Baseline Extraction Algorithm for Online Signature Recognition

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Abstract:- In this paper, we discuss baseline extraction algorithm for online signature recognition based on vector rules. In order to recognize, verify and analyze a signature, one needs to establish the feasible computational signature features which would be required to be extracted. The main features in this case are direction, slant, baseline, pressure, speed and numbers of pen ups and downs. Method of extracting features signature depends on the requirement features to be extracted. In this paper, we propose the construction of an algorithm to extract the baseline from signature. Signatures are taken from twenty randomly selected individuals with different background. In order to validate the algorithm, the capture image of each signature is use as samples for a developed questionnaire to be given to human expert. These questionnaires are all about identifying the baseline of the signatures. Both results from automatic baseline detector and the questionnaire are compared, and it shows that the algorithm is 90% accurate. It can be concluded that the algorithm proposed are acceptable to represent extraction of signature features based on baseline.

Keywords: - Automatic Signature Identification, Baseline Extraction Algorithm, Dynamic Signature, Signature Analysis

1 Introduction

Signature is a complex behavior which is developed through repetition. The brain is trained to control the muscles which hold the signature element. Once signature becomes routine the style tends to remain constant [13]. In another research, it is mentioned that signature is a biometric modality that most practiced handwriting in everyday life. So much so that, the act of signing is almost entirely subconscious and habitual, thus the signature dynamics is extremely individualistic [4]. A signature is a handwriting that people writes on documents as a proof of identity. Furthermore the wide use of signature as personal attributes has made it accepted for identity verification and even reflects the psychological state of the signer [14]. Semantically, it is not only represents the name of the signatory, but it also reflects the intrinsic and unique features of the signer.

Signature had been used in many applications such in signature authentication [7], signature verification and recognition [13], forensic authentication [1] and many more. Furthermore, there has been a vast increase in the number of documents that are being transmitted and stored electronically which are exposed to forgery. This increasing dependence on electronic storage and transmission of documents has created a need for electronically verifying the identity of the sender. Generally there are two categories of signature verification and recognition, there are offline, which signature is usually scanned from paper documents where they were written, and online, which the signatures are written using an electronic instrument device that read the information regarding dynamic characteristic (pen tip location when signing). Online signature systems can also measure pen angle and contact pressure [2]. It is acknowledged that online signature is a versatile and powerful tool that enables software developers to add dynamic signature verification capability to a variety of online application. The graphometrical features usually extracted and suitable for online applications namely are direction, slant, baseline, pressure, speed and numbers of pen ups and downs. Each feature requires a method or algorithm to extract the raw data of the signature [8, 12, 16, 18, 9, 10]. Thus, an algorithm is needed to identify the signature features that often incorporate with complex geometrical patterns.

In this paper, we first describe some of the main signature features that are feasible computationally using online devices. Besides that, we describe the graphometrical meaning of baseline feature. Then, we

establish the baseline relationship from these fields in order to propose the extraction algorithm that can be applied as an automatic baseline detector. The performance of the baseline algorithm is evaluated on a dataset composed of 20 signatures from different background. Finally, we discuss the findings and future research directions inspired by these results.

2 Related Works

In analyzing signatures as a means of establishing or verifying identity requires the need to formulate robust algorithms for automatic signature verification and for the powers of human perception [3, 17]. Several features analyzed in signature recognition are direction, slant, stroke, pressure, baseline, caliber and shape of individual's signature. Thus, this paper would explore further the extraction of baseline feature.

Baseline is the imaginary or invisible line, which a signature is assumed to rest on. Baseline is normally straight, ascending or descending baseline. Normally straight baseline is where a baseline is horizontally straight. Ascending baseline is where a baseline is inclining upwards while descending baseline is where the signature is moving downwards. The example of normally straight baseline, ascending and descending baseline are shown in Figure 1.

