

## **Abstract**

**Werda Buana Putra:** A Facial Expression Recognition System to Monitor Student's Mood In A Classroom. **Thesis.Yogyakarta : Post-Graduate Program. Yogyakarta State University, 2019.**

Depression is a commonly unattended health problem, unbounded by age border, and greatly affecting student's performance in their study. To prevent it, the writer built a real-time facial emotion recognition system, so the teacher can monitor students' mood through class activity. The system should be reliable enough when running on mid-end computer specification.

The writer use transfer learning for the dataset, pre-trained by utilizing convolutional neural network theory. The system use Euclidian Distance as the basis to do the facial landmark, and applying FURIA fuzzy rules to calculate and get the desired facial emotion result. JAFFE image set will be used to test the system's accuracy by comparing the result shown by the system and the already expert-arranged image set. The student will be given questionnaire to measure their stress. The questionnaire result will be used to analyze whether the use of the system able to reduce student's stress or not.

The system built is able to properly classifying 7 human facial emotion captured by webcam. By comparing the result of the emotion recognition processing and the expert-arranged emotion on JAFFE image set, it is concluded that the system's accuracy reached 90%. The result from the questionnaire shows that the use of the system able to detect student's mood early so the teacher may minimize student's stress.

Keywords: Depression, convolutional neural network, Euclidian distance, FURIA fuzzy.

## Abstrak

**Werda Buana Putra: A Facial Expression Recognition System to Monitor Student's Mood In A Classroom. Tesis.Yogyakarta :Program Pascasarjana. Universitas Negeri Yogyakarta, 2019**

Depresi adalah masalah kesehatan yang umumnya tidak dihiraukan, dapat menyerang segala rentang umur, dan mempengaruhi kinerja siswa. Untuk mencegah ini, kami membangun sebuah sistem facial emotion recognition, agar guru dapat memonitor mood siswa selama kegiatan kelas. Sistem yang dibangun harus bisa menampilkan hasil yang memuaskan meskipun dijalankan menggunakan komputer dengan spesifikasi minimal mid-end.

Penulis menggunakan *pre-trained* dataset yang dilatih menggunakan *convolutional neural network*. Sistem akan menggunakan *Euclidian Distance* untuk mendapatkan *facial landmark*. Setelah itu, mengaplikasikan aturan fuzzy FURIA untuk mendapatkan emosi sebagai hasil akhir. Alat akan diuji menggunakan *image set* JAFFE yang sudah diklasifikasikan oleh ahlinya. Siswa akan diberi kuisioner untuk mengukur tingkat stres mereka. Hasil kuisioner akan dibandingkan pada saat sebelum dan setelah guru menggunakan sistem pengenalan emosi untuk mengukur pengurangan tingkat stres siswa.

Sistem yang dibangun berhasil mengklasifikasikan 7 emosi manusia yang tertangkap di webcam. Setelah dilakukan pengukuran menggunakan *image set* JAFFE, peneliti menyimpulkan bahwa sistem mampu mencapai tingkat akurasi 90%. Hasil kuisioner menunjukkan bahwa penggunaan sistem pengenalan wajah mampu mendeteksi mood siswa secara dini, sehingga guru mampu meminimalisir tingkat stress siswa.

Kata kunci : Depresi, *convolutional network*, *Euclidian distance*, *FURIA fuzzy logic*

## Letter of Authenticity

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Declare that everything written on this thesis is the result of my own hypothesis and analysis, and never been submitted to receive any kind of magister title in any university. As far as I concerned, there is no work, nor opinion which have been written or published, included on this thesis, unless it is cited as reference on this script and mentioned in reference list.

