Efficient Signature Pattern Generation by Using Latticed Bounding Box

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Abstract According to the growth of users' needs for security and human-machine interaction, many automated user verification method have been developed based on biometrics. One of the representative methods among them is on-line signature recognition. But, the previous on-line signature recognition methods require too much complex processing so that it is not well suited for the simple and fast processing application. In this paper, we deals with efficient signature pattern generation method by using the relatively adjustable latticed bounding box to make more efficient signature recognition for various human-machine interactions.

Keywords Latticed Bounding Box, Signature Pattern, Signature Recognition, Human-Machine Interaction

1. Introduction

As the technology for robotics and human-machine interaction is highly developed, user needs for security and convenience are both increasing. To meet these needs, there are many approaches for user identification or verification methods from the simple way using password or keys to the natural ways using biometrics such as fingerprint, iris, face, palm print, gait and signature [1,2,3]. Among these, dynamic feature-based biometrics such as gait or signature is more natural and human-friendly so that it is well-adapted for the use in human-machine interaction.

And, one of the representative methods among dynamic feature-based biometrics is using on-line signature. Signature verification methods can be classified into two groups according to the analyzed feature type, parameter-based approaches and function-based approaches. There are some algorithms such as hidden Markov model (HMM) [1], LDA [2], neural network (NN) and dynamic time warping in function-based matching methods.

But, the previous function-based matching methods in on-line signature recognition are too much complex to

handle the size-varying problem and the inconsistency problem of human signature. So, these previous methods are not well suited for simple and fast processing application. In this paper, a more efficient signature pattern generation method is addressed by using the relatively adjustable latticed bounding box.

2. Previous Study

One of the representative methods for computationally efficient signature pattern generation is using input window method [4] which uses the fixed sized input window with pre-defined invisible grid frame like Fig.1. By checking the crossing with each border line 1~5 of the grid frame, this method can generate a time series of alphabet pattern with varying size. And, this time series of alphabet pattern is used as a password for each user. Here, alphabet is one of the letters of {1, 2, 3, 4, 5}.

This input window method is simple and fast but it is not accurate when there are some changes in translational alignment, rotational alignment, or size since this method is based on the assumption that the hard outline of input window can make a user controlled behaviors so that the result of user signature will be also somewhat normalized naturally in the aspect of position, rotation and size.

Figure 1. Input Window Method [4]

3. Proposed Method

3.1. Basic Idea

The proposed method is based on the previous input window method. But, the proposed method also considers the translational alignment and size adjustment by using the relatively adjustable latticed bounding box like Fig.2.

Figure 2. 17-Latticed bounding box

3.2. Signature Pattern Generation based on n-Latticed Bounding Box

The proposed signature pattern generation method based on n-latticed bounding box are like the bellows: ($n \leq 26$)

(1) Find each coordinate value of 2D signature pattern data after discretization.

(2) Find the boundary values of signature pattern, ($x_{\min}$, $x_{\max}$, $y_{\min}$, $y_{\max}$) by scanning as x-axis or y-axis.

(3) Determine the border lines A, B, C and Z using the boundary values, A: $x = x_{\min}$, B: $x = x_{\max}$, C: $y = y_{\min}$, Z: $y = y_{\max}$. In Fig.2, there are 4 border lines and 13 grid lines so that $Z = Q$.

(4) Determine the remaining (n-4) grid lines using C and Z. i-th grid line: $y = y_{\min} + (y_{\max} - y_{\min}) / (n-3) \times i$, $i=1, \dots, n-4$. In Fig.2, there are 13 grid lines from D to P.

(5) Generate signature pattern by checking the crossings with each lines of n-latticed bounding box. If a signature crosses with the line D at a time, then the alphabet 'D' is generated as passcode for the user at the time.

3.3. Signature Pattern Registration

The output of proposed signature pattern generation method is always 1D string. And, this string is used as the pattern for registration. Fig. 3 (a) and (b) show signature patterns from different users. The signature in Fig.3 (a) consists of 60 alphabets such as 'ADEF GHIJ KLMNOP QPONMLKJIH IJ K L K J I H G F F G H I J K L M L M L K J I H G F F G H H G G H I J B' and the signature in Fig.3 (b) consists of 62 alphabets such as 'J K L M N O P Q P O N M L K J I H G F G H I J K B K J I H G F E D C D E F G H I J K L M N M L K J I H G F E E F G H I J K'. Table 1 shows the experimental results of various signature pattern generation based on the proposed latticed bounding box method. Here, signature length pattern means the number of alphabets used to represent the signature pattern and the signature pattern means the final results of our proposed signature pattern generation.

Figure 3. Examples of Signature on the Latticed Bounding Box

Table 1. Experimental Results of Various Signature Pattern Generation based on the Latticed Bounding Box

User ID	Signature ID	Signature Image	Signature Pattern Length	Signature Pattern
User1	1-1		90	JHGFEEFAGHIJJKJLMLMLKII KLMOPOMLKJIHGFEDCDEFG HIJLKMOPOMLKKLMOPQPOM LKJIHGGHIJJKJIHGIJLMOB
	1-2		85	HAGFEDCDEFGHIJJIHJLML KJIKJIHGFEDCDEFGHIJLMO POMLKKLMOPQPOMLKJIHGG HIJLMLKJIIMKLMOPB
	1-3		84	JHGFFGHIJJKJLMLKJIJLML OOMLKJIHGFEDCDEFGHIJL MOPOMLLMOPQPOMLKJIHGG GHIJJKJIHGGHIJKB
User2	2-1		52	AHIJLKMOPQPOMLKJIHHIJKL LKJIJGFEDCDEFGHIJJIHGGF HHHB
	2-2		51	AIJLKMOPQPOMLKJIJLKLKJI HGFEDCDEFGHIJJKJIHGGFGH GFFB

