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Research Article

Basic Emotion Recogniton using Automatic Facial Expression Analysis Software

Vivi Triyanti [1,2], Yassierli [2], Hardianto Iridiastadi [2]

[1]*Program Studi Teknik Industri, Fakultas Teknik, Unika Atma Jaya, Jln. Jenderal Sudirman No. 51, Jakarta 12930, Indonesia*
[2]*Teknik Industri, Fakultas Teknologi Industri, Institut Teknologi Bandung, Jln. Ganesha no. 10, Bandung 40132, Indonesia*

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CORRESPONDENCE

Phone: -

E-mail: vivi.triyanti@atmajaya.ac.id

A B S T R A C T

Facial expression was proven to show a person's emotions, including 6 basic human emotions, namely happy, sad, surprise, disgusted, angry, and fear. Currently, the recognition of basic emotions is applied using the automatic facial expression analysis software. In fact, not all emotions are performed with the same expressions. This study aims to analyze whether the six basic human emotions can be recognized by software. Ten subjects were asked to spontaneously show the expressions of the six basic emotions sequentially. Subjects are not given instructions on how the standard expressions of each of the basic emotions are. The results show that only happy expressions can be consistently identified clearly by the software, while sad expressions are almost unrecognizable. On the other hand surprise expressions tend to be recognized as mixed emotions of surprise and happy. There are two emotions that are difficult to express by the subject, namely fear and anger. The subject interpretation of these two emotions varies widely and tends to be unrecognizable by software. The conclusion of this study is the way a person shows his emotions varies. Although there are some similarities in expression, it cannot be proven that all expressions of basic human emotions can be generalized. Further implication of this research needs further discussion.

INTRODUCTION

Facial expressions are facial changes in response to one's emotional state, mind, or social communication [1]. One analysis of popular facial expressions is to recognize basic emotions. At present there are at least 6 basic emotions that are widely used in the analysis of expressions, namely happy, sad, surprised, disgust, anger, and fear [2]. These six expressions are related to the movement of specific specific facial points. Many studies using these six basic emotions are associated with various fields. For example, it is associated with a person's cognitive condition when sick [3, 4], honesty [5] and fatigue [6]. The application of facial expressions analysis is also widely used to find out one's preferences for a product [7] and to recognize one's nature [8]. In the transportation industry, observations of facial expressions have also been developed to detect drowsiness or fatigue in the driver [9]. Given the high work risk, observations of fatigue based on facial expressions also began to be carried out on workers in the mining industry [9]. The application of emotional recognition can be done in an integrated manner. For example a set of Human Computer Interaction is designed to recognize facial expressions and take necessary actions when certain facial expressions are detected. For a driver, when the system is detected expression of fatigue, the system will automatically provide a warning signal, or even can adjust the speed automatically.

Initially the introduction of facial expressions was done manually by using the ability of experts to recognize certain facial expressions [2]. But this manual introduction turned out to take a long time. It takes more than 100 hours of training to become proficient in the Facial Action Coding System and it takes about 2 hours for human experts to code every minute of the video [1]. This inefficiency will certainly be a problem if detection and assessment of expression must be carried out continuously, for example in the assessment of fatigue or drowsiness [10] and distraction [11] of a driver.

In its development, an automatic facial expression analysis was introduced, which is the analysis of facial expressions that can be done automatically with the help of applications or software. A series of images are recorded using a camera or video. By using a particular application, the face shape and components will be detected. Popular application for recognizing basic human emotions such as Affdex from Affectiva [12], iMotions [13], and FaceReader from Noldus [14]. So far, in some studies the three software have been able to recognize human facial emotions quite accurately [15-17].

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In Indonesia, researches related to expression analysis were mostly done for software development to detect and recognize expressions [18, 19], not the application of existing software. Therefore one of an interesting things to analyze is whether the expressions of Indonesian people for these six basic emotions are easily recognized by the existing automatic facial expression analysis software. Eastern culture might produce a different way of expressing emotions, compared to more spontaneous western cultures. The level of spontaneity of the subject in exposing certain emotions may also affect the level of recognition of the software on the emotion.

