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Facial expression recognition of 3D image using facial action coding system (FACS)

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Abstract

Facial expression or mimic is one of the results of muscle motion on the face. In a large Indonesian dictionary, the expression is a disclosure or process of declaring, i.e. showing or expressing intentions, ideas of feelings and so on. Facial expression is affected by the cranial nerve VII or Nervus Facialis. In research conducted Paul Ekman got a standardization of expression in the format of a movement called the Facial Action Coding System (FACS). In his research, Paul Ekman said six basic expressions of happiness, sadness, shock, fear, anger, and disgust. In muscle anatomy, that every moving muscle must be contraction, and in the event of contraction, the muscle will expand or swell. Muscles are divided into three parts of origo and insersio as the tip of muscle and belli as the midpoint of the muscle, so any movement occurs then the muscle part belli will expand or swell. Data retrieval technique that is by recording data in 3D, any contraction occurs then the belli part of the muscle will swell and this data will be processed and compared. From this data processing will be obtained the maximum strength of contraction that will be used as a reference for the magnitude of expression made by the model. In the detection of expression is ecluidience distance by comparing the initial data with movement data. The result of this research is a detection of expression and the amount of expression that occurs. A conclusion of this research, we can reconstruction of facial expression detection using FACS, for the example the happiness expression using AU 6 and AU 12 and in this research AU 6 and AU 12 in area 1 and area 4, and in this area it so higher than the other.

Keywords*: 3D image, facial recognition, FACS*

1. Introduction

Facial expression or mimic is one result of the result of muscle movement on the face. In a large dictionary of Indonesian expression is a disclosure or process of declaring, i.e. show or express intentions, ideas, feelings, and others. In the science of communication between people, there are three ways to communicate with humans is by oral, written and expressed. In the expression is subdivided into two parts namely the expression of the body or often called gestures and facial expressions. there are six facial expressions based on geometric and appearance that are happy, sad, shocked, scared, angry and disgusted [1-3].

MPEG-4 FBA (ISO14496) is an international standard that handles animation for body and faces especially parameter determination like Face Animation Parameter (FAPs) and Body Animation Parameter (BAPs) [4-7]. In ISO14496 described the way used to create an animation. There are some interesting things from an animation that will be used, namely how to take data well and quickly from a model and can be transferred to all existing animation models, not in human form only, but the existing data can be used for all animation models. One way of data retrieval is by combining facial anatomy, MPEG-4 and Facial Action Coding System (FACS) [7-10].

In facial anatomy there are muscles used for facial expression, those muscles are affected by cranial nerve VII or often called Nervus Facialis [11-13]. In medical science, this muscle is often called the Mimetic Muscles, which is the muscle used to perform the expression. From the movement of these muscles will produce a facial expression. Simply the anatomy of the muscle consists of the tip of the muscle called the origo and insersio and the midpoint of the muscle called belli. From the anatomy the muscle movement can only be contraction and the

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most moving point is belli. In a facial expression, it is not just one moving muscle, but it can be affected by other interconnected muscles. From the anatomy of the muscle is made a standard that is encapsulated in Facial Action Coding System (FACS) with muscle movement that has been encoded in Action Unit (AU).

Facial Action Coding System (FACS) is a coding of facial muscle movement or expression based on Action Unit (AU) [1]. FACS encoding based on muscle motion, every facial muscle movement encoded to form a standardization in the making of animation. The codes are called Action Unit (AU) [14]. Each facial muscle movement is encoded in the AU. The muscle motion of the face is affected by twelve Mimetic Muscles [12, 13].

Action Unit is the basis of FACS because AU is the movement of muscles individually or in groups. In the FACS there are 44 Action Units that have been successfully defined, but there are only 30 Action Units associated with facial muscle contraction. With the division of the top 12 faces and 18 under face. Using the Action Unit makes it easier to detect an expression because in FACS an expression is a combination of AUs, such as a happy expression influenced by Action Units 6 and 12 [15, 16].

The use of muscle contraction formula to calculate the maximum amount of muscle movement, with the muscle contraction formula will be obtained Expression Strength. Because with facial expressions we will be able to deliver nonverbal messages [17]. In his research stated that facial expressions are important in simulations for emotional stages that have a close relationship with many social functions [17]. The final result of this research will be Expression Strength.

