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Propitiating Behavioral Variability for Mouse Dynamics using Dimensionality Reduction Based Approach

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Abstract

To moderate the behavioral variability of mouse dynamics, the dimensionality reduction based approach was proposed. Mouse dynamics is the process of identifying the user based on their mouse operating behavior i.e.) how the user may operate the mouse on a particular period. The mouse dynamics data set includes mouse operation, co-ordinates axes and time stamp value, from the collected dataset, the schematic and motor-skill features were extracted to obtain feature vector. Then the dimensionality reduction based approaches were applied on feature vector space. Authentication task is done by SVM (Support Vector Machine) to identify whether the input sample was legitimate user(or)imposter. The test result proves that the proposed method Isomap (Isometric feature mapping) with SVM provides better performance than existing system KPCA.

Indexed term: *behavioral variability, mouse dynamics, feature vector, dimensionality reduction.*

I. INTRODUCTION

Authentication may take place a vital role in computer security and network security. Authentication is the process of identifying the identity of each user.Authentication can be provided based on the biometric technologies[2].Biometric technology may present the identity of the authentication with the use of physical characteristics i.e.) identify the user based on their physical characters like finger print, iris, face and behavioral characteristics [7] i.e.) identify the user based on their behavioral character like voice, signature, keystroke, mouse dynamics[15].

Keystroke dynamics mainly used in all environments and fieldwhich may authenticate the user based on their key operating behavior. Mouse dynamics is the process of verifying the individual identity of the userbased on their mouse operating behavior[5]. Mouse dynamics is the technique used to verify the identity of the user by measuring and utilizing the user's mouse behavior characteristics.

The main problem in mouse dynamics is behavioral variability which means each user can differently operate the mouse at different time [15]. From the result [12] various dimensionality reduction based approaches were proposed to analyze the performanceof all the methodologies and to reduce the error rate.

The performance of the mouse dynamics can be measured by the false acceptance rate (FAR) and false rejection rate (FRR). If the user is authenticated user but the system could not authenticate the user means that is under FRR. If the user is unauthorized user but the system could authenticate that user means that is under FAR[13].

II. RELATED WORK

In this section we demonstrated about the existing work related to mouse operating behavior and some methodologies to analyze the performance of the existing system.

C. Shen, Z. M.Cai, andX. H.Guan[10], proposed pattern-growth mining method to extracting the mouse operating behavior. Sequence number can be assigned to each operating behavior by USERID and timestamp value. The extracted the features can be applied to one-class classification algorithm to perform the continuous user authentication. The performance can be measured as FAR 0.37% and FRR 1.12%.

Chao Shen, Z.Cai, X.Guan [7] addressed behavioral variability issue with 10 computer user. Silence ratio, elapsed time of single click, movement speed movement direction, cursor position distribution features were extracted. Dimensionality reduction based approach, Isometric Feature Mapping (ISOMAP) was proposed and compared with principal component analysis (PCA) technique. The performance can be measured as FAR 3.12% and FRR 4.23%.

Youssef, Traore, E.Ahmed[4] proposed fuzzy clustering technique to extract the feature like average speed of each direction, average movement distance. Extracted feature can be employed to Learning Algorithm for Multivariate Data Analysis (LAMBDA) classification using score level fusion scheme, which is compared with neural network technique. The performance can be measured as FAR 2.45% and FRR 3.17%.

Z.Cai, Chao Shen, X.Guan[12] proposed dimensionality reduction based approach to mitigate the behavioral variability. Variability was measured over schematic feature and motor-skill features were extracted from the mouse behavior dataset. Feature vector employed to dimensionality reduction based approaches such as multidimensional scaling, linear laplacian Eigen value, laplacian Eigen maps, isometric feature mapping and compared the performance of direct classification with other classification like support vector machine, neural network, random forest, nearest neighbor algorithm applied to the feature vector. This may achieved the performance was better than the original feature space with improvement of FAR by 89.6% and FRR by 77.4%.

C.Shen, Z.Cai, X.Guan and Roy A.Maxion [11] proposed dynamic time warping method to address the behavior variability. Mean, standard deviation, movement offset, elapsed time, speed curve, acceleration curve were extracted from the dataset. Kernel PCA method was used to reduce the dimensionality of feature vector. One-class SVM classification classifier is applied to the legitimate or imposter. The performance can be measured as FAR 8.98% and FRR 8.25%.

