# 동적 서명인증시스템의 인증 서버에 관한 연구

## A Study on Authentication Server of Dynamic Signature Verification System

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### 초 록

본 논문은 동적(온라인) 서명인증 기술에 관한 것으로 서명의 특징 벡터, 유사 서명에 대한 변별력, 오류율 등에 대해서 살펴보고, 고성능 서명인증시스템을 위한 특징 추출과 매칭 방법을 제안하고, 보다 효율적인 사용자 인터페이스를 설계하였고, 다양한 OS플랫폼 지원을 위하여 Java 기술을 이용한 웹 인증 서버를 구현하였다.

### ABSTRACT

This paper is a research on the dynamic signature verification of error rate which are false rejection rate and false acceptance rate, the size of signature verification engine, the size of the characteristic vectors of a signature, the ability to distinguish similar signatures, and so on. We suggest feature extraction and comparison method of the advanced signature verification. Also, we have implemented web authentication server with Java technology for supporting various OS Platforms and designed for more efficient user interfaces.


키워드 : 동적 서명 인증, 생체 인증, 자바 기술

Dynamic Signature Verification, Biometric Authentication, Java Technology

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# 1. Introduction

The need to be able to identify other individual human beings is fundamental to the security of the family unit and has been true since the beginning of human history. Members of a tribe needed to be able to identify other members of the tribe quickly, easily and usually from a distance. Using the remembered physical or behavioral characteristics of each member achieved this. How a person looked, what they were wearing, how they moved or combinations of these were used to authenticate the person as a member.

The biometric technology allows for a greater reliability of authentication as compared with badges, card readers or password systems. The chances of an individual losing his/her biometric information are far less the forgetting a password or losing a card. Through these types of verification, comes an increased role of responsibility, and security.

Dynamic signature verification technology is to verify the signer by calculating his writing manner, speed, angle, and the number of strokes, order, the down/up movement of pen when the signer input his signature with an electronic pen for his authentication.

Verifying yourself to a machine is the first step of most automated transaction. The desire for increasing convenience and security motivates the development of biometric techniques in order to replace keys, passwords, and smart cards. Signature verification presents four advantages unlike over other physiological biometric techniques from the point of view of adoption in the market place. First, it is a socially accepted identification method already in use in bank and credit card transaction; second, most of the new generation of portable computer, personal digital assistants (PDAs) and especially smart phone use handwriting as the main input channel; third, a signature may be changed by the user, similarly to a password, while it is not possible to change fingerprints, iris or retina patterns; fourth, group users can share signature key with very simple pattern of signature unlike physiological biometric technology. That is, physiological biometric technology cannot be shared for group users.

All biometric techniques have false accepts generated by the imperfections of the classification method or by errors in the acquisition device. However, dynamic signature verification using behavioral biometric technique, compared with physiological biometric techniques such as fingerprint, face, iris or retina, have additional advantage that a forger with not-enough information about the true signature could not deceive the verification algorithm because multi-dimensional feature information of dynamic signature, that is, speed of stroke, size of signature, pressure, variable shape, pen down/up information and so on decrease the risk of accepting skilled forgeries since they are not

available to the forger.

The rest of this paper is organized as follows: Section 2 describes the dynamic signature verification system; Section 3 describes suggested feature extraction for the system; Section 4 describes comparison method of our system; Section 5 describes Java implementation of our system and conclusions follow it in section 6.

## 2. Dynamic Signature Verification System

Fig. 1 shows the diagram of a typical dynamic signature verification system (DSVS). DSVS, like all other biometric verification systems, involves two processing modes: registering and verifying. In the registering mode include three phases: training, testing and saving. In the training, the user provides signature samples that are used to construct a template (or prototype feature vector) representing some distinctive characteristic of his signature. In the testing, the user provides a new signature to judge authenticity of the presented sample and choose his own threshold security level for him. The performance of a verification system is generally evaluated with equal error rate (EER) as Fig. 2.

The errors of verification can be classified in two categories False rejection rate (FRR) indicates the rate of genuine signatures rejected that is, measures the number of genuine signatures classified as forgeries. False acceptance rate (FAR) indicates the rate of accepted forgeries that is, evaluates the number of false signatures classified as real one. The Equal Error Rate (EER) corresponds to the error value for which FAR is equal to FRR. These rates determine the quality of an authentication system, but the acceptable values depend on the level of security desired for a specific application.