2. Research Method

2.1. Facial Expression

Facial expression or mimic is the result of facial muscle movement that is affected by the *Nervus Facialis* or cranial nerve VII [11]. Facial expression is one form of non-verbal communication that can convey emotions from someone to the person who observes. With facial expressions can convey an emotionally delivered message, not only humans but animals can also be expressed when getting the stimulus [17].

Humans can change certain facial expressions deliberately, but in general, the facial expressions shown by humans are done by accident because it is influenced by human emotions [18]. Humans are usually difficult to hide certain emotions or feelings from their face, although many people want to do so. For example, a person who wants to hide his feelings of hatred against a person, at a certain moment the person will show the true feelings on his facial expression, even though the man is trying to show a neutral expression. The relationship of expression and emotion can also go the other way [18].

In Paul Ekman's 1976 study concluded six globally recognized basic expressions of happiness, sadness, shock, fear, anger, and disgust [1]. In research was conducted on infants [14]. There are some differences between the expression of adults and infants. In this study, it was done to classify the expression present in an infant and based on FACS. Differences of research is on the data used. Data used in the study based on 2D image data and in this study based on the 3D image.

2.2. Face Anatomy

Facial muscle or also called Mimetic Muscle is a series of muscles used to perform facial expressions [11]. These muscles are affected by the *Nervus Facialis* or cranial nerve VII. The muscle anatomy is largely composed of *origo*, *insersio,* and *belli*. With *origo* and *insersio* are muscle ends attached to the bone or on the ligaments, while the bellows are the contracted muscle parts as shown below [19, 20].

In Figure 1, it is seen that the muscle component influences movement in expression. In this study, each Action Unit will be affected by each muscle that is driven by nervous VII. To get the results of muscle movement will be carried out detection of muscle movements according to the way the muscles work if every muscle that moves will swell [11-13]. With the location of the movement between the origo and insersio the name is belli, as illustrated in Figure 2. In the face there are various muscles that exist, the interesting thing in the facial muscles is the muscles that exist on the face including higher complexity compared with other muscle body parts, in Figure 3 is the coding of each muscle into the action unit code. Every muscle movement and

combination of muscle movements will produce different action unit codes. This unit action code will be used to determine the expression of the model.

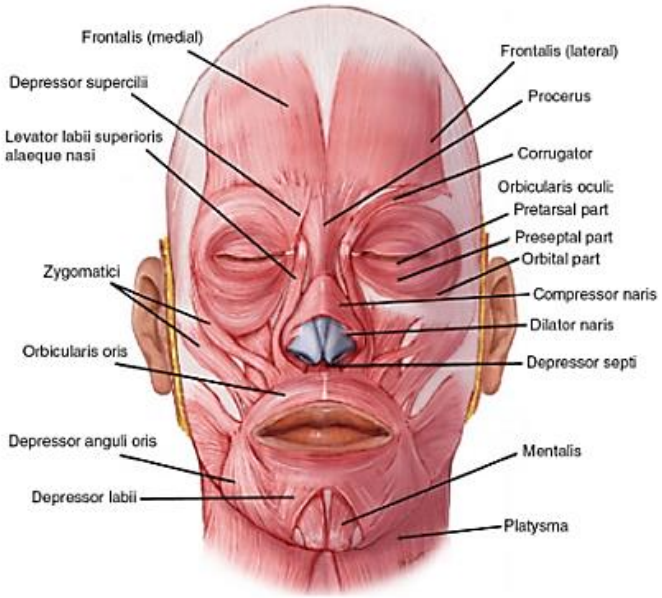


Figure 1.The anatomy of facial muscles [11, 21]

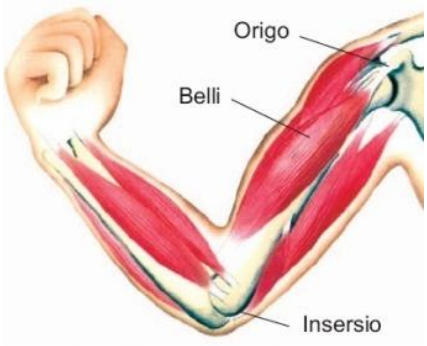


Figure 2. The *origo*, *insersio*, and *belli* position [11, 21]

In the face there are various muscles that exist, the interesting thing in the facial muscles is the muscles that exist on the face including higher complexity compared with other muscle body parts, in Figure 3 is the coding of each muscle into the action unit code. Every muscle movement and combinatio n of muscle movements will produce different action unit codes. This unit action code will be used to determine the expression of the model.