This study intends to examine whether the emotional expression shown can be identified by existing automatic facial expression analysis software, Affdex from Affectiva [12]. Affdex is software that is built to recognize human emotions based on facial movements or physiological responses. The expressions studied were mainly related to 6 basic human emotions, namely happy, sadness, surprise, disgust, anger, and fear. The consideration of using the software compared to other similar softwares, which are imotions from iMotions [13] and FaceReader from Noldus [14] at least based on two reasons: (1) Has relative high validity in detecting face [15-17] and (2) Can be used easily. The software can be used directly from gadget (mobile phone) and the analysis can be get directly (live). As long as researcher know, for other softwares, performing data collection and analysis that can be done live from the gadget/camera takes very high cost to access.

This research is a preliminary study to see the software's ability to recognize various expressions displayed by various kinds of people. Previous study usually performed by recording posed expression or spontaneous expressions in video or still image.

METHOD

Facial Expression

Humans are able to produce thousands of different sets of facial expressions, but there are only a few typical facial configurations associated with certain emotions, regardless of gender, age, cultural background and history of socialization. This category is anger, disgust, fear, happy, sad, surprised, and neutral position [2].

Analysis of facial expressions is often associated with a set of computer systems that automatically analyze and recognize facial movements and changes in facial characteristics from visual information [1]. By using a computerized system, the activities of tracking, detection, and facial expression, as well as the extraction of movements and expressions, can be done automatically quickly. Automatic facial expression analysis can be applied in many fields, such as emotional communication, psychiatry, pain assessment, lie detection, intelligent environment, and human computer interface [1].