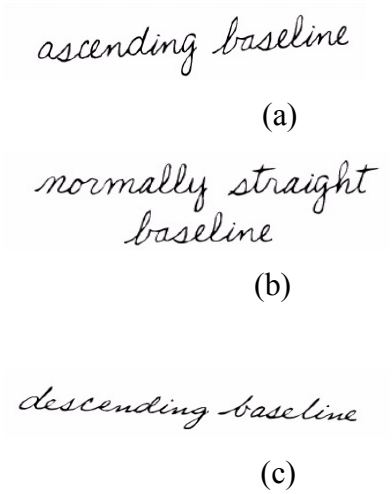

Figure 1: (a) Ascending Baseline (b) Normally Straight Baseline (c) Descending Baseline

A baseline is the line on which the letter sits. In our daily life, a baseline must be imagined when signing or writing in an unlined sheet of paper. The straightness and direction of the signature can be changeable features in a signature. For an individual the rise and fall of lines is usually a constant feature. It can be changeable or varies according to the conditions of writing and the focus or attention being given during the process of signing or writing. The emotions and feeling of the individual will also affect the signature.

Many different approaches have being used in order to extract discriminative information from online signature data [15]. The existing methods can be broadly divided into two classes, which are feature-based approaches and function-based approaches. Features-based approaches use a holistic vector representation consisting of a set of global features derived from the signature trajectories [6]. While function-based approaches describe local properties of the signature using time sequences for recognition [3, 5, 11].

In another study by Madabusi et al., [8] presents a relative slope based algorithm for online and offline signature verification. They used a slope based model in which the input signature is divided into many segments using optimized Hidden Markov Models method and then the slope of every segment are calculated with respect to its previous segment after the normalization process of a signature. The work by Tong et al. [18] present a stroke based algorithm for dynamic signature verification. Their algorithm is developed to convert sample signatures to a template by considering their spatial and time domain characteristic and also by extracting features in term of individual strokes. They proposed system call Dynamic Signature Verification (DSV) that consists of four subsystems which is data acquisition, signature preprocessing, feature extraction and signature verification.

3 Approach and Method

There are two major approaches that was employed in this research namely prototype development and conducting experiment.

3.1 Prototype development

In conducting this approach, a few steps have been identified and it is as discussed in the subsection below.

3.1.1 Data Acquisition

The WACOM Model CTE-440 tablet and pen is used in this research. The tablet is capable of sampling data

at 100 samples per second. The Wacom's pen captured samples during the interaction of the pen tip with the tablet. The raw data available from Tablet Pen consists of two dimensional series data which are *x* and *y* coordinates of signature's route which are recorded and representing the pen position. In the online signature recognition, stroke sequence strings are available in the online signature acquisition process. The next step is to group all points into strokes to create image of signature.

3.1.2 Preprocessing

In the preprocessing phase, the position points are counted from when the pen is down until it is lifted up. If the amount of points of data is less then 10 then the set points of data would be discarded from the process of extracting features. It would reduce processing time where only the possible set points of data that have extracted features would be processed.

3.1.3 Features Extraction and Classifications of Baseline

After the preprocessing steps, features are extracted from the pen position with respect to the *x*-axis and *y*-axis. An algorithm is proposed in this study to extract baseline signature features. Baseline has three attributes, which are normally straight, ascending or descending baseline. Normally straight baseline is where a baseline is horizontally straight. Ascending baseline is where a baseline is inclining upwards while descending baseline is where the signature is moving downwards.

3.2 Conducting Experiment

Meanwhile the next subsection would explain the processes involved in conducting experiment to test the algorithm constructed.

3.2.1 Collection of Signature through Random Sampling

There are a few steps in the process of gathering and collecting data through sampling signature. Firstly, 20 individuals are randomly selected to have their signature taken using the Wacom tablet device. The data would be stored in binary files that are readable by the system for future analysis. The image of the signature is created by the system based on those signatures. The images would be used as samples for the questionnaire to identify the features of baseline, where the questionnaire would be given to human expert for evaluation purposes.

3.2.2 Creation of Questionnaire from Individual Signature Sampling Data for Baseline Identification

The questionnaire was created base on image produce by the system. It contains 3 parts. The first part contains the introduction and explanation of baseline. The second part comprises of questions regarding the sample signatures and the last part is verification of questionnaire. Questionnaires are distributed to several experts from different organizations as listed n table 1.

Table 1: List of Organizations contributes in Questionnaire

No.	Organization	No of Experts
1.	BANK ISLAM MALAYSIA BERHAD	6
2.	AFFIN BANK	8
3.	MALAYAN BANKING BERHAD (MAYBANK)	6
4.	BANK RAKYAT	4

3.3 Measurement and analysis

The next research method is the Measure and Analyze procedure. It comprises of the following steps. Firstly the system would analyze the stored data. It would then store the extracting features of the baseline. The next step is where the result of the questionnaire would be gathered for analysis and comparison. Analyzed result from questionnaire would be used to adjust the classification of baseline in order to suite as close as possible with human expert's judgment. The testing would be done several times until satisfied classified results are produced.

