

# Evaluation of Handwriting Characteristic for Two-factor Authentication Interface on Touch-pad Panel

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**Abstract:** Frequencies of user authentication increase and spread of smartphone and tablet advances rapidly in recent years. However, it is a great challenge that password authentication is easy to be attacked and must be solved. We assume authentication, which use touch panel and handwriting as an authentication element in this paper. As far as we know, there have few papers about generating a digital data from handwriting. Therefore, our contribution of this paper is to define handwriting characteristics of a letter that can convert into a digital data and evaluate possibility of the conversion.

## 1 INTRODUCTION

In recent years, with spreading smartphone and tablet, it is possible to be easily connected to Internet. In addition, frequencies of user authentication increase when users use service on Internet. Password authentication accounts for approximate 80% of user authentications (Symantec Corporation, 2013). However, it is thought that users set a password that is easy to be guessed in user authentication because of difference of security awareness of users. By the reasons that I mentioned above, assailants can easily attack such as dictionary attack, which enters from beginning to end in all of words.

Two-factor authentication is known as solution to problem of password authentication. A security token is used as an authentication element to use together with a password in two-factor authentication. However, users must have it. In contrast, users don't have to have it in the case of biological information. In addition, touch-pad panel, which device have become widespread. Therefore, we use handwriting as a authentication element with a password in two-factor authentication in this paper.

Because it is thought that an input pattern is not the same digital data every time, general handwriting authentication apply pattern matching of handwriting and measure similarity by comparing an input handwriting pattern with a handwriting pattern registered beforehand. On the other hand, digital data

are considered to be password and can be introduced into an existing authentication protocol(Masaki, 2015). If digital data which are different each individual can be output every time by a handwriting pattern, they can be used generating of key for authentication. Handwriting authentication can be implemented by an existing authentication protocol without implementing a new protocol for handwriting authentication and can be expected cost reduction.

Therefore, our contribution of this paper is to define handwriting characteristics of a letter, which can convert into a digital data and evaluate possibility of conversion. We suggest differences of characteristics of the handwriting inputted by the application and examine whether to convert it into  $\{0,1\}^n$ .

The remainder of this paper is organized as follows. In section 2, we denote examples of user authentication and its problems. In section 3, we describe the characteristic of a handwriting which convert into a binary digit. In section 4, we denote procedures in the experiment to collect handwriting. We provide a conclusion and a discussion in section 5.

## 2 USER AUTHENTICATION

In section 2.1, we denote challenge response method in password authentication and problem of password

authentication. We denote two-factor authentication in section 2.2, and physical characteristic in section 2.3.

## 2.1 Password Authentication

### 2.1.1 Challenge Response

Challenge response is proved that third party can't obtain password of users because a response code, that is encrypted and a challenge code, that is generated by random number generator are delivered on packet on network (Atsuko and Hiroaki, 2003).

The following procedure is CHAP (Challenge Handshake Authentication Protocol) (Simpson, 1996), which is used challenge response method in password authentication. A password is encrypted by hash function with the key in challenge response method. Just for information, hash function link hash value and digital data that is called for private key and calculate it.

1. Users send a server authentication demand.
2. The server generates challenge code (hereinafter it is called C) by random number generator and sends the user it.
3. The user encrypts C with a password (hereinafter it is called PW) that the user has by hash function with the key (hereinafter it is called R ←  $H_K(PW, C)$ ) and sends the server it with user's ID.
4. The server encrypts C with administered PW bound to the ID, verifies whether generated value and received value in procedure 3 are identical or not ("ACK" means success of this verification, and "NAK" means failure of this verification), and notifies the user of result of this verification.

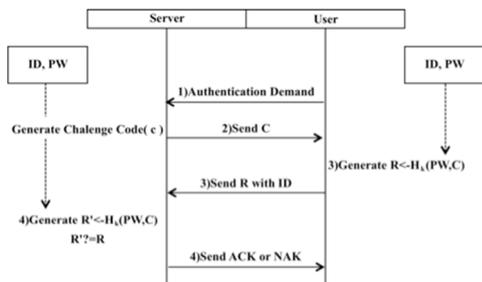


Figure 1: Procedure of CHAP.