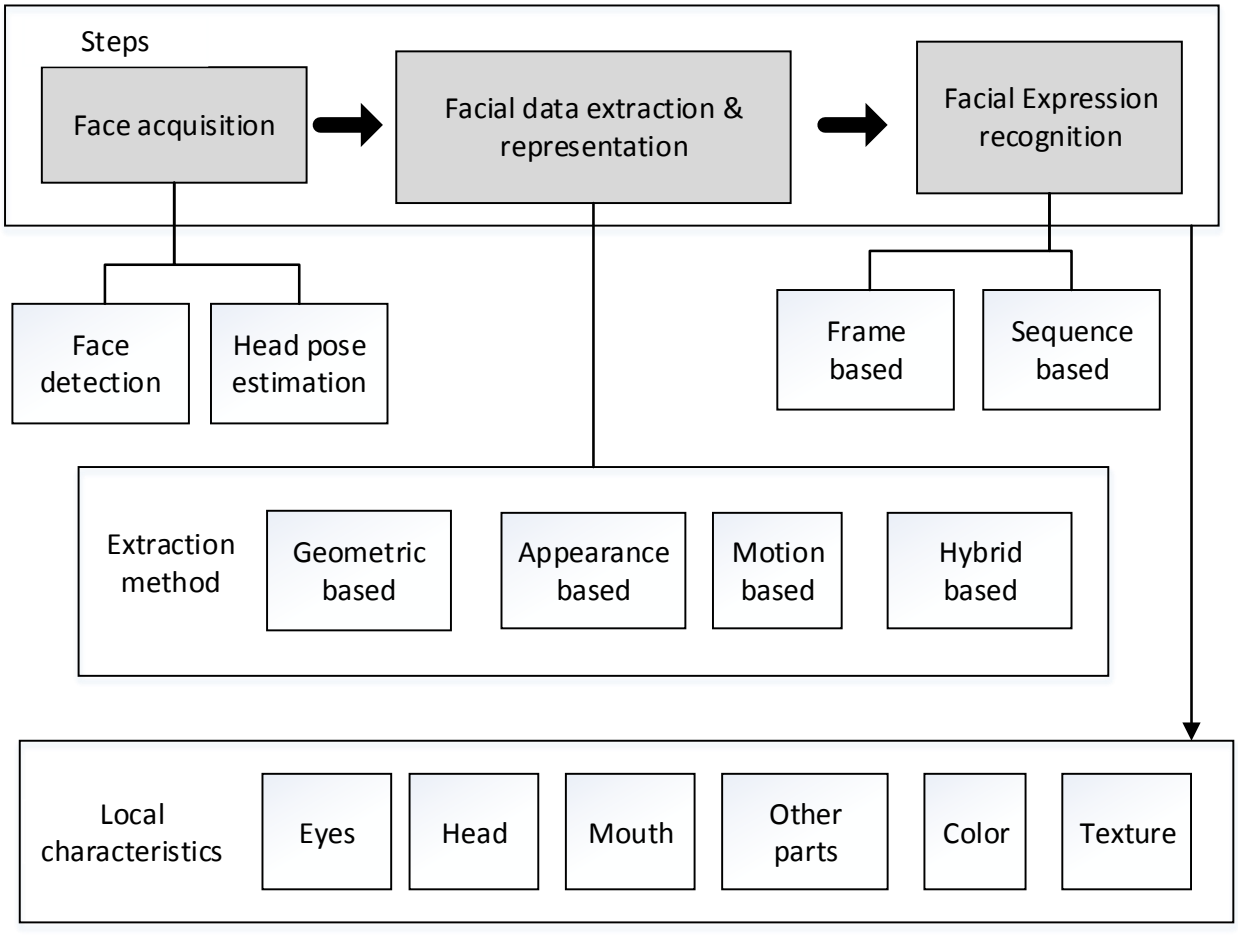

Figure 1. Basic steps of Automatic Facial Expression Analysis [1, 20]

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Facial Expression Analysis

Analysis of facial expressions includes facial movement measurements and recognition of expressions. The general approach to Automatic Facial Expression Analysis (AFEA) consists of three steps (Figure 1). These steps are face acquisition, facial data extraction and representation, and facial expressions recognition [1]. Face acquisition is the processing stage that aims to detect and determine the face area automatically so that images can be obtained or sequence of facial images for a certain period of time. Face acquisition can be done in two ways, namely detecting the position of the head or directly detecting the position of the face [19].

After the face location is determined, the next step is to extract and identify facial changes caused by facial expressions. Extraction of facial characteristics can be done with several approaches, including using face points which are assumed to form certain geometries such as eyes or mouth (geometric based), based on the overall face appearance such as color, wrinkles, and facial flow (appearance) [1, 19], motion based on the face (motion based), or a mixture of several of these approaches (hybrid based) [20]. Change analysis can be done based on analysis of current frame conditions, with or without image reference (frame-based), or identifying temporary relationships from frame (sequence-based) sequences [20]. This structure can be seen in Figure 1.

Some other parts of the face are sometimes also used in several studies to indicate certain expression. For example an increase in outer eyebrows indicated as being associated with fatigue. This movement is carried out when someone tries to overcome sleepiness [21]. The movement of the points around the nose is also associated with predictions of minor accidents [10]. Other facial characteristics that are also used to detect fatigue in the driver, for example, are wrinkles [21] and skin color [22]

Approach to detect facial expression

Face observations were conducted on 10 people of various ages, using Affdex software from Affectiva (www.affectiva.com) .The subjects were asked to spontaneously express emotions of haappy, sad, surprised, disgust, anger, and fear. Each subject was not informed how "should" the facial expressions of each feeling. So the subject interpreted each of the expressions requested according to his/her own experience or knowledge. All images of the subject were captured from the front. Tools used to capture images of subjects is a Samsung Galaxy Note 6 smartphone.

The output of the application is a percentage or how much the expression displayed by the subject is recognized by the software as a certain basic emotion (Figure 2). Values for each basic emotion (anger, disgust, fear, joy, sadness, and surprise) range from 0 - 100%, so that the total value of a certain facial expression can be more than 100%. The greater the percentage value, the greater the intensity of a particular expression. The value can be seen in Appendics section, in the left part “Detected Expression (%)”.