	2-3		45	AJKLMOPOPMLKJIIJKLMLK JIHGFEDCDEFGHIJIIHHHGH
User3	3-1		78	MLKJIIJKLMOOMLKJIIJKLLKJ JKLMOOMLKKLMLKKLMOPQ POMLKJIHGFEDCDEFGHIJKL MBMLKJIIHHJK
	3-2		80	LKJIHGFEGHIJKLMLKJIIHHJK KJIIJKLMLMLKJIIKKKLMO QPOMLKJIHGFEDCDEAFGHIJ KLMBLKJIHGG
	3-3		75	OMLKJIIJKLMOPPOMLKJJKL MMLKKLMOPQPOMLLMOPPO MLKJIHGFEDCDEAFGHIJKL OOBMLKJIIJK
User4	4-1		60	QPOMLKJIHGFEDCADEFGHIJ IHGFFGHIHGGHHGFEGFHHH GFEEFGHIHBHGF

	4-2		51	QPOMLKJIHGFEDCADEFGHIIH GFEDDEFHGFGFFGGFFGHHGFF GHHBGFE
	4-3		65	QPOMLKJIHGFEDCADEFGHIJ KJIHGGHIJKKJIHGGFGHIHGGF GFFGHIHGGFGHIIBHGF
User5	5-1		42	KJHGFAGHBCDEFGHGFFGH HGGHHGFEEFGHIJKLMNOPQ
	5-2		40	KJIHGFAGHICDEFGGFFGHII HHGFGHIJKLMNOPQB
	5-3		39	JIHGFEAEGHCDEFFFGHHGG HHGFFGHIJKLMNOPQB

User6	6-1		55	ANOPQPONMLKJIHGFEDCDEF GHIJKLMNOPPONMLKJIHGFF GHIJJHGGHB
	6-2		52	AMNOPPONMLKJIHGFEDCDE FGHIJKLMNOPPONMLKJIHH IJJHGGHB
	6-3		50	ANOPQPONMLKJIHGFEDCDEF GHIJKLMNOPPONMLKJIHHIJ KKJJB
User7	7-1		41	OOONNAMNMLKLKONMLB KKLMNOPQPONMLKJIHGFED C
	7-2		45	NMNMAKLLKJINNMLLBKJII JKLMNOPQPONMLKJIHGFEDC
	7-3		42	NNOONLMNMLKJANNMBLK JKLMNOPQPONMLKJIHGFEDC

User8	8-1		154	QPONMLKAJIHIJKLMNOPPON MLKJIIJKLMNOONMLKLLKJ IHGFEDCDEFGHIJKLMNOPQ ONMLKJIIHHIJKLLKJIHGFEF GHIJKLMNOPPONMLKJJKLMN OONMLKJIHGGHIJKLLKJJKL MNNMLKJIHGFFGHIJKLLBJ
	8-2		124	QPONMLKJIHAGFEFGHIJKL MNOONMLKJIIHHIJKLMNNML KJJJIHGFEDEFGHIJKLMNO PPONMLKJIIKKJIHGFEDEFG HIJKLMNNMLLMMLKJIHGGG FEDEFGHIIHHIB
	8-3		112	PONMLKJIAHHIJKLMNOPQPO NMLKJIIJKLMNNMLKKJIHGFE DCDEFGHIJKLMNOONMLKKL LKJIHGFEDEFGHIJKLMNOPP ONNNMLKJIIHHIHGFFGHIJKL B

3.4. Signature Pattern Recognition by using String Matching

Since the pattern for signature is just 1D string data, the pattern recognition problem in this paper could be also regarded as the problem of finding the most similar string pattern among the pre-registered string patterns. Therefore, well-known string matching algorithms such as KMP string matching method [5] or Boyer-Moore-Galil string matching method [6] could be used as the comparator.

4. Discussion

Since the pattern by the input window method [4] does not consider about the outside data of input window and just consider the crossing points with 5 reference lines, the

generated signature pattern can be varying widely by the starting position, ending position, writing direction and size of signature (See Fig. 4 (a) and (b)). Besides, the proposed method using latticed bounding box is less affected by the variation of starting position, ending position and size of signature since it takes a kind of size normalization as a preprocessing. As a result, the generated signature pattern by the latticed bounding box is more stable than the input window method such as Fig. 5 (a) and (b).

In addition, latticed bounding box can give us more information on the original signature still guaranteeing the simplicity of algorithm and fast processing since it uses 17 reference lines including 4 border lines and 13 grid lines. Therefore, lattice bounding box approach could be understood as more informative, more stable and still efficient compared with the previous input window method.

Figure 4. Signatures on the Input Window Method for the Comparison with the Latticed Bounding Box Method

Figure 5. Signatures on the Latticed Bounding Box Method for the Comparison with the Input Window Method

5. Concluding Remarks

The proposed signature pattern generation method for the simple and fast processing is basically based on the input window method so that it can still guarantee simple and fast processing. In addition, the proposed method can handle some changes in translational alignment and size difference. As a result, the proposed method is more informative, more stable and still efficient compared with the previous input window method. But the error in rotational alignment is still open problem since there is no standardized signature form and its shape cannot be assumed as oval type. In addition, big variations in starting and ending phase of signature also make the rotation more difficult.

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