### 2.1.2 Problems

Password authentication is a user authentication that use password bound to user's ID as an authentication element. Password authentication accounts for approximate 80% of user authentications (Symantec Corporation, 2013). However, it is thought that users set a password that is easy to be guessed such as

user's birthday in user authentication because of difference of security awareness of users. In addition, there are a lot of the users who use a same password in plural sites because remembering plural passwords is a burden for the users (Information-technology Promotion Agency Japan, 2014).

From the above a reason, assailants obtain lists of user's ID and password bound to user's ID and try login using it illegally (Information-technology Promotion Agency Japan, 2015). As a result, information leaks occur frequently.

## 2.2 Two-factor Authentication

Two-factor authentication is a user authentication, that uses two authentication elements in three authentication elements shown below (SOPHOS, 2014).

- 1) Information that users memorize (E.g. password, personal identification number)
- 2) Objects which users possess (e.g. IC card, token)
- 3) Characteristics that users have (E.g. handwriting, fingerprints)

The problem that was described in 2.1.2 needs a solution. Therefore, a goal of this study is to strengthen security of password authentication by adding one authentication element.

Handwriting is used for an authentication element with a password in this paper and the reason is denoted in 3.1.

## 2.3 Behavioral Characteristic

First, biological information is classified in two types. The first of two types is physical features such as iris and fingerprint, and the second of two types is behavioral characteristics such as handwriting and walking (Atsuko and Hiroaki, 2003). Using biological information for an authentication element has advantages for users. We denote advantages and defects of the two types as follows.

Possibility of the authentication that use physical features accept another persons is extremely low (Information-technology Promotion Agency Japan, 2012). However, changing physical features that are used for an authentication element is difficult when physical features leaked out. On the other hand, users feel less resistance to authentication that use behavioral characteristics (Kensuke et al., 2015) and can easily change behavioral characteristics (Information-technology Promotion Agency Japan, 2015).

### 3 HANDWRITING FOR SAMPLING DIGITAL DATA

As described in section 2.3, authentication that uses behavioral characteristics has many advantages. Device with touch-pad panel are widely diffused. Therefore, we focus on handwriting that can be inputted by touch-pad panel.

A few authentication systems that use handwriting are proposed (Hitachi Systems, 2002; Witswell, 2012). However, few studies have focused on possibility of conversion from handwriting to digital data. Therefore, we discuss using handwriting not only for an authentication element with password but also for private key. As a previous step, we define handwriting characteristics of a letter to convert into digital data and evaluate possibility of the conversion in this paper.

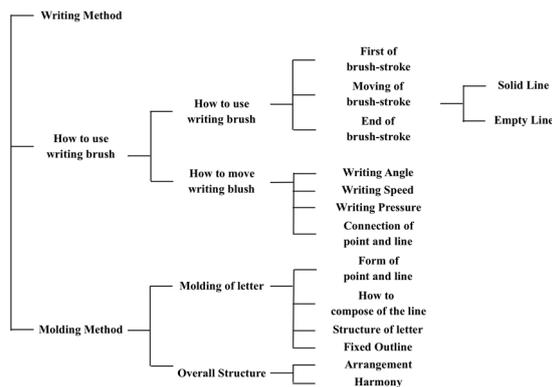
We denote handwriting skill in section 3.1 and standard for converting handwriting into a digital data in section 3.2.

#### 3.1 Handwriting Skill

We convert handwriting into a digital data based on difference of a handwriting characteristic.

It has been proposed that individual difference of handwriting is caused by difference of handwriting skill (Yoshikazu and Junichi, 1994). Table 1 shows classification of handwriting skill (Yoshikazu and Junichi, 1994). Therefore, we define handwriting characteristics based on handwriting skill.

Table 1: Category of Handwriting skill.



#### 3.2 Data Judgment by Difference in Handwriting Letter

Image data of handwriting are collected in the experiment. Therefore, molding method was referred

as standard for evaluation in handwriting skill because handwriting characteristics are easy to be distinguished in image data.

Molding method is constitution of length and direction of points and lines in a letter, or constitution of how lines in a letter cross. We choose how lines in a letter cross on the basis of standards of handwriting characteristics in molding method because it is easy to convert it into a binary digit such as 0 or 1.