To simplify the interpretation, in this study the percentage value was categorized into 3 categories, namely high intensity (percentage> 50%), moderate intensity (percentage 21-50%), and low intensity (percentage of 1-20%). The value can be seen ini Appendices section, in the right part “Detection Expression (score). The consideration of using a 50% value as a threshold for high intensity was because a value of more than 50% indicates that most of the related face points have shown that expression. Furthermore, high intensity was given a value of 3, medium 2, and low 1. The values of this category were used in data processing and analysis.

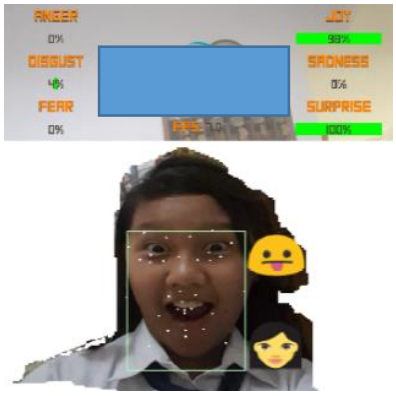


Figure 2. Example of software output

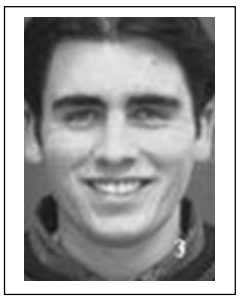
RESULTS AND DISCUSSION

Data processing was done by grouping categorical values according to the methods described in previous section. Table 1 states the number of emotions correctly recognized and the total intensity. For example, from 10 respondents who express emotions "surprised", the software is recognized correctly (as a surprised expression) with high intensity 5 times, moderate intensity 2 times, and low intensity 1 time. There are 2 respondents who have surprised facial expressions that are completely different from what is recognized by the software, so the intensity value is 0.

It turns out that the respondent's interpretations of certain emotion were quite varied and tended to be difficult to recognize correctly by the software. Of the six expressions studied, only 1 expression was consistently recognized correctly by the software, namely happy/joy. All respondents tended to do the same to reflect happy expressions, which were to move the tip of the mouth towards the top and cheeks to rise (Figure 3). This is in accordance with the expression indicators for standard happy emotions, namely the movement of the tip of the mouth and cheek upwards [2]. Of the 10 subjects who showed happy expressions, the expressions of 9 subjects could be categorized correctly with high intensity.

Table 1. Basic emotion that can be correctly recognized by software

Intensity	Happy	Sad	Surprised	Disgust	Anger	Fear
3	9	0	5	2	1	0
2	0	1	2	0	0	1
1	0	0	1	2	0	1
0	1	9	2	6	9	8
Total	**27**	**2**	**20**	**8**	**3**	**3**

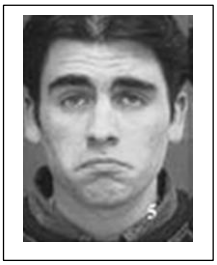


(a)

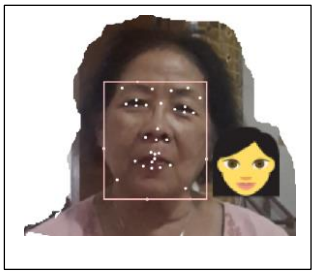
(b)

Happy	100%
Sad	0 %
Surprise	4 %
Disgust	0 %
Anger	0 %
Fear	0 %

Figure 3. Example of "Happy" expression (a) and software facial recognition value for a subject (b)



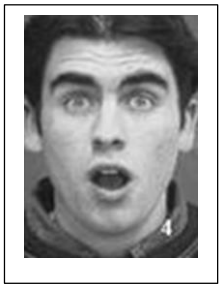
(a)



(b)

Happy	0%
Sad	0 %
Surprise	0 %
Disgust	3 %
Anger	0 %
Fear	0 %

Figure 4. Example of "Sad" expression (a) and software facial recognition value for a subject (b)



(a)

(b)

Happy	98 %
Sad	0 %
Surprise	96 %
Disgust	1 %
Anger	0 %
Fear	0 %

Figure 5. Example of "Surprised" expression (a) and software facial recognition value for a subject (b)

On the other hand, there is an expression that is relatively unrecognizable by the software, which is a sad expression (Figure 4). Most respondents interpret sad emotions by moving the tip of the mouth down. That was in accordance with the standards of sad expression. However, maybe because the movement of facial points performed by the subject was not too extreme, the software did not detect the movement as sad (0% value).