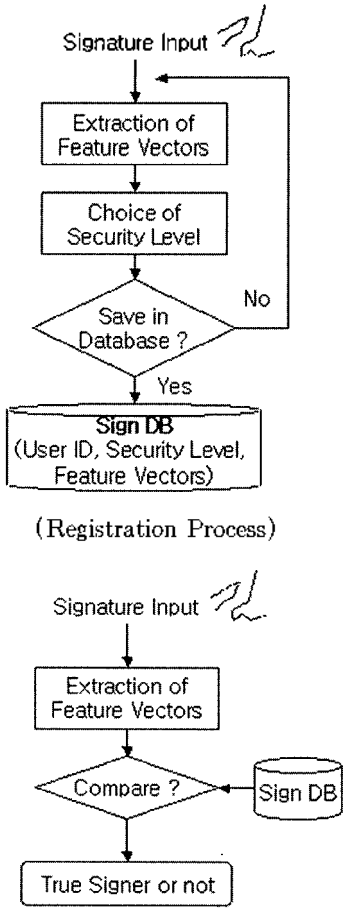



Fig. 1 Dynamic Signature Verification System

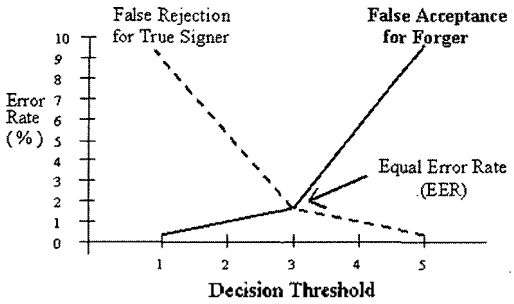



Fig. 2 Graph of Equal Error Rate

Anyway, EER provides an estimate of the statistical performance of the algorithm, i.e., it provides an estimate of its generalization error.

## 3. Feature Extraction

We introduce useful feature points in our dynamic (on-line) signature verification system. Finding out the best method to calculate the degree of similarity is very important. The previous approach for that is to select and arrange distinctive points. For the best signature verification, it is important to reduce the range of variation of the true signature and to extend distinctiveness between the true and forgeries. Assigning the adequate weight for each feature is another important point.

The useful feature points are below:

- velocity, acceleration, pressure information
- Shape of coordinates
- Direction and slope between two points
- Number of pen down/up points
- Information of pen down/up movement (Fig. 3)
- Total time taken in signing
- Pen down/up time between strokes
- Number of strokes
- Total number of coordinates

Our system primarily uses directions and absolute distances (in Fig. 4) between two points for the pen down/up strokes. We have known that these two features include many information of the signature that is, the shape and velocity, information of strokes, elapsed time and so on with our experiment and experience.

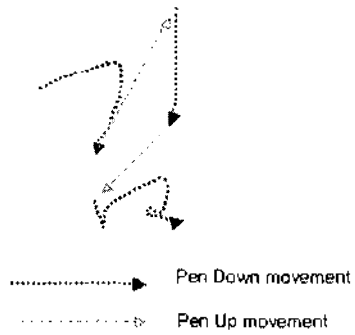



Fig. 3. Pen Up/Down movement

The feature vectors of pen down movement have values of 1 to 36 directions. And the feature vectors of pen up movement have values of 91 to 126 directions. But, distances have absolute length of value between two points as Fig. 4. All distances are defined less than 128. So, these directions and distances

can be stored in byte strings of small memory.

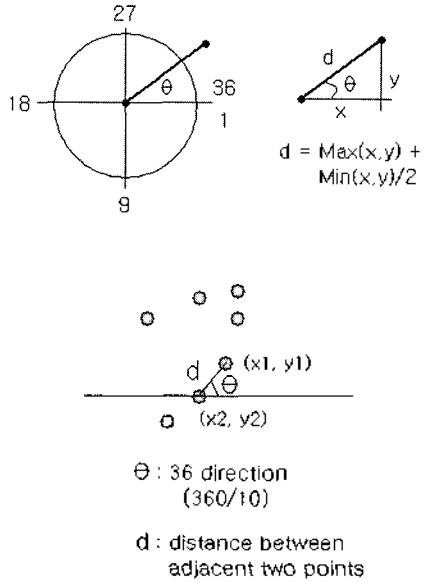



Fig. 4.Signature features of direction and distance

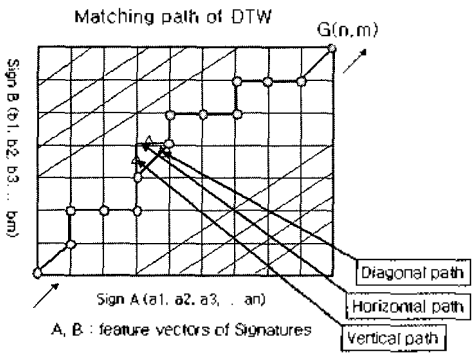
## 4. Comparison Method

Given two signatures to compare, it is natural to ask "how similar are they?" or "what is their similarity?". It is intuitive to answer the similarity with a value between 0%-100% and this value should make sense. For example, when we gain the similarity of two signatures as 90%, they should be very close to each other objectively, even it is subjective to say how similar they are.