The performance results of the previous work demonstrated with error rates and accuracy rate. A technique related to the work is proposed which defines schematic features, motor-skill features and Isometric Feature Mapping for Eigen space computation with One-Class Support Vector Machine for classification.

III. SYSTEM DESCRIPTION

The proposed system contains the following methodologies to perform user authentication.

- Feature extraction
- Dimensionality reduction
- Classification

The feature extraction includes schematic features and motor-skill features were extracted from the collected mouse behavior dataset.

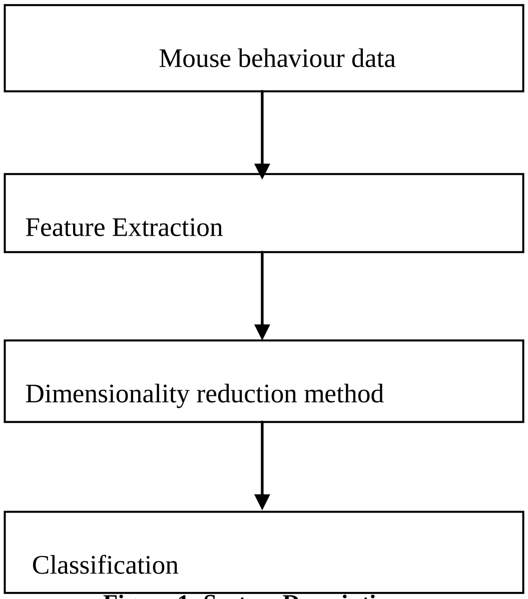

Figure 1: System Description

Dimensionality reduction based approach was proposed to reduce the behavioral variability[1] and also reduce the dimension of the feature space. Classification methodology, SVM was applied to classify whether the input sample is legitimate or imposter. The performances of the techniques were measured by the false rejection rate and false acceptance rate.Figure1 shows the overview of the proposed work and work flow of the system.

IV. IMPLEMENTATION

This section describes the implementation of the proposed work. The proposed work consists of the following methods implementation

- Feature extraction
- Dimensionality reduction
- Classification

A. *Feature Extraction*

From the collected dataset[14], we needed to extract the feature to identify the identity of each user because from the dataset we could not identify the individuality of the user. The following schematic feature and motor-skill feature can be extracted.

1) *Mouse Operation Frequency*

Number of frequent occurrence of each mouse operation(left, right, double click, drag and drop).

2) *Mouse Silence Ratio*

The amount of time the mouse should be ideal to the session.

$$\frac{\text{Amount of time that the mouse is ideal}}{Totalamountoftimetakenbymouse} \qquad (1)$$

3) Movement Elapsed Time

Elapsed time is time difference between starting point and ending point of a mouse movement.
Elapsed time = Start time-end time (2)

4) Movement offset

Offset is the distance between the practical mouse trajectory and the ideal mouse trajectory for each movement.
Movement offset = Position of start point – Position of end point. (3)

5) Average Movement Speed

Speed can be calculated as the ratio of the distance between the start and end point of the mouse and the time difference between the start and end time.

$$speed = \frac{distance}{time} \qquad (4)$$

6) Distribution of Cursor Position

Mean and standard deviation for both X co-ordinate and Y co-ordinate were calculated as,

$$Mean = \frac{\sum_i^n co-ordinate\ value}{number\ of\ co-ordinate\ value} \qquad (5)$$

7) Average Movement Distance

Mean and standard deviation for distance(distance between two co-ordinate values) were computed as,

$$Di = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \qquad (6)$$

The extracted feature may generate the feature vector space.

B. Dimensionality Reduction

In this sectiondescribes about the dimensionality reduction approach used to reduce the dimensionality of the extracted feature space. The following steps were used to reduce the dimensionality of feature vector.

Step 1:

The feature distance vector between all pair of feature samples was calculated.

Step 1.a:

Euclidean distance was calculated as,

$$Dj = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \qquad (7)$$

Where D is distance between co-ordinates and x_i,y_i represents the co-ordinate vales.