Surprised expressions (Figure 5) tend to be correctly recognized by software (Table 1). But on the other hand, the software also categorized these expressions as other expressions (Table 2 and Table 3). Table 2 presents the number of expressions performed by subjects that were recognized as various basic expressions by software. Because 1 subject expression can be related to some basic expressions, if this is totaled, this number can exceed the number of respondents. For example, in Table 2, surprised expression performed by 10 participants were classified as happy

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for 5 times, sad 1 times, surprised 8 times, and disgust 7 times. The totals were more than 10 because 1 performed expression can be recognized as more than 1 expression.

The value of recognition actually was different, can be high or low. In the Table 2, all values of recognition were neglected. However, in Table 3, values of recognition were taken into account by categorized them into 3 levels (high, moderate, and low recognition). Numbers of expressions that had high value recognition (above 50%) were multiplied by 3. Meanwhile numbers of expressions that had medium (21 - 50%) and low (1 - 20%) value recognition were multiplied by 2 and 1. As an example, in Table 2, the performed expression of "surprised" were recognized to "happy" expression of 5 persons. Each person can be categorized as an expression of "happy" with different intensities (can be worth 1, 2, or 3). In this example, for surprised expression that was recognized as happy expression, the total intensity was 15 (Table 3).

Table 2. Recognition value of software (#)

Performed expression	**Software recognition (#)**					
	Happy	**Sad**	**Surprised**	**Disgust**	**Anger**	**Fear**
Happy	9	0	5	3	0	0
Sad	0	1	0	3	1	0
Surprised	5	1	8	7	0	0
Disgust	2	1	5	4	1	1
Anger	2	3	3	1	2	0
Fear	2	2	5	3	2	2

Table 3. Recognition value of software (total intensity vale)

Performed expression	**Software recognition(total intensity value)**					
	Happy	**Sad**	**Surprised**	**Disgust**	**Anger**	**Fear**
Happy	27	0	8	3	0	0
Sad	0	1	0	3	1	0
Surprised	15	1	20	10	0	0
Disgust	4	1	5	8	2	1
Anger	6	3	6	1	5	0
Fear	2	2	7	3	6	3

Based on Tables 2 and 3, it can be seen that there were expressions accompanied by other expressions. In this study, which seemed quite noticiable were an expression of happy and surprise. From Table 2 it can be seen that happy expressions were also associated with surprised expressions, although with relatively low intensity. Using Mann Whitney test, happy and surprises value in happy expresson then was compared. The hypothesis was median of happy expression value is greater than median of surprise expression value. Resulting in *p*-value of. 0.000942, it can be concluded that median of happy expression data value is significantly greater than median of surprise expression data value

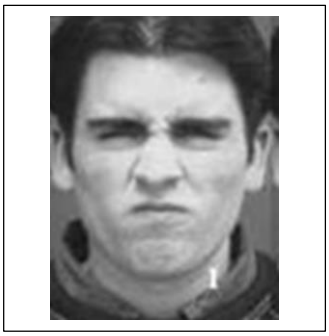
On the contrary, a surprised expression came with a happy expression with high intensity too. This might be interpreted to mean that the surprised expression shown by the respondent was related to the happy thing. Using the same statiastical test, it is tested that in surprised expression, median of happy value was lesser than surprised value. The result gave the p-value of 0.469109, it meant that there was no strong evidence to conclude that median of happy value was lesser than surprised value. In this case both values were high.

