} + t_{nj} \rangle\}$, where n refers towards gesture size (GS) and each $\langle x_{ij}, y_{ij}, t_{ij} \rangle$ where $(1 \leq i \leq n)$ is recognized as data point. The primary objective is to recognize variations between individuals on their behavioural biometrics while drawing patterns.

Mouse pattern assessment systems incorporate the mentioned modules:

(a) Gesture creation module.
(b) Data acquisition and preparation module.
(c) Feature extraction module.
(d) Classification module.

a. **Gesture Creation Module**

The development module is basic drawing software which collects the users' gestures as they use the mouse. The primary objective for this module to ensure that gestures are drawn by users in their personal manner. There is no specific pattern of language that the collected patterns are organized into, and neither do the gestures have any particular meaning. There are three parameters to consider for each pattern: horizontal, vertical and elapsed millisecond timing.

b. **Data Acquisition and Preprocessing Module**

Data Acquisition: Data acquisition module considers loads all gestures pin pointed by the user during registration phase for the new user to duplicate. Human interaction to the computer is also assessed during this procedure.

Data Preprocessing: All possible affecting elements during the collection procedures are ignored, so that accuracy in collection can be maintained.

Following the preprocessing phase, the data collection module executes two types of data stabilization: centre and size. Centre normalization moves pattern towards the drawing area's centre as executed under the gesture development module. Following such, the size is normalized in order to ensure that the final pattern is identical in size to the one that is register, allowing for contrasts to be made within either pattern that are created by users, whose sizes are bigger or identical to the size of registered patterns. In case that gesture size is bigger than registered sample, the k-denotes to the algorithm executed for clustering data points into 64 respective nodes. Euclidean distance, the distance assessed amidst the data points under three dimensions are executed. The centre of clusters is therefore utilized for development of newer gestures.

Outlier removal and data smoothing: The procedure for removing noise and deriving precise pattern is called smoothing. It is used to smoothen the collection information along the various processing spectrums. In essence, it is not possible for humans to virtually replicate identical patterns, leading to fluctuations between the inputs of the same user. The procedure of smoothing will ensure that such occurrence is kept to them minimal, indirectly making the software simple for users. The weighted least squares regression (WLSR) method is utilized for the smoothing procedure. Peirce's criterion is utilized for removing all outliers. Peirce's criterion is an effective statistics system that does not establish any assumptions regarding the information. This system processes data values constituting multiple suspicious or fluctuating values. Peirce's criterion evaluates outliers through processing higher possible deviation from the template average. M refers to template size, n refers to volume of outliers while R refers to the ratio amidst the highest possible and average deviation. The higher possible deviation is acquired through $d_{\max} = R \times \sigma$, where σ is template's average deviation and x_i is a data item that is considered to be outlier given $|x_i - x_m| > d_{\max}$, where x_m is the template average. Utilizing Peirce's criterion beginning from $n = 1$, outliers get eliminated successively through increasing the volume of possible outliers, while sustaining the original average, template size and template deviation. The procedure is continually executed to the point that no other value requires removals. Data smoothing and outlier elimination are implemented solely to horizontal and vertical data coordinates. The vector established to sum the identical occurrence of initial data point from each individual duplication. Peirce's criterion is once again utilized. The implementation of WLSR method to the data inside vector created smoothed and effective data. The procedure is continuously executed until all pattern data points have been processed. The act of smoothing is applied not to test data, but rather only training samples.

c. **Feature Extraction Module**

This module derives characteristics from unprocessed data. Feature choosing is facilitated through assessing template data and recognizing features. Extracts from vectors that are seized amidst two mouse clicks can be utilized. The finished list of obtained features is detailed under Table 1. Figure 3 depicts the angels tangent creates under x-axis and furthermore the span of origin path.

d. **Classification Module**

For the classification of patterns, principal component analysis is firstly executed. It was noted that the method provided inefficient and unattractive results. Subsequently, feed-forward back-propagation multilayer network was trailed; the training measures of the network were tiresome and lengthy. It took a total of five hours for the training procedure, encompassing two individuals to finish (using a machine equipped with 2 GHz Core2 Duo CPU and 2 GB RAM).