2.3. Facial Action Coding System (FACS)

Facial Action Coding System (FACS) is a coding of facial muscle movement or expression based on Action Unit (AU) [1, 8, 9]. FACS encoding based on muscle motion, every facial muscle movement encoded to form a standardization in the making of animation. The codes are called Action Unit (AU). Each facial muscle movement is encoded in the AU. The muscle motion of the face is affected by twelve Mimetic Muscles.

Action Unit is the basis of FACS because AU is the movement of muscles individually or in groups. In the FACS there are 44 Action Units that have been successfully defined, but there are only 30 Action Units associated with facial muscle contraction. With the division of the 12 upper face Action Units and 18 lower face Action Units. Using the Action Unit will make it easier to detect an expression because in FACS an expression is a combination of AUs, such as the happy expression influenced by Action Unit 6 and 12 [15, 16]. Figure 3 is a collection of Action Units located at the top of the head. The Action Unit is heavily influenced by Frontalis muscles, Procerus, Corrugator, and Orbicularis Oculi.

3. Results and Discussion

3.1. Data Image

At this step will be done 2 times the data retrieval process, the first is the 2D data and the second is 3D data. 2D data collection using the standard pocket camera in the market with a resolution of 640 x 240. While the 3D camera data with a large data 320x240.

3.2. 2D Data

2D data to be used in this study serves as the primary data for data processing using linear regression. Data are taken based on facial muscles present in humans and those affected by cranial nerve VII or *Nervus Facialis*. The muscle that affects expression and is affected by the cranial nerve VII or *Nervus Facialis* in Figure 4 is an animation-making reference based on mimetic muscle. With this reference, animation creation will be able to walk easily and realistically. Form Table 1, in taking 2D white data symbolizes the muscles that surround the midpoint of *Belli*. So the main movement to be taken data is a pink or *Belli*.

NEUTRAL	AU 1	AU 2	AU 4
Eyes, brow, and cheek are relaxed.	Inner portion of the brows is raised.	Outer portion of the brows is raised.	Brows lowered and drawn together
AU 5	AU 6	AU 7	AU 1+2
Upper eyelids are raised.	Cheeks are raised.	Lower eyelids are raised.	Inner and outer portions of the brows are raised.
AU 1+4	AU 4+5	AU 1+2+4	AU 1+2+5
Medial portion of the brows is raised and pulled together.	Brows lowered and drawn together and upper eyelids are raised.	Brows are pulled together and upward.	Brows and upper eyelids are raised.
AU 1+6	AU 6+7	AU 1+2+5+6+7	
Inner portion of brows and cheeks are raised.	Lower eyelids cheeks are raised.	Brows, eyelids, and cheeks are raised.	

Figure 3. Action unit [15-16]

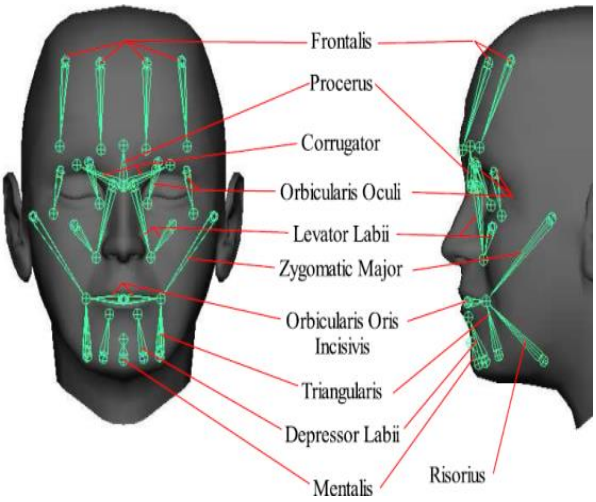
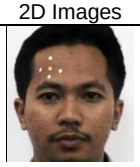


Figure 4. Facial muscles in the animation [22]

Table 1. Retrieval of Muscle Test Data with Marker

Muscle's Name	2D Images	Movements Examples	Muscle's Position
Frontalis			
Corrugator			
Levator Labii			
Orbicularis Oculi			
Procerus			