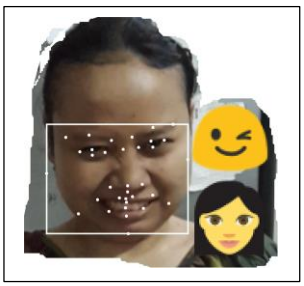
There were expressions that were often detected as other basic expressions. An example was disgust (Figure 6). Of the 10 people, only 4 people detected by the software demonstrated basic expressions of disgust (Table 2). From Table 3, the greatest intensity for the expression of the subject of disgust remained related to the emotion of disgust, but only with a total value of 8. This total point is relatively very small. From Table 1, it appears that only 2 people displayed expressions of disgust according to software interpretations, with high intensity. This inferred that the subject's interpretation of expressions of disgust was quite varied.

In some emotions, there are a lot of wrong detections. For example in fear and anger emotions (Figures 7 and 8). From Table 1, it can be seen that out of 10 subjects, only 1 person could show high intensity of angry expressions, the rest were not detected as angry emotions. Even for fear emotions, there was no single expression that could be recognized by software as fear emotions, with high intensity. All 8 subjects did not show fear at all according to the software interpretation. Both fear and anger expressions were often interpreted as other basic emotions by software, whether happy, sad, surprised, or disgusted. But even these recognition only had a relatively low intensity. Frequently, software did not interpret expressions of fear or anger that are shown by the subject as any expression.

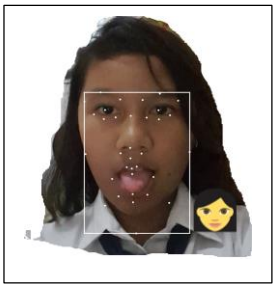
The results of the study showed that many expressions cannot be recognized properly by software. This might be caused because the application is only able to detect if changes to the face are clearly visible. If there are only a few changes to the face point, the change is not detected by the software. As shown in Figure 4 which illustrates sad expressions, all participants actually showed an appropriate sign, namely the movement of the lip angle downward. However, apparently the movement shown by the participants was less intense, so the software did not detect the movement. The second reason for the possibility is that there were several expressions that are mixed, making it difficult to distinguish from each other.

For example, the surprised expression on average was also recognized as a happy expression. This is because an open mouth can be interpreted as happy or surprised emotions. Wide-eyed eyes can also be interpreted as happy or surprised. The third cause is there are differences in interpretations of an expression. For example for expressions of disgust. Figure 6 shows two different interpretations for disgusting expressions, namely by tilting the lips up and frowning (Figure 6a) and sticking out the tongue (Figure 6b). Some other participants also showed different expressions. The last cause is that participants are difficult to express their feelings. For example for emotions of anger and fear. During and after observation, research subjects admitted that they were difficult to express this emotion spontaneously, especially without the trigger of certain events. Therefore these two emotions are also not detected by software. Broadly speaking the results and analysis of this study can be seen from Table 4 amd Table 5.





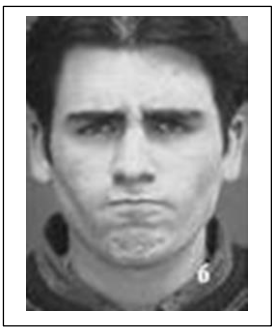
Happy	67%
Sad	0 %
Surprise	4 %
Disgust	94 %
Anger	29 %
Fear	0 %

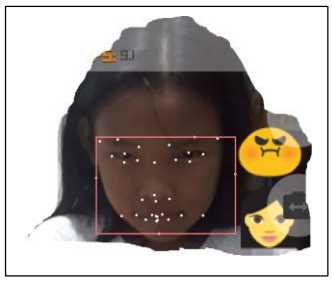


Happy	0%
Sad	0 %
Surprise	5 %
Disgust	1 %
Anger	0 %
Fear	0 %

(a) (b)

Figure 6. Example of "Disgust" expression (a) and software facial recognition value for a subject (b)