A new procedure titled hidden Markov model (HMM) is implemented for contrasting and recognizing of mouse patterns. HMM is the most efficient classification software for gesture, speech handwriting and language recognition. It

Table 1 Feature extracted from raw data

Feature description	Notation
Horizontal coordinate	x
Vertical coordinate	y
Absolute time	t
Horizontal velocity	h_{v}
Vertical velocity	v_{v}
Tangential velocity	t_{v}
Tangential acceleration	t_{a}
Tangential jerk	t_j
Path from the origin in pixels	l
Slope angle of the tangent	θ_i
Curvature	c
Curvature rate of change	δ_c

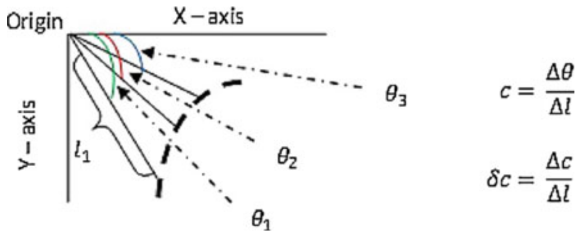

Fig. 3 Angle of curvature and its rate of change for a portion of a drawn gesture

appears to be the most time, resource and result efficient tool for easily establishing and editing data. In order to ensure greater accuracy of the data, the HMM is implemented on training data. Given that multiple hours are allocated to the computer solely for processing, this system will certainly provide effective results in regard to mouse pattern recognition.

3 Experimental Results

This section presents the experimental assessment of the suggested system.

The framework consists of two phases for authentication. Registration is the first phase in which the user is asked to register his/her name by drawing gesture using mouse. The user is allowed to draw any type of gesture which may include alphabet type or numeric type or combination of both or any other type of symbols. The gesture will be stored in the database for future reference. The gesture is then trained to understand the input given by the user.

Figures 4, 5, 6, 7 and 8 show the process involved in registration phase. In this phase, user is required to register along with their name by drawing their own gesture in the given window. Soon after this system will be trained and it will shown the display the gesture drawn by user on display window.