3.3. 3D Data

In 3D data retrieval, the data taken is the depth of the data, in particular, is the face [23]. In addition, the data taken are faced coordinate, left eye, right eye, mouth, and nose. From this data will be processed so that the desired Action Unit out according to FACS. Three-dimensional data that will be processed in this research is point cloud, face tracking, and MPEG-4 standard data issued by Intel Realsense cameras. And the following is the data obtained in Figure 5. Figure 5 is a data point cloud that is simulated in 3D. This data will be the primary reference data used in the distance image process. Figure 6 is the result of shooting with normal expression. Figure 6 will be used as reference data in the form of 2D images [24, 25].

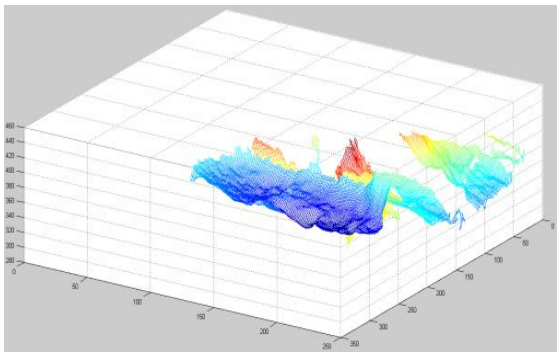


Figure 5. Normal expression

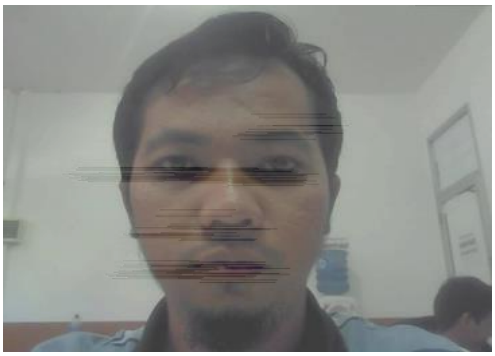


Figure 6. 2D image normal expression

Table 2 is an MPEG-4 table obtained from libraries provided by Intel Realsense. This data is reference data that will be used as reference point for data processing. In Figure 7 is the raw data from the 3D camera in Figure 8. Figure 7 is a landmark data of a happy expression, this data will be processed and done template matching with data from the normal expression. Table 3 is data from Senz3D cameras taken using the provided libraries. This data will be processed to perform the transformation.

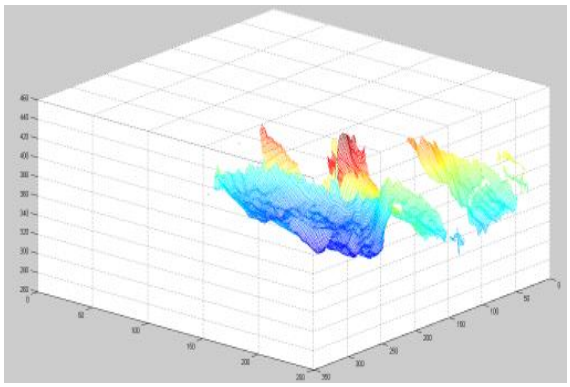


Figure 7. Happy expression

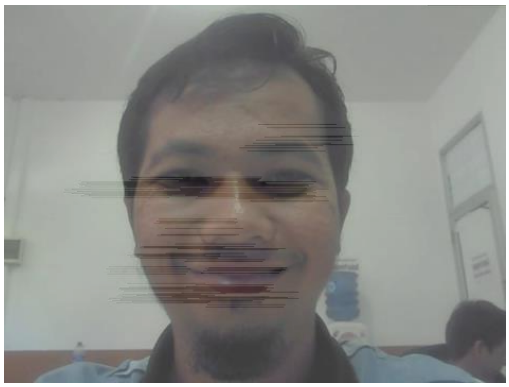


Figure 8. 2D image happy expression

Table 2. MPEG-4 Data Normal Expression

Name	Data Contents
Left Eye Inner	392.229
Left Eye Outer	464.237
Right Eye Inner	319.229
Right Eye Outer	254.239
Nose	345.292
Mouth Left	394.360
Mouth Right	306.361

Table 3. MPEG-4 Data Happy Expression

Name	Data Contents
Left Eye Inner	379.224
Left Eye Outer	438.232
Right Eye Inner	317.224
Right Eye Outer	259.232
Nose	345.276
Mouth Left	411.334
Mouth Right	281.334

Figure 9 is a landmark data of a shocked expression. This data will be processed by matching with normal expression data using template matching method so that AU can know where there is movement. Figure 10 is a 2D drawing of a shocked expression and will be used as a reference for data processing. Table 4 is data from Senz3D cameras taken using the provided library. This data will be processed to do the transformation.