Yogyakarta, 28 February 2019

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# CHAPTER I

## INTRODUCTION

### A. Research Background

Social anxiety disorder (SAD) is one of the most common mental health disorders, with approximately 13% of the population meeting diagnostic criteria for SAD during their life. Hence, the need to quickly recognize such anomaly surfaced. If left untreated, SAD typically runs a chronic course and total remission is rare. Though depression is classified as an adult disorder, and depression in very young children is rare, middle to late adolescence is the most common age when depression symptoms first appear or a first major depressive chapter happens. Lewinsohn, Hops, Roberts, Seeley, and Andrews sampled random adolescents within a U.S. community and figured out that the average age of onset of major depression was 14 years old.

According to National Institute of Mental Health data in 2014, about 2,8 million American teenagers ranged 12-17 years old would at least suffered by one episode of major depression and only 30% of them get a proper treatment (NIH 2014). In Indonesia, there are approximately 40 million teenagers, and more than 3,4 million of which in range 10-19 years old suffer from mental disease in 2013, with depression as the most common symptom.

In Indonesia, depression is categorized as mental-emotional disorder and its prevalence as high as 6% of total population (Ministry of Health Republic of Indonesia 2016). A number of research investigate the role some factors to depressive symptom, such as emotion regulation (Marroquín, Boyle and Nolen-Hoeksema 2016), self-esteem, mindfulness trait, emotion deregulation, and life quality. Illegal drugs usage is proven to be the byproduct of depression and because the bigger prevalence on men, depression and comorbidity affected by gender. Data from particular newspaper in Indonesia shows that 90% of drug users is on large, unattended (Hanifah and Unayah 2011). Psychological researchers have proved that there are negative effects of depression on student's academic performance (Khurshid, et al. 2015). Figure 1 shows an artist concern on people's misconception about depression symptoms.

In response to that condition, the writer proposed a way to monitor student's mood through class activity. The teacher should be able to constantly aware on the fluctuation of their student's mood by using facial emotion recognition system. At this point, the problem only lies on the willingness of the system developer and the educator to collaborate. But here is where the problems lies, Indonesia, where the research will take place upon, is a developing country. As sad as it sounds, 55% of under-15 Indonesian is functionally unable to read (Fauzie 2018). All this is happened all the while the education field received 20% of national budget (Indonesian Financial Ministry 2018).



Figure 1. Basic Understanding Of Depression In A Form Of Cartoon Image (Babis 2014)

All that being said, when developing a system for educational purposes, Indonesian developers must weight the development cost and gain while strictly monitoring the risk management. Deducting from that fact, developers have to put into consideration the equipment which Indonesian school able to provide before they move forward to develop the system. This restriction may or may not be completely determined even at the final stage of the project development.

## **B. Problem Identification**

From research background, some imminent problems were detected, which is:

1. Indonesian teenager's depression rate is high.
2. Depression will negatively impact student's academic performance.
3. Lack of measure to detect student's depression symptoms.
4. Indonesian school's lack of budget to develop comfortable environment for students.
5. There are no light, real-time facial expression recognition software that able to detect student's expression.

## **C. Problem Limitation**

Seeing how much problems arisen from earlier problem identification, there is a need on problem limitation so this research will contain only the highlighted problems that need to be resolved. This is purposed so the result from this research would be optimum. This research will highlight the facial expression recognition system usage on the classroom. The problem limitation listed as followed:

1. Depression will negatively impact student's academic performance.
2. Student's depression symptoms detection is lacking.
3. There are no light, real-time facial expression recognition system yet that able to detect student's expression with decent performance.

Writer intended to solve highlighted problems by build a real-time facial recognition system to monitor student mood in a classroom. The idea of building this system is to help the teacher control the situation in the classroom.

#### **D. Problem Formulation**

The problems would further formulated as:

1. Design a real-time facial expression recognition system?
2. Implement the facial emotion recognition system to the computers provided by school?
3. Measures students stress while in a classroom?

#### **E. Research Purpose**

To solve the problem efficiently, there is a need to decide research purposes. Amongst them is:

1. Build a real-time facial emotion recognition system to detect student's facial expression that able to be executed on provided computers.
2. Measure the system's performance.
3. Early detection on student's expression to help teachers monitor their student's mood, so the teacher could minimize their student's stress.