Step 1.b:

If the dimensionality reduction is ISOMAP then Geodesic distance function was applied. Geodesic distance is a curve based distance. It may calculate the shortest or minimum distance of the feature vector.

$$Di(f_m, f_n) = \min_t \sum_{i=1}^{|t|-1} D_{iISO\,(s_i, s_{i+1})}. \qquad (8)$$

Where s_i, s_{i+1}were i[th] and i+1[th] feature samples.

Step 2:

Normalize the feature vector by calculating the similarity matrix.

$$Mj = normalize(M) \qquad (9)$$

Where Mj represents the normalized feature vector and M represents the original feature vector.

Step 3:

Each sample in the feature vector can be used to calculate the Eigen value and Corresponding Eigen vector.

$$V_i = \sum\nolimits_{\Phi} V = \frac{1}{n}\sum_{i=1}^{n} \overline{\Phi}\,(X_i)^T V \overline{\Phi}(X_i) \qquad (10)$$

Where $V_i$be the Eigen vector space. The k largest Eigen values from Eigen space and corresponding Eigen vectors was taken as

$$E_i = \max_i(e_i). \qquad (11)$$

Where $E_i$represents the largest Eigen space and e_i represents the original Eigen space.

Step 4:

If the dimensionality reduction algorithm is MDS,ISOMAP then the transformed matrix as,

$$E_{ij} = \sqrt{E_i} V_i \qquad (12)$$

Step 5:

If thedimensionality reduction algorithm is LLE,LE then the transformed matrix as,

$$E_{ij} = V_i \qquad (13)$$

Where E_{ij} denotes Eigen value space and V_i denotes Eigen vector.

C. Classification

In this section explained the implementation part of classification. Classification is the continuous process of recognizing to which of a set of groups a new observed sample belongs on the basis of a training set of data containing observation whose category membership is known to the system[15]. This paper considered the output of the Eigen space is the input of one-class SVM classifier.

SVM constructs a hyper plane in a high dimension space; a good separation can be achieved by the hyper plane[8].

The authentication task considered the one class problem that construct the legitimate user profile, using that profile it could find the imposter sample with legitimate user sample. The following procedure can be used [13].

Step1:

Train the classifier, the given training features samples are legitimate sample.

Step2:

Test samples are comparedwith the trained feature sample whether the taken sample was legitimate (justifiable) or imposter (pretender).

Step3:

If test data and trained data were matched then the sample was legitimate otherwise the sample was imposter.

V. PERFORMANCE

The performance of the ISOMA with one-class classifier can be evaluated using the following measurement

FAR: The instance of a security system incorrectly verifying an unauthorized user. It measured as False acceptance rate[10].

$$FAR = \frac{Number\ of\ false\ acceptance}{Number\ of\ invalid\ sample}$$

FRR: The instance of a security system failing to verify an authorized user. It is measured as False rejection rate[1].

$$FRR = \frac{Number\ of\ false\ rejection}{Number\ of\ valid\ sample}$$

One class SVM (Support Vector Machine) classifier can achieved the performance with FAR as 2.12 and FRR as0.26.

VI. RESULT AND ANALYSIS

This section demonstrates about the result and performance analysis of the proposed system.

Table 1.Performance (Far And Frr) Analysis

Algorithm	FRR (%)	FAR(%)
One-class SVM with ISOMAP	4.25	5.25
One-class SVM with KPCA	6.25	7.25

Table 1 describes the performance of various technique that can be measured as FAR and FRR. The statistical analysis may shows the result and ISOMAP with one-class SVM can be evaluated to the KPCA with one-class SVM beside the ROC curve [9]. ROC curve is a curve which may plot the true positive rate against false positive rate for various cutpoints.

VII. CONCLUSION

Mouse operating behavior based authentication is a most powerfultechnique that can present the authentication within a petite period of time and provides the better accuracy**.** Feature can be extracted from the mouse behavior and dimension can be reduced using Isomap technique and the selected feature can be applied to the SVM classifier to identify the user. The performance can measured as FAR 4.26% and FRR 5.25%. This provides the reduced authentication time and good accuracy than the existing system.

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