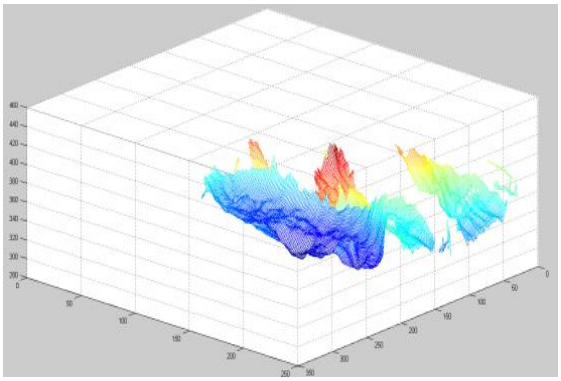


Figure 9. Shocked expression

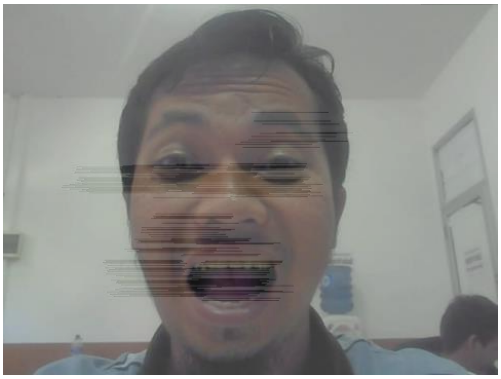


Figure 10. 2D image shocked expression

3.4. Expression Testing

In this step will be transformed so that the model occupies the desired place. After that done template matching process to test the muscle movement. From the existing data is divided into several AU movements, and this division is depicted in Figure 11.

Table 4. MPEG-4 Data Shocked Expression

Name	Data Contents
Left Eye Inner	380.216
Left Eye Outer	438.213
Right Eye Inner	314.217
Right Eye Outer	247.215
Nose	354.300
Mouth Left	399.344
Mouth Right	291.345

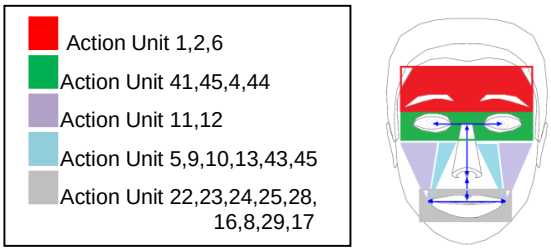


Figure 11. AU distribution based on position

3.5. Happy Expression

At a happy expression according to the FACS is affected by muscle in Action Unit 41 to perform its movements. From the Figure 12 data visible changes in both image data. The change has been in accordance with the results at the time of observation. Observation seen movement occurs in the face and around the mouth. In testing will be done mapping the location of the facial muscles. The data obtained in the form of reference point to do the calculation, the points can be seen in Table 5.

Table 5 is a table of coordinate points of 3D data obtained from 2D facial data. The starting point will be scaled because the data from 2D has the size 640x480 while the 3D data has the size 340 X 240. The first step is to eliminate face data, so that will be taken only face data, and the result of elimination as follows, from Figure 12 the normal expression of data can be seen in Figure 13 and at the time of happy expression the data can be seen in Figure 14. From the Figure 15 data look blue is the result of the movement of the model at the time of data retrieval. Movement of data many are on the cheek or zygomatic muscles and the area around the eyes caused by *corrugator* and *bicularis* muscle. For the percentage of movement according to FACS hence data of propulsion for happiness expression is muscle residing in area 2 and 4. From Table 6 area 2 having movement 13.6% and on area 4 move equal to 14.3%.