No matter what kind of features is extracted, such a similarity measure is unavoidable. Euclidean distance, DTW (Dynamic Time Warping in Fig. 5) or other distances are relative meaning. That is, the distance itself cannot give us any information about similarity without comparing it with other distances.

DTW is one of the best for curve matching with optimal alignment for the dynamic signature verification. Alignment is absolutely necessary, because no user writes his/her signatures exactly the same each time. There always exists some difference in the total length and overall shape.

One of the most important difficulties in authentication using dynamic signatures is the choice of the comparison method. Dynamic signatures are given by a sequence of points sorted with respect to acquisition time. Since two signatures of the same person cannot be completely identical, we must make use of a measure that takes into account this variability. Indeed, two signatures cannot have exactly the same timing, besides these timing differences are not linear. Dynamic Time Warping is an interesting tool: it is a method that realizes a point-to-point correspondence. It is insensitive to small differences in the timing. Calculation distances between signatures with DTW allows to achieve a verification system more flexible, more efficient and more adaptive than the systems based on neural networks or Hidden Markov Models, as the training phase can be incremental. This aspect is very important when we must enroll our new signature along the years or new environment.




$$G(i,j) = \left\{ \begin{array}{l} cost(a[i], b[j]) + \\ \min \left( \begin{array}{l} G(i-1, j) + w1, \\ G(i, j-1) + w1, \\ G(i-1, j-1) + w2 \end{array} \right) \end{array} \right\} * \max(i,j) / \min(i,j) \Big/ (i+j)$$

$\forall$ $0<i<n$, $0<j<m$, $w1>w2$ : fixed weights
$G(i,0) = \infty$, $G(0,j) = \infty$, $G(0,0) = 0$

Sign A : (a[1], a[2], ... , a[n]),
Sign B : (b[1], b[2], ... b[m])
I and j are length of features,
a[i] and b[j] are feature vectors
w1, w2 are weight values such that w1 > w2.

Fig. 5 Method of Dynamic Time Warping

W1 is a weight value adopted in case horizontal path or vertical path, and w2 is a weight value adopted in case diagonal path. Given two sequences A = (a1, a2, ..., an) and B = (b1, b2, ..., bm), the distance DTW(A,B) is similar to find shortest path to G(n,m) in Fig. 5. To calculate the DTW distance G(A,B), we can first construct an n-by-m matrix, as shown in Fig. 5. Then, we find a path in the matrix which starts from cell (1, 1) to cell (n,m) so that the average cumulative cost along the path is minimized. If the path passes cell (i, j), then the cell (i,j) contributes cost(ai, bj) to the cumulative cost. The cost function can be defined flexibly depending on the application, for example, cost(ai, bj) = |ai-bj|*weight. This path can be determined using dynamic programming of our suggested recursive equation:

$$G(i, j) = [cost(ai, bj) + \min\{G(i-1,j) + w1, G(i-1,j-1) + w2, G(i,j-1) + w1\}] * \max(i,j)/\min(,j)/(i+j)$$

The path may goes several cells horizontally along A or vertically along B, which makes the matching between the two sequences not strictly one-one but one-many and many-one. This is the robustness that DTW provides to align sequences. Also we suggest that w1 and w2 are very important weight value for the measure of similarity in DTW. We are very satisfied with the EER (Equal Error Rate) of our system. Now, many companies have adopted our system in Korea

## 5. Java Implementation

We provide two windows (Fig. 6 and Fig 8) for the dynamic signature verification system. Fig. 6 is a window to save signer's signature feature vectors in remote database. First step: Signer writes his signature on the white rectangle area and then click 'Register' button. Second step: Signer writes his same signature again and then clicks 'Test & Verify' button to see recommended security level and degree

of similarity in Fig. 7 between two signatures. According to the results of several times trial, the signer can choose his security level. If the signer clicks 'Save' button finally, his signature's feature vectors, security level, ResidentID and password are saved in remote sign database.