In the final process of analyzing the data, the results regarding the features of baseline from the system are compared with the result from the questionnaire. Analysis would be made on the number of similarity and differences between the results from the prototype and from the questionnaires.

4 Baseline Algorithm

The baseline is the invisible line used to guide a signature. Some baselines are relatively straight while others are ascending or descending baseline.

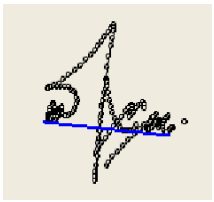

Figure 2: The signature Image with a drawn Baseline

Figure 2 shows how baseline is drawn to examine the properties of baseline in signature. The calculation is based on the angle of start point of baseline to the last point of baseline.

4.1 Raw Data Collection

The raw data available from tablet (WACOM) consists of two dimensional series data:

$$(x_i, y_i) \in R \quad (1)$$
$$i = 0,1,2,3,4,5,6,7,8,\ldots\ldots,I$$

Where $(x_i, y_i) \in R$ is the pen position with respect to the *x*- and *y*-axis. When *i* is equal to zero, it represents the starting point of the data. The raw data gathered from the tablet shows that the smaller value in *y*-axis stand as the higher position. For *x*-axis, the higher value is towards the right site compared to left.

4.2 Design of Algorithm to Identify Baseline

The baseline is the invisible line used to guide a signature. Some baselines are relatively straight while others are ascending or descending baseline.

4.3 The Angle and Degree of Baseline

For baseline extraction in signature, there are three possible positions that will categorize the type of baseline namely ascending, straight and descending as shown in figure 3. The technique used to get the degree of baseline is the same as the technique used to calculate the degree of two points in slant identification [19]. However for baseline, the two points in this case are based on the starting and end points of the baseline. Where x_i and x_{i-1} refers to the ending baseline point and starting baseline point of *x*-axis and y_i and y_{i-1} refers to the ending point and starting point of *y*-axis. The calculations to get the degree are as shown in Equation 2 up to Equation 4.

Let

$$dy(i) = y_i - y_{i-1}$$
$$dx(i) = x_i - x_{i-1}$$
$$i = 1,2,3,4,5,6,7,8,\ldots\ldots,I \quad (2)$$

The Angle, of each two point of pen position in radians are given by

$$\text{Angle} = atan2\left(\frac{dy(i)}{dx(i)}\right) \quad (3)$$

Since the Angle is positive when measured counterclockwise and negative when measured clockwise, the degree of each two points are given by

$$\text{Degree, } \theta_i = (\text{Angle} \times 180) / \pi \quad (4)$$

where $\pi = 3.142$, radians = Degree $(\pi / 180)$.

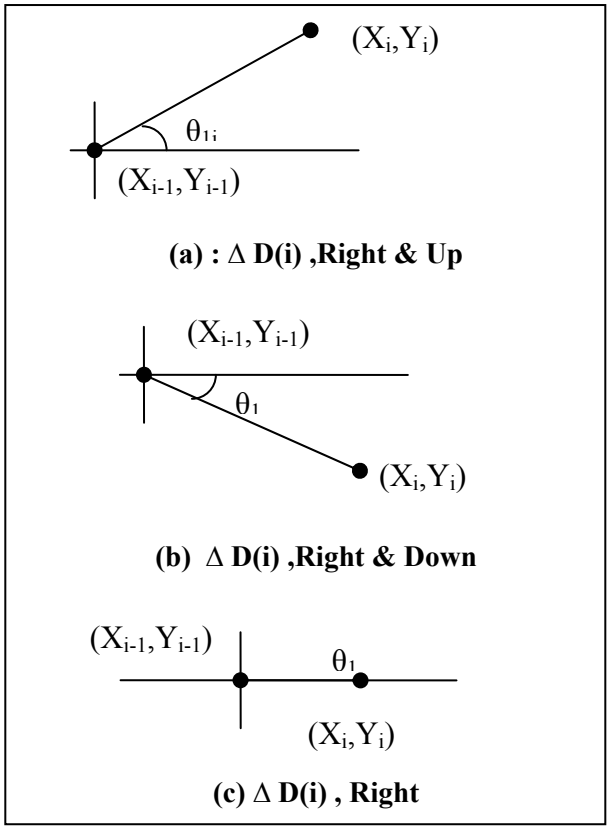

Figure 3: Position of Baseline Degree between Start Baseline Point and End Baseline Point.