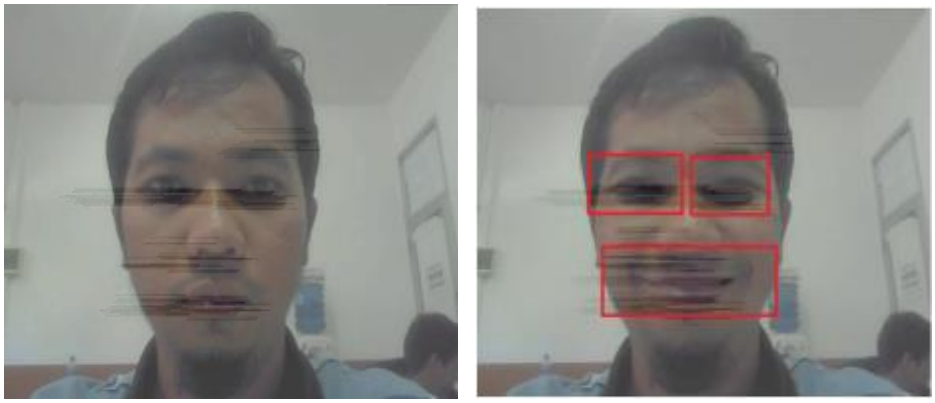


Figure 12. Comparison of AU position

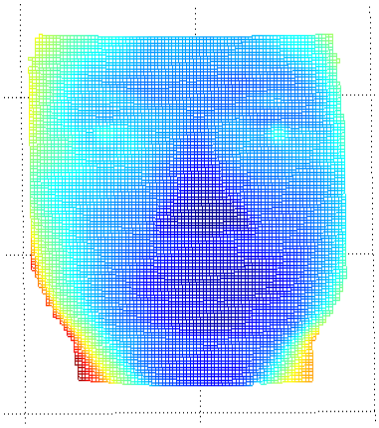


Figure 13. Normal expression

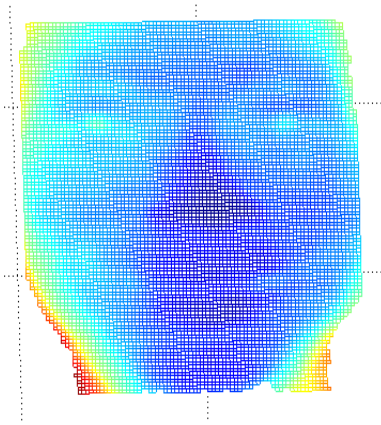


Figure 14. Happy expression

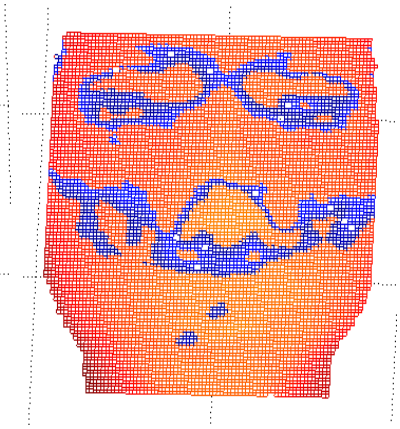


Figure 15. Normal and happy distance data

Table 5. 3D Data Coordinates

Name of Point	Initial Coordinates	Final Coordinates
Left Eye Inner	392.229	196.114
Left Eye Outer	464.237	232.118
Right Eye Inner	319.229	160.115
Right Eye Outer	254.239	127.119
Nose	345.292	172.146
Mouth Left	394.360	197.180
Mouth Right	306.361	153.180

Table 6. Percentage of Normal and Happy Expression Movement

N_B	Total	Movements	Percentage
Area 1	1293	209	16.16395978
Area 2	1580	215	[.60759494
Area 3	1573	174	11.06166561
Area 4	1221	175	14.33251433
Area 5	2467	1	0.040535063

3.6. Shocked Expression

In the FACS data, the shocked expression is affected by some muscles to perform the expression. From the Figure 16 data, can be observed, that the movement is almost happening on the entire face and the results of testing its 3D data as below, from Figure 16 the normal expression of data can be seen in Figure 17 and at the time of shocked expression the data can be seen in Figure 18. From 3D in the Figure 19, the data testing from Table 7 can be seen that the data in accordance with the movement made by 2D data. In accordance with FACS for expression, shock muscles are in areas 1, 3 and 5. From the data in Table 7 area movements 1 by 62%, for area 3 of 12% and area 5 of 11.2%. From the data, the biggest movement in area 1 and area 2 reaches 34.1%.