## **F. Research Interest**

This research will produce a system which able to detect human facial feature, extract it, and analyze it as an expression. This writing infers the interest by theoretic and practical approach.

### 1. Theoretic Interest

The product built in this research will use FURIA fuzzy rules and Euclidian Distance to reduce the system weight and minimum specification. Even though some details on this part will be omitted, the algorithm and part of the code will be shown. A lot of research with similar interest may use this research to help them understand the actual application of FURIA fuzzy rules and Euclidian Distance on image analysis.

### 2. Practical Interest

In this research, the system will monitor student's emotion which inferred as their mood and display it as one of seven emotions (neutral, happy, sad, disgust, surprise, anger, fear). In future, the tool's framework which has been built may used by researchers and practitioners alike to gather data or monitor related, subsequent subject's expression.

## **G. Product Specification**

The final product from this research were built using Microsoft visual studio 2017. The researchers used library from dlib.net to import the functions and procedures for dataset operation. The product is able to detect the user's facial expression in real-time based on captured image through webcam.

Before the software able to work properly, the computer this software installed on required at least 1 GB memory RAM and core 2 duo processors. The computer need the latest .NET framework and C++ redistributable package to process the image processing library.

## **H. Research Assumption**

In this research, facial expression recognition systems were developed with some assumption, which is:

1. Cited by Rohman, according to Bloom, the goal of education can be seen from behavior displayed by students which segmented into three domains, cognitive, affective, and psychomotor.
2. Stress levels may escalate to significant proportions in some students (Bedewy and Gabriel 2015).
3. Human facial expression are rich in information about individual identity, mood, and mental state.

## **CHAPTER II**

### **LITERATURE STUDY**

#### **A. Theory Background**

##### **1. Depression and Stress**

Stress can potentially have both positive and negative effects on a child. Some stress, for everyone is normal and healthy, because it keeps people to try harder reach the goal of their life. However, excessive stress can be quite harmful, not only to children, but to adults as well. Hence, not only how to treat it, but how one would be able to tell when someone is depressed is as important as the former.

School and many other academic facilities can be highly competitive, and students are required to cope with it. This condition, require them to have abilities and skills to manage their stress level (Acosta-Gómez, et al. 2018). To prevent negative outcomes regarding stress such as depression and anxiety, educators must have a method to measure student's stress level to improve their mood and increase their coping strategies so they can manage their stress and improve their life quality.

Diah Krisnatuti Pranadji and Nurlaela (2009) believe that stress would affect student's concentration and sleeping habit. Not only stress would affect student's psychology, but also their physiology.



## 2. Real-Time Teacher Student Interaction

The various teaching methods, including lectures, discussions, and small-group work have tried to understand student's psychological state. Some students may raise their voices more than the others; this variation is a result of differences in learning preferences as well as differences in their personalities. As an example, some students who do not speak often in the class are reflective learners, who typically develop ideas and questions in their minds before speaking; others are shy students who feel uncomfortable to speak in front of a group (at least initially).

Many students who frequently volunteer themselves to contribute are included in active learners group, who typically think before they speak. The goal is to make teachers able to create active communication cycles and adapt (Pennings, et al. 2014). Identifying the interpersonal content and interpersonal structure in teacher-student interactions may be critical for understanding teacher-student relationships. Because as overall, students without behavior problems were less likely to respond to teacher behaviors in a negative fashion and likewise, teachers were less likely to respond in a negative fashion to inappropriate behaviors of students.

## 3. Facial Expression

Charles Darwin wrote in his 1872 book, *The Expression of the Emotions in Man and Animals* that “facial expressions of emotion are universal, not learned differently in each culture”. There have been arguments both in favor and against ever since.

The seminal research into the topic came from psychologist Paul Ekman, who pioneered research into emotion recognition in the 1960s. His team of scientists provided their test subjects with photos of faces showing different emotional states. The test subjects had to classify the emotional states they saw in each photo, from a predetermined list of possible emotions. Other research studies over the years have used similar methods.