In this algorithm, the degrees for each baseline have only three possible options since baseline angle is only counted from the left to the right of the signature. The three possible degree, $\boldsymbol{\theta_i}$ for baseline in this research uses the selected equation below;

$$\text{Right \& Up, degree , } \theta_i = \theta_i \quad (5)$$
where $dy(i) < 0$, $dx(i) > 0$

$$\text{Right \& Down, degree , } \theta_i = 360 - \theta_i \quad (6)$$

where $dy(i) > 0$, $dx(i) > 0$

Right, degree , $\theta_i = 0^o$ (7)
where $dy(i) = 0$, $dx(i) > 0$

4.4 The Algorithm

The algorithm to detect baseline begins by processing raw sequential data from beginning to the end of a signing process. From the raw data, the lowest and highest point in the *x*-axis is located to represent the width of the signature. The reference distance is calculated by getting 15% of the difference in the width of the signature. Then, locate the lowest point of the *y*-axis from the lowest point of *x*-axis up to the length of reference distance in order to find the start baseline point of *x* and *y*.

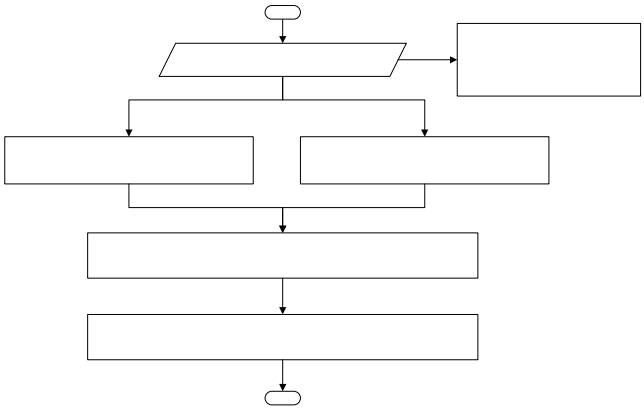

Figure 4: Flow Chart of Algorithm to Detect Baseline in Signature

Next will be to find the lowest point of the *y*-axis from the highest point of *x*-axis up to the length of reference distance to find the end baseline point of *x* and *y*. Calculation are then conducted on the degree of baseline from the start to the end of baseline points. Lastly the baseline will be categorized based on ascending baseline, normally straight baseline and descending baseline. A baseline is categorized as normally straight baseline when the degree of baseline is in the range of less than four or more than 356 degrees. If the degree of baseline is more or equal to four, it will be categorized as ascending baseline while descending baseline is when the baseline is less than 356 degree. The flow of the algorithm is further illustrated in figure 4.

5 Findings and Discussions

Questionnaire results of twenty signatures that were gathered from 24 experts are shown in table 3 to table 9. Percentage of results for baseline signature features attributes for each question are calculated. The analysis is based on questionnaire given to experts during part of the experiment (refer to subsection 3.2.2). The following characters represent the baseline attributes that are used in the analysis table of the baseline detector system and the questionnaire.

Table 2: Character that Represent Slant and Baseline Attributes

No.	Symbols	Symbolize Meaning
1.	A	Ascending Baseline
2.	S	Normally Straight Baseline
3.	D	Descending Baseline

Table 3 shows the result of question one, two and three from the questionnaire. Result from question one gives normally straight baseline as the highest chosen baseline with the score of 75%. Question two, 87.5% choose ascending baseline as the highest score. Meanwhile question three, the highest chosen value is normally straight baseline with only 4% higher than ascending baseline.