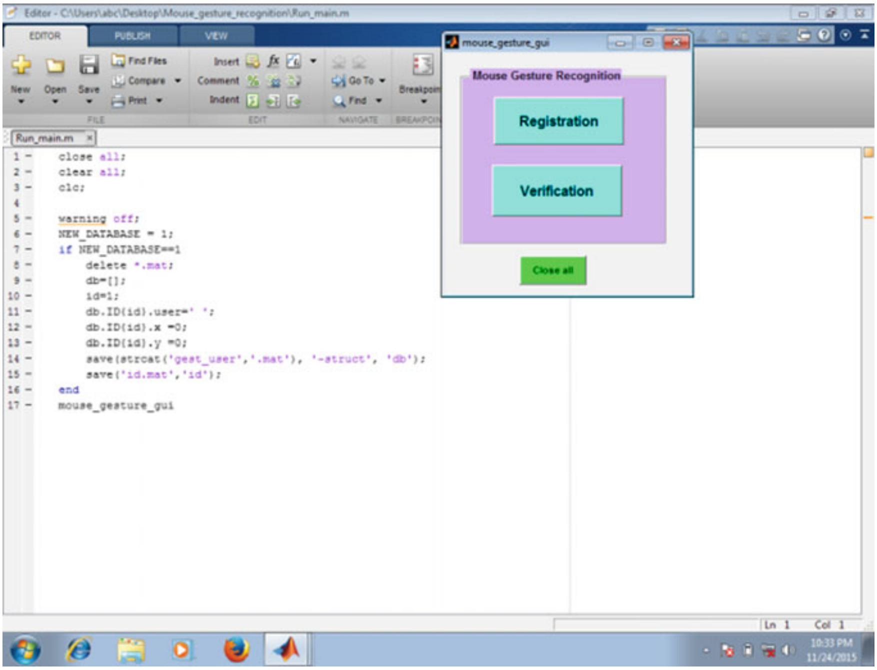

Fig. 4 Mouse gesture main window

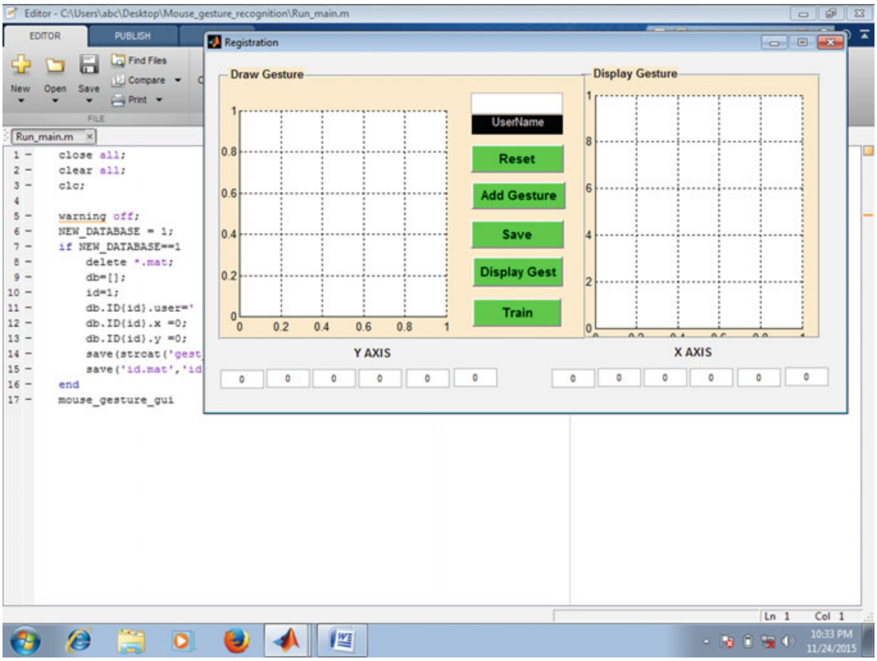

Fig. 5 Drawing window and display window in registration phase

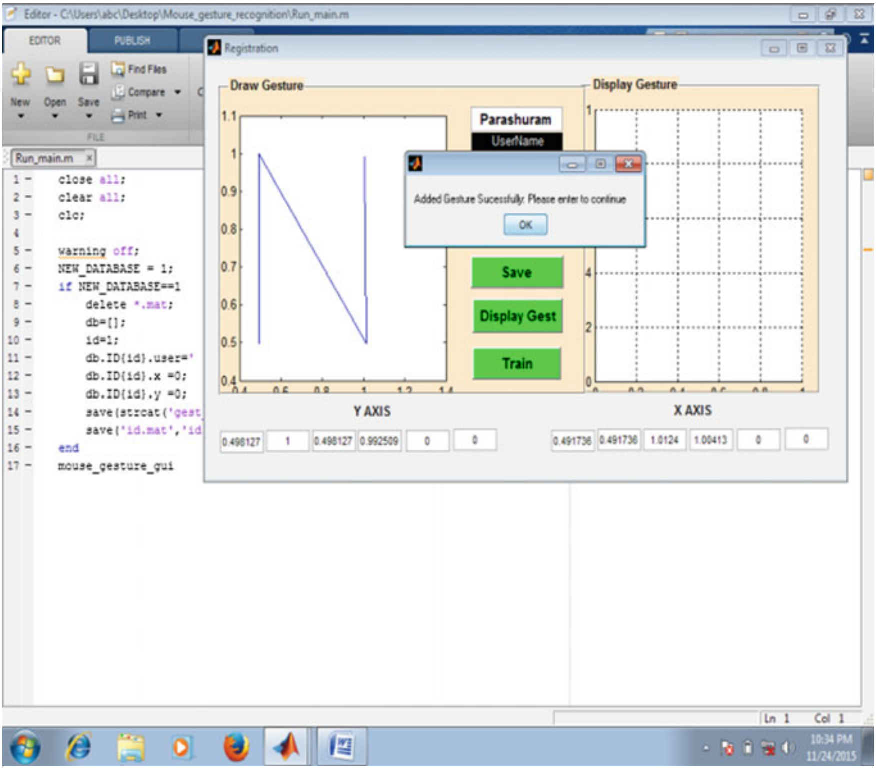

Fig. 6 Method of adding gesture along with user name

After registration phase, the system will determine whether the user is valid or invalid user using verification phase. The steps involved in the verification phase are as given in Figs. 9, 10 and 11.

Figure 9, 10, and 11 show the result of valid authentication. If the user is valid, his/her name will be displayed on the window soon after the drawn gesture matches with gesture stored in database. If gesture does not match, then “unknown user” will be displayed. Following snapshot represents the failure case (Fig. 12).