Ekman's initial research determined that there were six core emotions, which he termed *universal emotions*. These original universal emotions are:

- a. Joy (Sometimes referred to as 'Happiness') - symbolized by raising of the mouth corners (an obvious smile) and tightening of the eyelids
- b. Surprise - symbolized by eyebrows arching, eyes opening wide and exposing more white, with the jaw dropping slightly
- c. Sadness - symbolized by lowering of the mouth corners, the eyebrows descending to the inner corners and the eyelids drooping
- d. Anger - symbolized by eyebrows lowering, lips pressing firmly and eyes bulging
- e. Disgust - symbolized by the upper lip raising, nose bridge wrinkling and cheeks raising
- f. Fear - symbolized by the upper eyelids raising, eyes opening and the lips stretching horizontally

There is a seventh emotion that is sometimes considered universal.

7. Contempt - symbolized by half of the upper lip tightening up (using what is called the risorius muscle) and often the head is tilted slightly back.

#### 4. Emotion and Education Performance Relations

Researchers are effectively advancing in the understanding of connection between regulation of emotion and behavior to student's performance and achievement (Valiente, Swanson and Eisenberg 2012) (Bryan and Bryan 1991). Baumeister and Bushman (2011) conceptualized the emotion experience as a "Subjective state" accompanied by a bodily reaction. During 15 years back, emotion has become important topic within psychological field. Masami Horikawa and Akihiro Yagi (2012), in their seminal work described anxiety as having two forms, trait and state. Trait academic emotions are relatively stable, while state academic emotions are momentary experience which tends to follow a fluctuation of the course.

Situational emotional responses and individual different negative emotionality have prominent roles in many social development models and emotional disorders increases the risk for school dropout potential (Ahmed, et al. 2013) (Valiente, Swanson and Eisenberg 2012). Although researchers are typically expect the positive emotions to foster academic success, high-arousal positive emotions (such as exuberance, excited state, and elatedness) may potentially make students detract from achievement. The different positive emotions load on different factors in statistic analyses, and high and low factors are only moderately correlated in adults (Valiente, Swanson and Eisenberg 2012).

## 5. Facial Recognition

In the 1960's Woody Bledsoe, Helen Chan Wolf, and Charles Bisson pioneered the first facial recognition system (Thorat, Nayak and Dandale 2010). The program was required to locate facial feature such eyes, nose, ears, mouth, and brows on the photograph. The program then calculates the distance and ratios according to references. This technology was taken over by one of USA's National Intelligence Agencies in 1993 (Writer 2017). The project named FERET (Face Recognition Technology Evaluation). The Face Recognition Grand Challenge (FRGC) evaluated the latest face recognition algorithms available in 2006 (Writer 2017). Some of the algorithm is able to identify uniquely identical twins.

Back in the past, facial expression analysis was essentially a topic for psychologists' research. However, the research about image processing and pattern recognition have significantly progressed recently, motivated significant research activities on automatic facial expression recognition. Basic facial expressions, typically recognized by psychologists are neutral, anger, sadness, surprise, happiness, disgust and fear. The biggest problem with facial recognition is racial bias. The algorithm and software developed by Japanese and Chinese companies recognize Asian faces with a great degree of accuracy, but other races to a lesser degree. European and US companies recognize Caucasian faces very accurately, but not so much on the other races.

Today, Facial Recognition attracted all kind of attention from researchers and business players alike, mainly due to recently increasing support from computer hardware

development. The market for facial recognition application is expected to grow to \$7.7 billion in 2022 from \$4 billion in 2017 (Mordor Intelligence 2018). That's because facial recognition has all kinds of commercial applications, it can be used for everything from surveillance to customer's satisfaction analysis.