Table 3: Result of Question 1,2 and 3 of the Questionnaire

Question #	**Q 1**			**Q 2**			**Q 3**		
Expert	**Baseline**			**Baseline**			**Baseline**		
	A	**S**	**D**	**A**	**S**	**D**	**A**	**S**	**D**
E 1	x			x			x		
E 2		x		x				x	
E 3		x		x				x	
E 4		x		x				x	
E 5		x		x			x		
E 6		x		x					x
E 7			x	x			x		
E 8			x		x			x	
E 9		x			x				x
E 10		x		x			x		
E 11		x		x				x	
E 12			x	x				x	
E 13	x			x					x
E 14		x				x	x		
E 15			x	x			x		
E 16		x		x				x	
E 17		x		x				x	

E 18		x		x				x	
E 19		x		x			x		
E 20		x		x				x	
E 21		x		x			x		
E 22		x		x				x	
E 23		x		x			x		
E 24		x		x			x		
TOTAL (%)	A=	8.33		A=	87.50		A=	41.67	
	S=	75.00		S=	8.33		S=	45.83	
	D=	16.67		D=	4.17		D=	12.50	

Table 4 shows the results for question four, five and six of the questionnaire. Question four gives the highest chosen value of 70.83% for normally straight baseline and expert select ascending baseline as the highest score of 79.17% for question 5. All experts agree that the normally straight baseline is the most appropriate result to represent the signature in question 6.

Table 4: Result of Question 4, 5 and 6

Question #	**Q 4**			**Q 5**			**Q 6**		
Expert	**Baseline**			**Baseline**			**Baseline**		
	A	**S**	**D**	**A**	**S**	**D**	**A**	**S**	**D**
E 1		x		x				x	
E 2		x		x				x	
E 3		x		x				x	
E 4		x		x				x	
E 5			x	x				x	
E 6			x	x				x	
E 7		x		x				x	
E 8			x		x			x	
E 9	x			x				x	
E 10		x				x		x	
E 11	x					x		x	
E 12		x		x				x	
E 13	x					x		x	
E 14			x			x		x	
E 15		x		x				x	
E 16		x		x				x	
E 17		x		x				x	
E 18		x		x				x	
E 19		x		x				x	
E 20		x		x				x	
E 21		x		x				x	
E 22		x		x				x	
E 23		x		x				x	
E 24		x		x				x	
TOTAL (%)	A=	12.50		A=	79.17		A=	0.00	
	S=	70.83		S=	4.17		S=	100.00	
	D=	16.67		D=	16.67		D=	0.00	

Table 5 shows the result of question seven, eight and nine. 87.50% experts select normally straight baseline to represent signature in question seven. For question eight, the participants of the questionnaire have selected ascending baseline as the highest score of 70.83%.

Meanwhile, next question shows experts have some difficulties to differentiate between ascending baseline and normally straight baseline with a difference of 16.66%.

Table 5: Result of Question 7, 8 and 9

Question #	**Q 7**			**Q 8**			**Q 9**		
Expert	**Baseline**			**Baseline**			**Baseline**		
	A	**S**	**D**	**A**	**S**	**D**	**A**	**S**	**D**
E 1		x		x				x	
E 2		x				x	x		
E 3		x		x			x		
E 4		x		x			x		
E 5		x		x			x		
E 6		x		x				x	
E 7		x		x			x		
E 8		x				x		x	
E 9		x				x	x		
E 10		x				x		x	
E 11		x				x		x	
E 12			x	x			x		
E 13			x	x				x	
E 14	x					x		x	
E 15		x		x			x		
E 16		x		x				x	
E 17		x				x		x	
E 18		x		x			x		
E 19		x		x			x		
E 20		x		x				x	
E 21		x		x			x		
E 22		x		x			x		
E 23		x		x			x		
E 24		x		x			x		
TOTAL (%)	A=	4.17		A=	70.83		A=	58.33	
	S=	87.50		S=	0.00		S=	41.67	
	D=	8.33		D=	29.17		D=	0.00	

Table 6 shows the summary of results for question ten, eleven and twelve of the questionnaire. Normally straight baseline is the most chosen answer for question ten. Question eleven, the experts choose ascending baseline as their answer while for question twelve they choose normally straight baseline.