We define three handwriting characteristics in a letter that can convert into a digital data.

The first handwriting characteristic in this paper is whether two lines protrude in other words; two lines intersect in a part that the two lines contact in normal situation. A binary digit becomes 1 when two lines intersect in the part in a letter. A binary digit becomes 0 when the two lines contact in the part. Figure 2 shows “A” of a capital letter of alphabet as an example of the first handwriting characteristic in this paper.

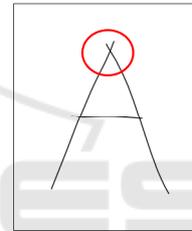


Figure 2: Example of two lines intersect.

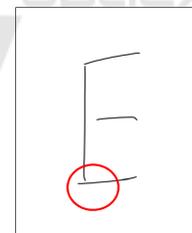


Figure 3: Example of one line protrudes.

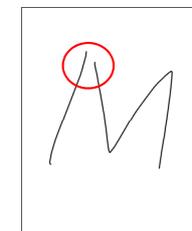


Figure 4: Example of two lines don't contact.

The second handwriting characteristic in this paper is whether one line of two lines protrudes in a part that the two lines contact in normal situation. A

binary digit becomes 1 when one line of two lines protrudes in the part in a letter. A binary digit becomes 0 when two lines contact in the part. Figure 3 shows “E” of a capital letter of alphabet as an example of the second handwriting characteristic in this paper.

The third handwriting characteristic in this paper is whether two lines don’t contact in a part that the two lines contact in normal situation. A binary digit becomes 1 when two lines don’t contact in the part in a letter. A binary digit becomes 0 when two lines contact in the part. Figure 4 shows “M” of a capital letter of alphabet as an example of the third handwriting characteristic in this paper.

### 4 EXPERIMENT METHOD

We assume authentication that use touch-pad panel because of spread of smartphone or tablet, and accessibility for users in this paper.

Therefore, we make an android application that saves image data of letters that is written with a finger. Figure 5 shows a screen shot of collecting letters. The application collected image data of capital letters of alphabet from 22 subjects (All Japanese). Capital letters of alphabet was chosen because it was desirable that there were many letters that were comprised of straight lines on using the three handwriting characteristics.

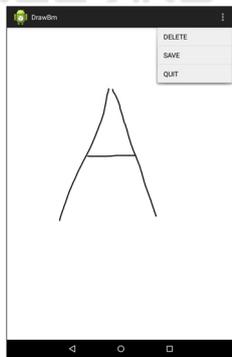


Figure 5: Screen shot of collecting image data.

### 5 EVALUATION

We collected image data of letters by the experiment shown in section 4 and evaluated every letter. We denote result of evaluation of letters in section 5.1 and show consideration of the result of evaluation in section 5.2.

### 5.1 Result of Evaluation

Table 2 shows result of evaluation of letters. Standard 1 or 2, 3 correspond to handwriting characteristics shown in section 3.2. Total pattern is the maximum number of bit that a letter can express and is an object for comparison in this paper. To give an actual example, “A” has six characteristic points. Therefore, total pattern of “A” is  $2^6 = 64$ .

Letters that were surrounded with bold frame have individual difference of form of the letters in table 2. Explanation every letter is below.

Firstly, there are subjects who write after the second of stroke order of G such as Figure 6 or Figure 7. As a factor of the result, we expect difference in form of ‘G’ that subjects write.

Table 2: Result of evaluation.

letter	Standard 1	Standard 2	Standard 3	Total pattern
A	1	2	3	64
B	2	2	3	128
C	0	0	0	1
D	2	2	2	64
E	2	3	3	256
F	1	2	2	32
G	0	2	2	16
H	0	2	2	16
I	0	2	2	16
J	0	1	1	4
K	0	2	2	16
L	1	1	1	8
M	3	3	3	512
N	2	2	2	64
O	0	0	1	2
P	1	2	2	32
Q	0	0	1	2
R	1	3	3	128
S	0	0	0	1
T	1	1	1	8
U	0	0	0	1
V	1	1	1	8
W	3	3	3	512
X	0	0	0	1
Y	1	1	1	8
Z	0	0	0	1



Figure 6: Example1 of “G”.



Figure 7: Example2 of “G”.