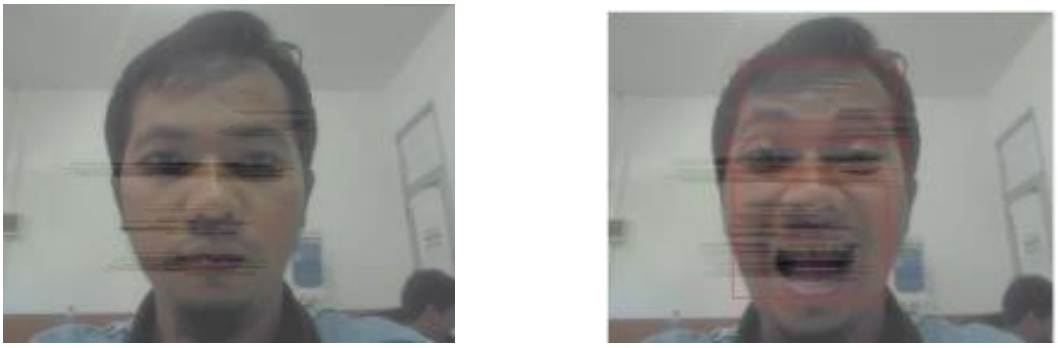


Figure 16. Shocked Expression

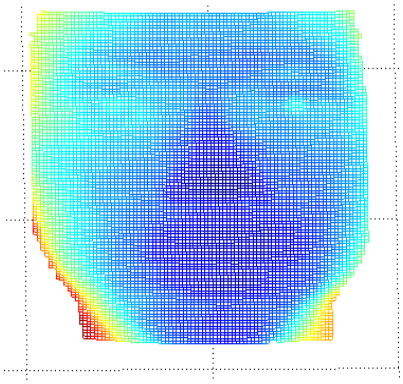


Figure 17. Normal face data

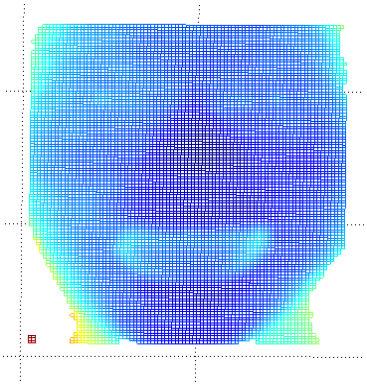


Figure 18. Shocked face data

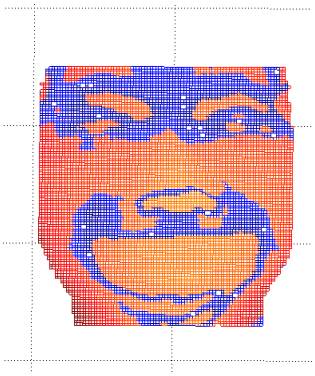


Figure 19. Normal and shocked distance data

Table 7. Percentage of Normal and Shocked Facial Expression

N_T	Total	Movements	Percentage
Area 1	1115	692	62.06278027
Area 2	1321	451	34.14080242
Area 3	1640	198	12.07317073
Area 4	1284	268	20.87227414
Area 5	2289	258	11.27129751

4. Conclusion

In muscle anatomy, that every moving muscle must be contraction, and in the event of contraction, the muscle will expand or swell. In Paul Ekman's 1976 study concluded six globally recognized basic expressions of happiness, sadness, shock, fear, anger, and disgust. The result of this research is a can detection of expression and the amount of expression that occurs. This can look at happy expression testing and shocked expression testing. The result of this research is a detection of expression and the amount of expression that occurs. A conclusion of this research, we can reconstruction of facial expression detection using FACS, in the testing 3.5, the happiness expression using AU 6 and AU 12 and in this research AU 6 and AU 12 in area 1 and area 4, and in this area it so higher than the other. In area 1 is highest, with data move is 16% and in area 4 is 14% data move. In the shocked expression, almost all area is a move, and highest move area is area 1, in this area more than 65% data is move, and the second is area 2 with data 34%, area 4 with data 20%, area 3 with data 12% and area 5 with data 11%. In FACS shocked expression use data AU 1, AU 2, AU 5B and AU 26. AU 1 and AU 2 in area 2 and AU 5B in area 1. and AU 26 in area 3 and 4.

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