Table 6: Result of Question 10, 11 and 12

Question #	Q 10			Q 11			Q 12		
Expert	Baseline			Baseline			Baseline		
	A	S	D	A	S	D	A	S	D
E 1		x		x				x	
E 2	x			x				x	
E 3	x			x			x		
E 4	x			x			x		
E 5		x		x				x	
E 6		x				x		x	
E 7	x			x				x	
E 8		x			x			x	
E 9		x			x			x	
E 10		x				x			x
E 11		x				x			x
E 12	x			x			x		
E 13			x		x		x		
E 14		x		x				x	
E 15		x		x				x	
E 16		x		x				x	
E 17		x		x				x	
E 18	x			x			x		
E 19			x	x			x		
E 20		x		x			x		
E 21		x		x			x		
E 22		x		x				x	
E 23		x		x			x		
E 24		x		x				x	
TOTAL (%)	A=	25.00		A=	75.00		A=	37.50	
	S=	66.67		S=	12.50		S=	54.17	
	D=	8.33		D=	12.50		D=	8.33	

Table 7 shows the summary of results for question thirteen, fourteen and fifteen of the questionnaire. For question thirteen and fourteen, the most given answers is ascending baseline. The result of 79.17% of ascending baseline found to be the most appropriate result to represent signature fifteen of the questionnaire.

Table 7: Result of Question 13, 14 and 15

Question #	Q 13			Q 14			Q 15		
Expert	Baseline			Baseline			Baseline		
	A	S	D	A	S	D	A	S	D
E 1	x			x			x		
E 2	x				x		x		
E 3	x			x			x		
E 4	x			x			x		
E 5	x			x			x		
E 6	x				x		x		
E 7			x	x					x
E 8	x					x		x	
E 9			x		x			x	
E 10			x			x			x
E 11		x		x			x		
E 12	x			x			x		
E 13			x			x	x		
E 14		x				x			x
E 15	x				x		x		
E 16	x				x		x		
E 17	x				x		x		
E 18	x			x			x		
E 19	x			x			x		
E 20		x		x			x		
E 21	x			x			x		
E 22	x			x			x		
E 23	x			x			x		
E 24	x				x		x		
TOTAL (%)	A=	70.83		A=	54.17		A=	79.17	
	S=	12.50		S=	29.17		S=	8.33	
	D=	16.67		D=	16.67		D=	12.50	

Table 8 shows the summary of results for question sixteen, seventeen and eighteen of the questionnaire. Ascending baseline is the most chosen answer for question sixteen. Result from question seventeen shows a total of 87.50% of experts choose normally straight baseline. However, for signature eighteen the

experts selected ascending baseline with the result of 70.83%.

Table 8: Result of Question 16, 17 and 18

Question #	Q 16			Q 17			Q 18		
Expert	Baseline			Baseline			Baseline		
	A	S	D	A	S	D	A	S	D
E 1		x			x		x		
E 2	x				x			x	
E 3	x				x			x	
E 4	x				x		x		
E 5	x			x			x		
E 6	x				x		x		
E 7	x				x				x
E 8		x			x				x
E 9		x			x				x
E 10			x		x				x
E 11		x		x			x		
E 12	x				x		x		
E 13	x					x	x		
E 14		x			x		x		
E 15	x				x			x	
E 16	x				x		x		
E 17	x				x		x		
E 18	x				x		x		
E 19	x				x		x		
E 20		x			x		x		
E 21	x				x		x		
E 22	x				x		x		
E 23	x				x		x		
E 24	x				x		x		
TOTAL (%)	A=	70.83		A=	8.33		A=	70.83	
	S=	25.00		S=	87.50		S=	12.50	
	D=	4.17		D=	4.17		D=	16.67	

Finally, table 9 shows the summary of results for question nineteen and twenty of the questionnaire. For question nineteen and twenty, it is observed that ascending baseline gives a more prominent answer with the readings of 79.17% respectively with slight differences of result for straight and descending value for both questions.

Table 9: Summary of Question 19 and 20 of the Questionnaire

Question #	Q 19			Q 20		
Expert	Baseline			Baseline		
	A	S	D	A	S	D
E 1	x			x		
E 2	x			x		
E 3	x			x		
E 4	x			x		
E 5	x			x		
E 6	x			x		
E 7	x			x		
E 8		x				x
E 9		x				x
E 10			x			x
E 11	x				x	
E 12	x			x		
E 13			x			x
E 14		x		x		
E 15	x			x		
E 16	x			x		
E 17	x			x		
E 18	x			x		
E 19	x			x		
E 20	x			x		
E 21	x			x		
E 22	x			x		
E 23	x			x		
E 24	x			x		
TOTAL (%)	A=	79.17		A=	79.17	
	S=	12.50		S=	4.17	
	D=	8.33		D=	16.67	

Table 10 shows the comparison results for baseline between the automatic baseline detector system and the answer to the questionnaire by human expert. Out of the twenty questions, two answers are not identical which are question eleven and thirteen. As for question six, 100% of human expert classified the signature as upright baseline, the same as being

classified by the system. Overall, the below table shows 90% of the results give identical answers between the system and the human expert.