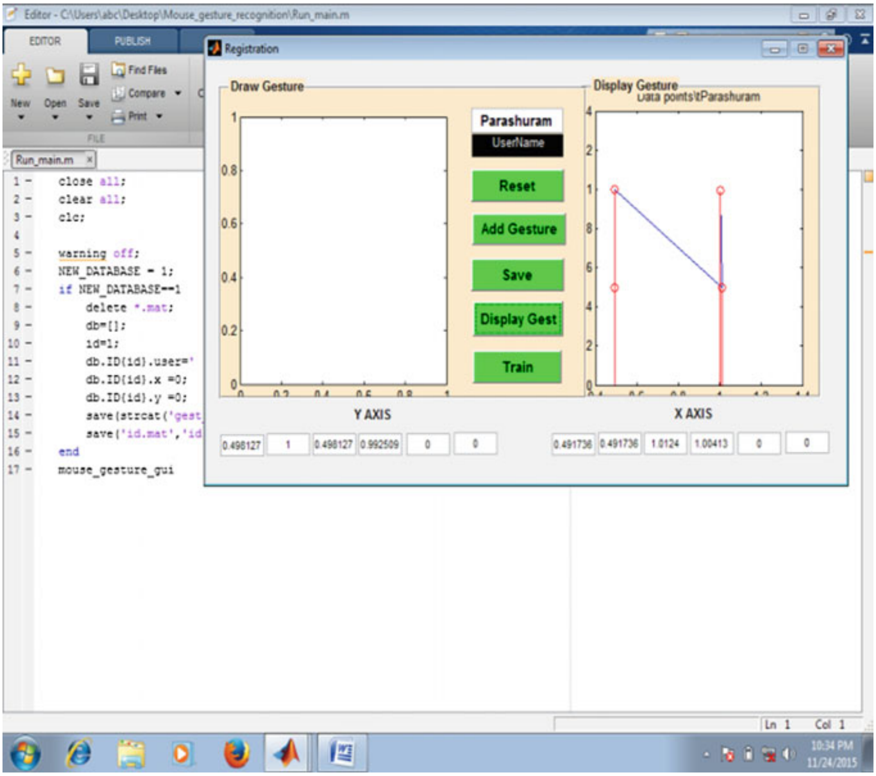

Fig. 7 After training, gesture will be displayed on display window

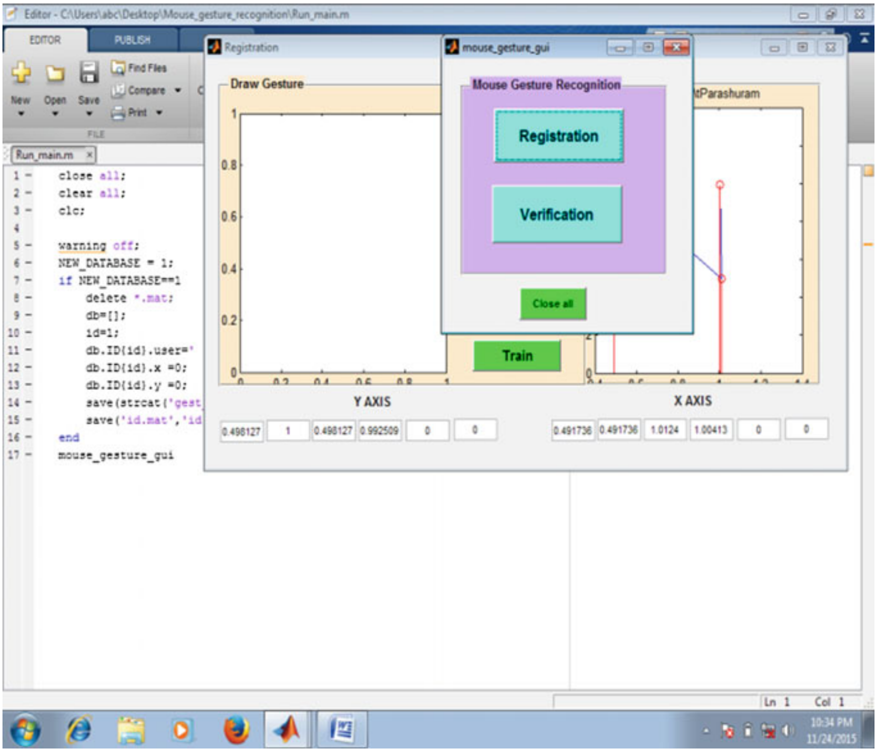

Fig. 8 After training, system will come back to main window

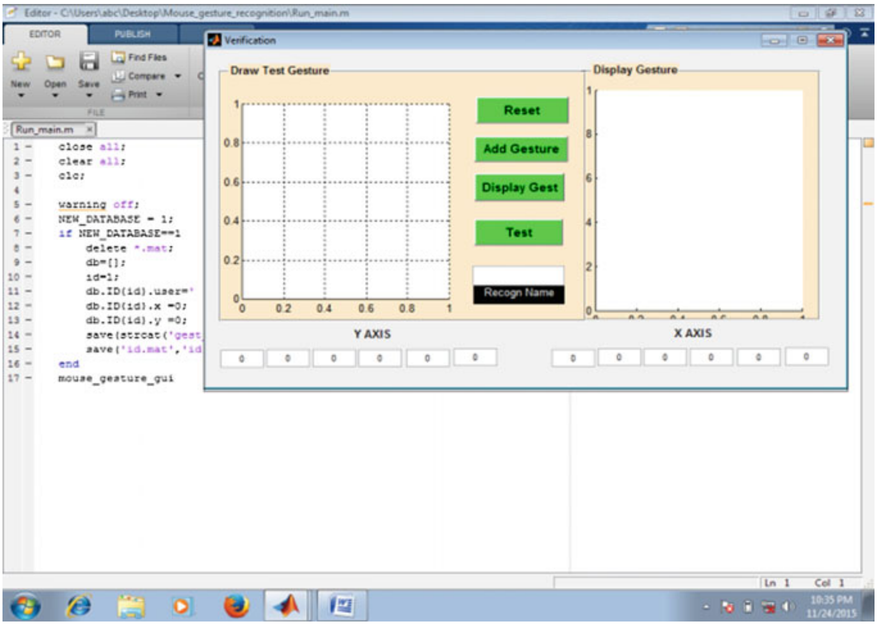

Fig. 9 Drawing window and display window in verification phase

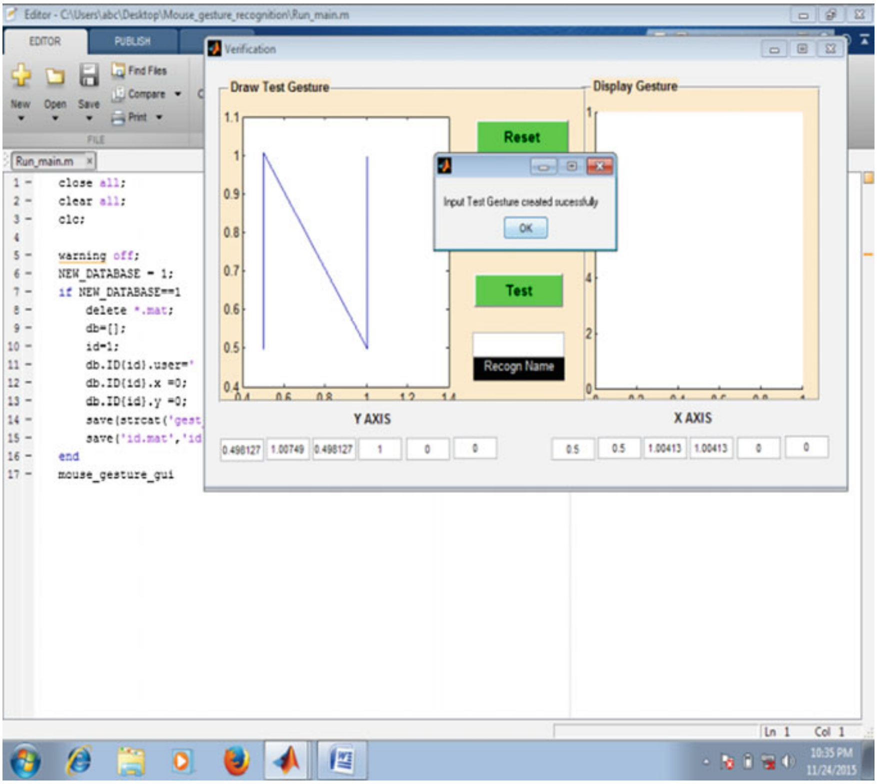

Fig. 10 Gesture drawn by user for verification

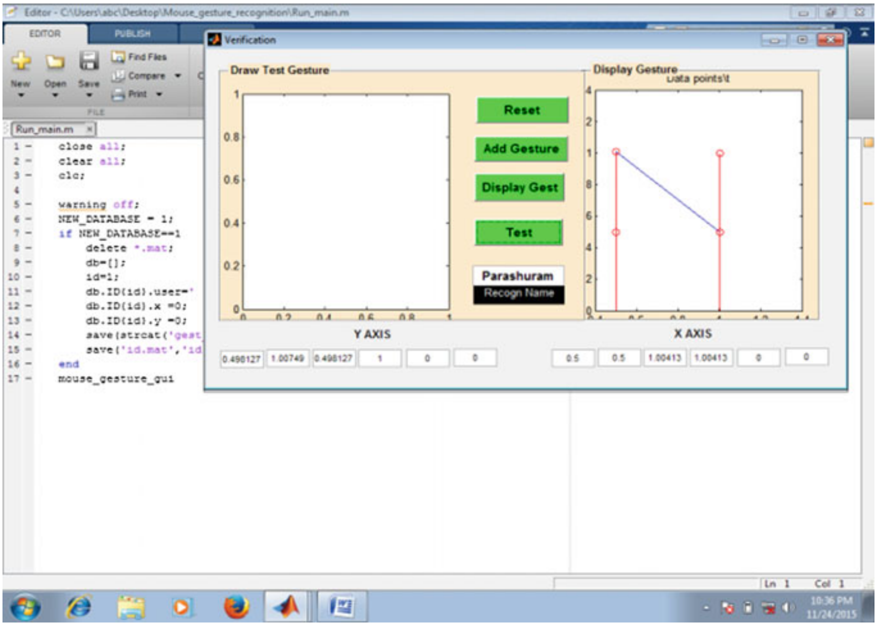