Secondly, there were subjects who write “R” or “Q” in block letters or in cursive letters, they were mixed. As a factor of the result, we expect that difference in form of the letters that subjects write is big because English is not native language for the subjects.



Figure 8: Example of “Z”.

Thirdly, there are subjects who add one line to “Z” such as Figure 8 or don’t add one line to “Z”. As a factor of the result, it is thought that there are subjects who add one line to “Z” to distinguish number of 2 from it.

## 5.2 Discussion

### 5.2.1 Handwriting Characteristic

We compared three handwriting characteristics shown in section 3.2. The mean value of total pattern that is the maximum number of bit that a letter can express was used for comparison. The following is a result of comparison.

Standard 1 < Standard 2 < Standard 3

Standard 1 is whether two lines intersect, Standard 2 is whether one line of two lines protrudes, and Standard 3 is whether two lines don’t contact. Standard 3 had a mean value that was bigger than mean values that the others standards had.

As a factor of the result, a part that lines received for the subject’s finger writing letters was hard for subjects to be seen because line weight that is used in the application which the subjects wrote letters with a finger was thin. Therefore, future issue is to change line weight that is used in the application and test it.

### 5.2.2 Evaluation of Letter

We found that there are differences of form of the letters that subjects write shown in section 5.1. These differences of form of the letters are future issues.

The number of the letters that is valid as an authentication element is shown below. Standard that was chosen is that the maximum number of bit that a

letter can express is more than two patterns. As a result, 21 of 26 characters are valid. In other words, approximate 80% of alphabet of capital letter is valid. In addition, the mean of the maximum of bit that alphabet of capital letter can express was 90 patterns. (The decimal value was cut off.)

Evaluation in this paper is only whether conversion from the three handwriting characteristics to a binary digit is possible and comparison of the maximum number of bit that a letter can express. Therefore, future issues are combination of the letters and the number of digits of bit that is used for an authentication element.

## 6 CONCLUSION

We define handwriting characteristics of a letter to convert into digital data and evaluate possibility of the conversion. As a result, the present result suggested validity of converting the handwriting characteristics into digital data. Future topics of discussion are line weight that subjects write letters with a finger and individual difference of form of letters.

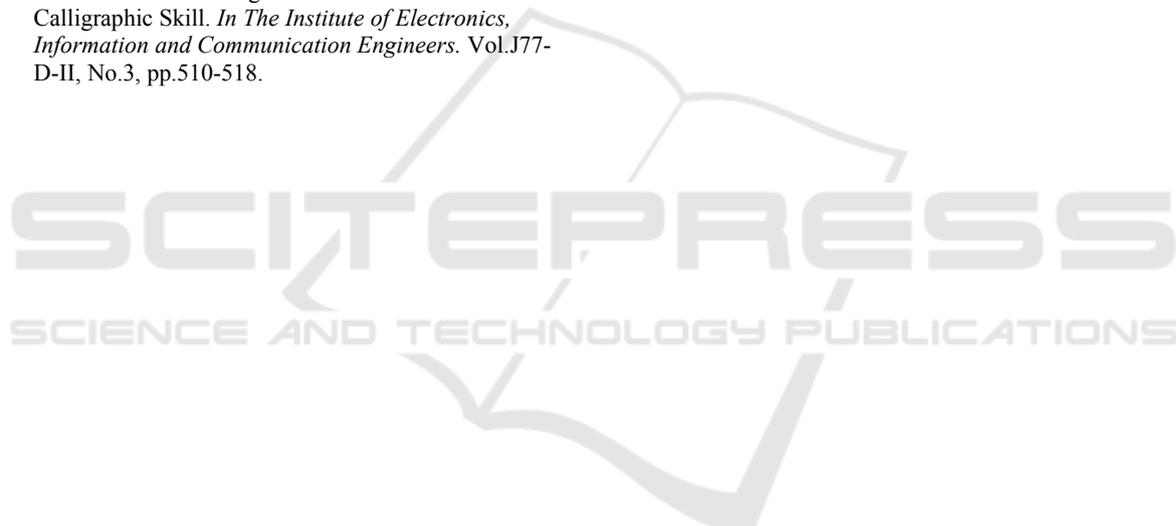
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