Happy	0%
Sad	0%
Surprise	0 %
Disgust	0 %
Anger	75 %
Fear	0 %

Happy	0%
Sad	0%
Surprise	0 %
Disgust	0 %
Anger	0 %
Fear	0 %

(a) (b)

Figure 7. Example of "Anger" expression (a) and software facial recognition value for a subject (b)

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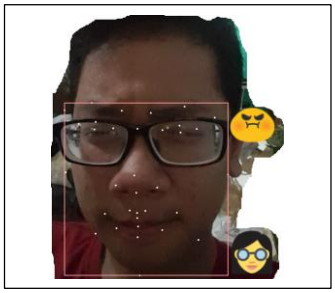
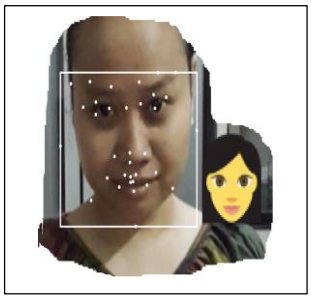


Happy	0%
Sad	0 %
Surprise	3 %
Disgust	5 %
Anger	0 %
Fear	0 %



Happy	0 %
Sad	0 %
Surprise	3 %
Disgust	0 %
Anger	0 %
Fear	0 %

(a) (b)

Figure 8. Example of "fear" expression (a) and software facial recognition value for a subject (b)

Table 4. Summary of facial expression recognition of 6 basic emotions by software

Facial expression	Software recognition
Happy	The expression can be recognized precisely with relative high intensity
Sad	The expression really difficult to recognize by the software. The recognition value (in procentage) of any emotion tend to be low, or even 0
Surprised	The expression can be recognized by the software. However, usually there are another expression that also be recognized, with the same or even higher recognition value. In this research, the other expression usually is happy expression.
Disgust	The expression is relatively difficult to recognize by the software. Frequently, this expression is recognized as other expression
Anger and Fear	The expression is relatively difficult to recognize by the software or recognize as other expression. The recognition value usually is small

Table 5. Analysis of basic emotion recognition by software

Facial expression	Analysis
Happy	Happy emotion tend to be interpretated with the same expression for all subjects. The software also define happy expression with the same cues
Sad	When subjects express sad, they only made small movement in the face. Although the cues are the same with software interpretation about sad expression, since the movements are not significant, the software cannot read the movement. As the result, recognition value of all basic expression usually were 0 (or near 0).
Surprised	Surprised can occur because of happy, terrify, or shocked with a specific event. Because of the mix feeling, for instance between excited and surprised, the recognition value also be mixed up. Moreover, there are some similarities between facial points that indicate happy and surprise.
Disgust	The emotion is difficult to recognize because there are varied interpretation of disgust expression. For instance, there is respondent that showed smirking expression, or move the nose, or even stick out the tounge.
Anger and Fear	It is very difficult for respondents to express these emotion spontaneously, without any trigger or special occasion.

This research is an initial study for facial expression analysis related to basic human emotions. The main weakness of this study is that the number of subjects is very limited, only 10 people. The limited number of subjects causes a lack of quantitative analysis that can be done. Going forward, a study with a larger number of respondents needs to be done. In addition, only one type of software was used in this study. Therefore, the results of this study have not been able to represent the average ability of automatic facial expression analysis software. Due to the limitation of the study, more comprehensive study should be done. Except the number of subjects, big issues that should be accommodate was the expression it self. Should it be "posed expression" or "spontaneous expression". Each expression might has different software recognition.

Furthermore, this research will be further developed so that the recognition of expressions can be applied to detect fatigue in humans, especially when they do cognitive work. Monitoring fatigue when working is a crucial thing to do, given that many cognitive jobs have a high risk and can lead to fatalities, both for workers and the larger environment. In the actual work environment, the method of fatigue detection based on facial expressions is quite potential to be applied because of its nature that does not disturb workers. With detection of fatigue in real

time, the negative and fatal effects that can be caused by fatigue conditions are expected to be overcome and prevented.