Fig. 11 After selecting test, if gesture matches then it recognizes authenticated user and displays name of user

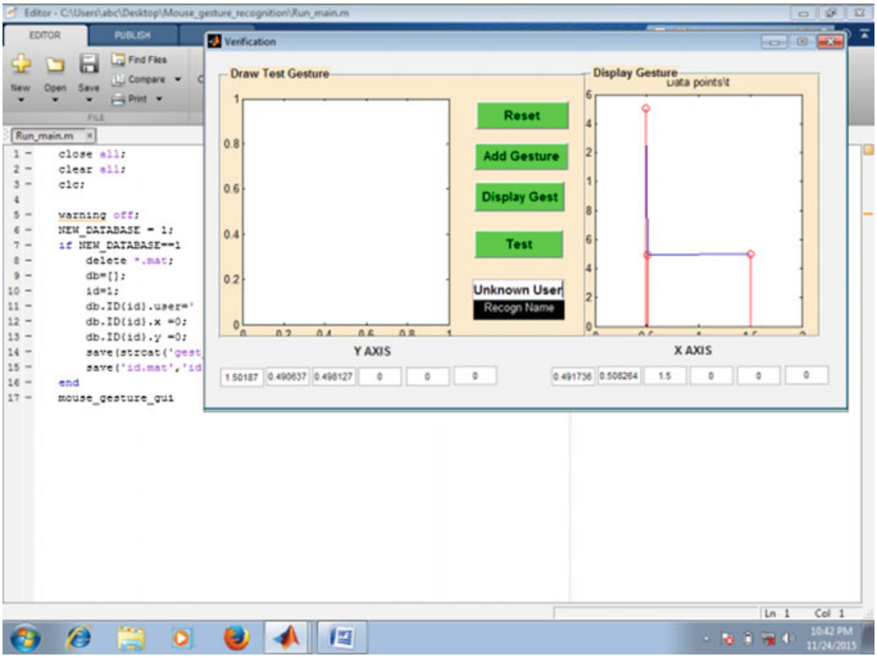

Fig. 12 When gesture does not match, then user will be considered as unknown user

4 Conclusion

This text recognizes the challenges confronted by mouse dynamics biometric technology whenever implemented to recognition. We have suggested a fresh and effective mouse pattern assessment system for data testing. Our system provided effective and efficient results. The suggested system utilizes hidden Markov model for organizing and Peirce's criterion collaborated under weighted least-square regression procedure for smoothing outlier elimination.

Experimental results demonstrate that the proposed algorithm reliably recognizes users with higher recognition rate when compared to existing methods. The result obtained confirms the high security in mouse pattern-led biometric recognition frameworks.

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