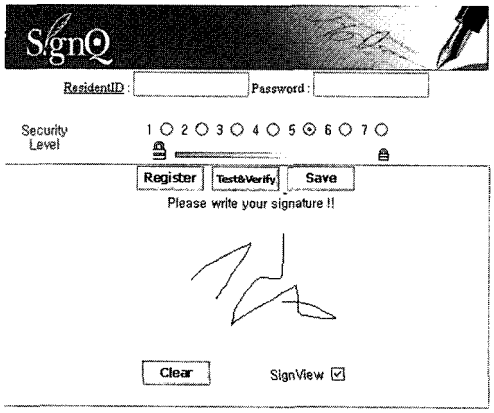



Fig. 6. Interface window for the signature register

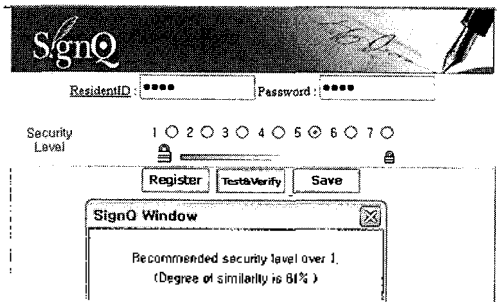



Fig. 7. Signature testing window

Above Fig. 8 is user interface window to verify the signer's authentication and 'SignView' check button is a function to display or disappear the writing signature. These interface windows for the DSVS are implemented with JAVA to

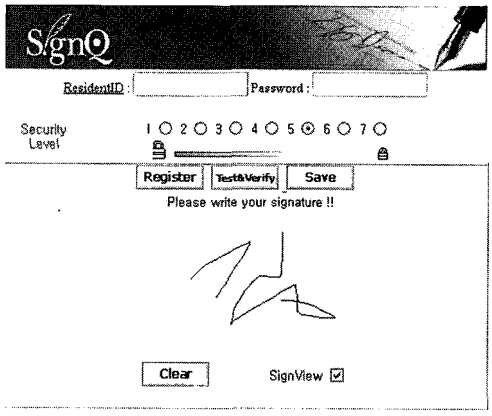



Fig. 8. Interface window for the signature verification

support various OS platforms and anyone can test the DSVS at our web site:

(http://www.mmigroup.net/en/mmi_products_signq.php)

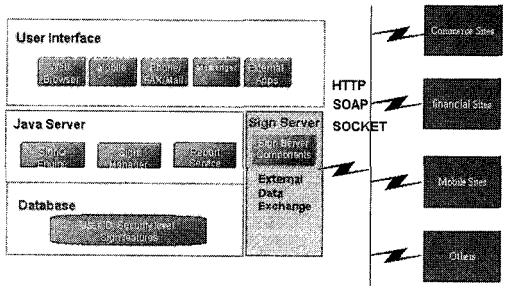



Fig. 9. Components of the sign server and interface structure

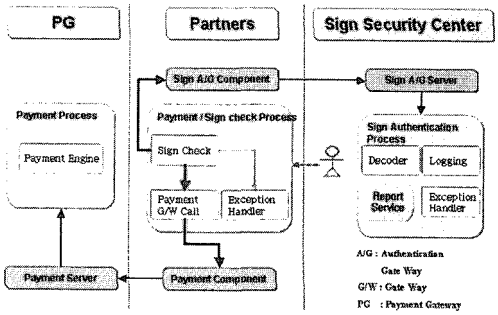



Fig. 10. System architecture of the DSVS

Fig. 9 and Fig. 10 are component of the sign server and interface structure and system architecture of the DSVS respectively.

## 6. Conclusions

It is quite evident that biometrics is here to stay as the most valuable form of not only computer-related security, but in a plethora of other forms also. Markets to be penetrated include using biometrics for passports, birth certificates, forensics, banking, ticket-less air travel, computer log-in, driving licenses, automobile ignition and unlocking, anti-terrorism, anti-theft, and to replace the archaic use of PIN and passwords. As the technologies become increasingly produced and the market fully embraces the newest forms of biometric security, biometric solutions will inevitably become cheaper and more abundant in the information systems market and therefore available to almost anybody with a need for enhanced security measures.

We have implemented the DSVS with Java based various technologies such as Java applet, Java servlet, JSP, HTML, servlet container of Resin and MySQL database. The importance of security is emphasized more and more at present, this system is applicable to the security of a computer, important document, the access restriction of network server, on-line shopping, credit card, military secret, national administrative security, internet banking, cyber trading, admittance to building, personal approval and so on. Government owes people to protect from an unsafe transaction in Internet. Also we have to pay attention to adopting the verification approval system teenagers to protect from the numerous immoral adult sites. This dynamic signature verification technology has been realized as one of the highly valued, useful and efficient technology for the security all over the world.

Descending with years, a useful bibliography is also provided for interested readers.

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