CONCLUSIONS

Basic human emotions tend not to be easily recognized. Although there have been many studies that standardize the expression characteristics of the six basic emotions: pleasure, sadness, surprise, disgust, fear, and anger, in reality a person's interpretation of these six emotions can vary. Based on this study, it was concluded that the way a person shows his emotions varies. Although there are some similarities in expressions, it cannot be proven that all expressions of basic human emotions can be generalized. Only one relative expression can be clearly recognized by facial expression analysis software, which is happy emotions. Other emotions are sometimes not recognized, mixed with other expressions, or difficult to be spontaneously displayed by the subject. This causes the ability to recognize software for various expressions is quite low.

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APPENDICES

Exp.	Part.	Detected expression (%)						Detected expression (score)					
		H	Sa	Su	D	A	F	H	Sa	Su	D	A	F
Anger	**1**			4	1			0	0	1	1	0	0
	2					75		0	0	0	0	3	0
	3		2					0	1	0	0	0	0
	4		1					0	1	0	0	0	0
	5	97		93				3	0	3	0	0	0
	6							0	0	0	0	0	0
	7							0	0	0	0	0	0
	8		16			39		0	1	0	0	2	0
	9	90		44				3	0	2	0	0	0
	10							0	0	0	0	0	0
								6	3	6	1	5	0
Disgust	**1**				96			0	0	0	3	0	0
	2							0	0	0	0	0	0
	3	67			94	29		3	0	0	3	2	0
	4			5	1			0	0	1	1	0	0
	5		2					0	1	0	0	0	0
	6			1				0	0	1	0	0	0
	7							0	0	0	0	0	0
	8			1			1	0	0	1	0	0	1
	9	1		3				1	0	1	0	0	0
	10			3	2			0	0	1	1	0	0
								4	1	5	8	2	1
Fear	**1**	3						1	0	0	0	0	0
	2		4			87		0	1	0	0	3	0
	3			3				0	0	1	0	0	0
	4			95	1		3	0	0	3	1	0	1
	5	7		2				1	0	1	0	0	0
	6							0	0	0	0	0	0
	7						22	0	0	0	0	0	2
	8			3	5			0	0	1	1	0	0
	9			3				0	0	1	0	0	0
	10		2		14	99		0	1	0	1	3	0
								2	2	7	3	6	3
Happy	**1**	99			2			3	0	0	1	0	0
	2	100		4				3	0	1	0	0	0
	3	100						3	0	0	0	0	0
	4	100						3	0	0	0	0	0
	5	95		26	7			3	0	2	1	0	0
	6			97				0	0	3	0	0	0
	7	100						3	0	0	0	0	0
	8	52			5			3	0	0	1	0	0
	9	100		9				3	0	1	0	0	0
	10	100		4				3	0	1	0	0	0
								27	0	8	3	0	0

Continue

Exp.	Part.	Detected expression (%)						Detected expression (score)					
		H	Sa	Su	D	A	F	H	Sa	Su	D	A	F
Sad	**1**							0	0	0	0	0	0
	2							0	0	0	0	0	0
	3							0	0	0	0	0	0
	4							0	0	0	0	0	0
	6				3			0	0	0	1	0	0
	7							0	0	0	0	0	0
	9							0	0	0	0	0	0
	10				49			0	0	0	2	0	0
	11		34		5	57		0	2	0	1	3	0
	12							0	0	0	0	0	0
								0	2	0	4	3	0
Surprise	**1**		1		36			0	1	0	2	0	0
	2			21	3			0	0	2	1	0	0
	3	100		37				3	0	2	0	0	0
	4	98		100	4			3	0	3	1	0	0
	5			93	100			0	0	3	3	0	0
	6	100						3	0	0	0	0	0
	7	98		96	1			3	0	3	1	0	0
	8			98	1			0	0	3	1	0	0
	9	96		64				3	0	3	0	0	0
	10			6	1			0	0	1	1	0	0
								15	1	20	10	0	0
								39	**6**	**26**	**15**	**13**	**4**

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