Table 10 Overall Result of Comparison Between Baseline Detector System vs Questionnaire for Baseline

Data	System	Questionnaire Result			System vs Questionnaire
		Ascnd	Strgh	Dscnd	
1	S	8.3%	75%	16.7%	Identical
2	A	87.5%	8.3%	4.2%	Identical
3	S	41.7%	45.8%	12.5%	Identical
4	S	12.5%	70.8%	16.7%	Identical
5	A	79.2%	4.2%	16.7%	Identical
6	S	0 %	100%	0%	Identical
7	S	4.2%	87.5%	8.3%	Identical
8	A	70.8%	0%	29.1%	Identical
9	A	58.3%	41.7%	0 %	Identical
10	S	25.0%	66.7%	8.3%	Identical
11	S	75.0%	12.5%	12.5%	Non Identical
12	S	37.5%	54.2%	8.3%	Identical
13	D	70.8%	12.5%	16.7%	Non identical
14	A	79.2%	8.%	12.5%	Identical
15	A	75%	10%	15%	Identical
16	A	70.8%	25%	4.2%	Identical
17	S	8.3%	87.5%	4.2%	Identical
18	A	70.8%	12.5%	16.7%	Identical
19	A	79.2%	12.5%	8.3%	Identical
20	A	79.2%	4.2%	16.7%	Identical

S – Normally Straight; A – Ascending;
D - Descending

The non-identical signature for signature data number 11 shaded in table 10 is as shown in figure 5 below.

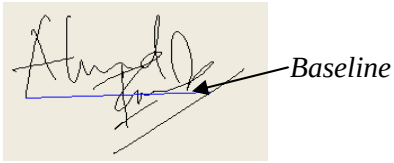

Figure 5 The Image of Signature for Signature 11

Table 10 shows the overall results of the baseline extraction from the system, which indicate that it is normally straight baseline. While from the questionnaire, majority participant chose ascending baseline as their results. Human expert will see that there are two groups of words from the signature. The second word seems that the baseline is ascending sharply while the first word looks like it is ascending slightly or in normally straight categories.

Meanwhile the second non-identical signature is signature data number 13 as shaded in table 10 is as shown in figure 6 below.

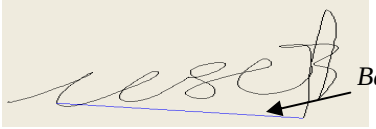

Figure 6 The Image of Signature for Signature 13

Table 10 shows the results of the baseline (i.e. for data number 13) extraction from the system, which indicate that it is descending baseline. While from the questionnaire, ascending baseline is the most chosen type of baseline for the signature. The human eye seems to see the signature baseline based on every character except for the last character of the signature while in the system the baseline is taken from the whole signature as shown in figure 6. The inclusion of the last character of this signature will affect the overall results of the extracted baseline.

6 Conclusion and Future Works

This research introduces a new algorithm for extracting baseline in signature. The algorithm for extracting baseline has been successfully implemented as automatic baseline detector. In the design of the baseline algorithm, it incorporates variable values that can be adjusted to work according to the required application. It shows the flexibility of this algorithm to adapt to requirements regarding baseline extraction. Results from the propose algorithm are compared with the human expert judgment in questionnaire to show that the algorithm works and produced similar results. Results produced by the algorithm for baseline extraction show 90% identical answers compared with the judgment by human expert. With these results, it can be concluded that the algorithm is a success.

This proposed algorithm will help community in the field of signature verification, signature analysis and signature recognition. It can be used as a tool to extract the required signature features depending on application requirement. In character recognition or handwritten recognition, the algorithm for baseline extraction can be used as baseline correction before the character can be recognized.

The preprocessing steps used in this algorithm might be enhanced to increase its accuracy. Further preprocessing techniques can be explored to reduce noise or jitter during data acquisition before proceeding to extract the baseline feature. Technique to adjust and realign any small movement of lines towards different direction during signing process should also be considered. Besides that, further study on how human expert look and classified the baseline

will help the process of classification. Additional study on classification of baseline in the algorithms may produce a better decision.

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