## 6. Convolutional Neural Networks

Convolutional Neural Networks are very similar to ordinary Artificial Neural Networks. They are made up of neurons that have learnable weights and biases. Each neuron receives some inputs, performs a dot product and optionally follows it with a non-linearity. However, Convolutional Neural Network architectures make the explicit assumption that the inputs are images, which allows us to encode certain properties into the architecture. These factors can make the forward functions more efficient to implement and vastly reduce the amount of parameters in the network. Its rough system can be seen in figure 2.

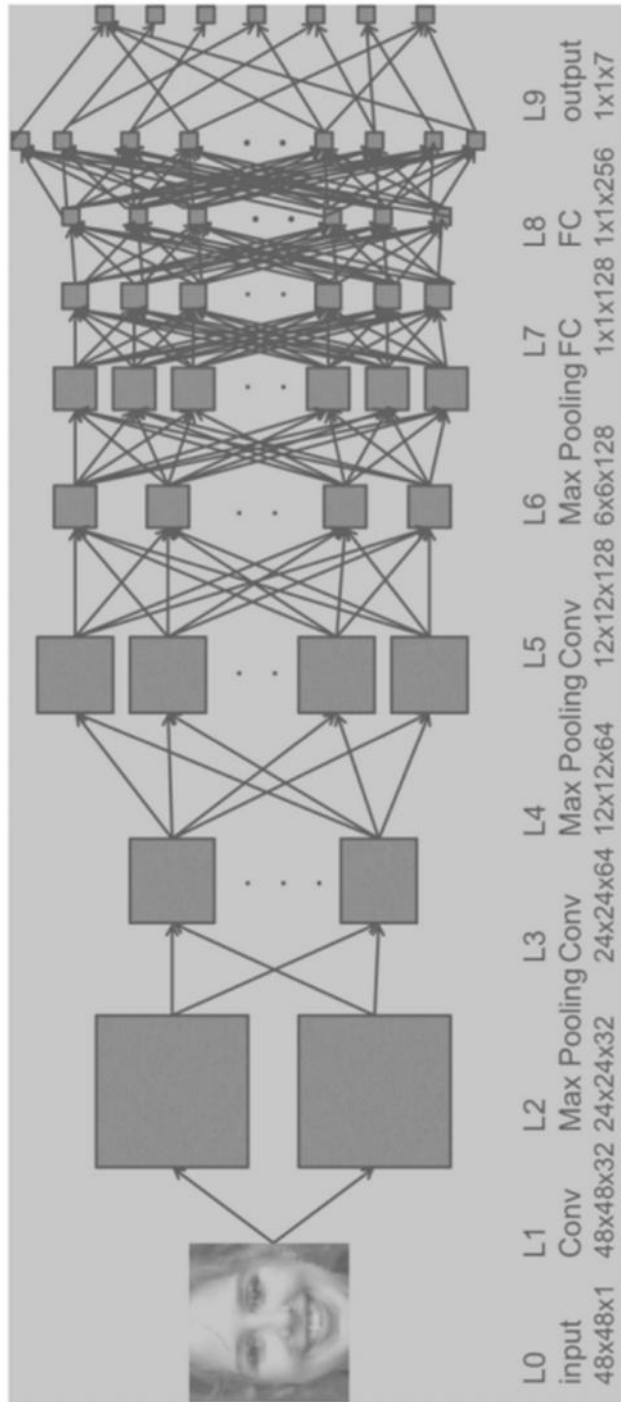


Figure 2.CNN Architecture (Li 2017)

## 7. Layers

The first layer in a CNN is always a Convolutional Layer. For now, make the input a  $32 \times 32 \times 3$  array of pixel values. The best way to explain a convolution layer is to imagine a flashlight that is shining over the top left of the image just like illustrated in figure 3. Let's say that the light this flashlight shines covers a  $5 \times 5$  area. And now, imagine this flashlight sliding across all the areas of the input image. This flashlight is called a filter. Take the first position the filter is in for example. It would be the top left corner. As the filter is sliding, or convolving, around the input image, it is multiplying the values in the filter with the original pixel values of the image until it has a single number. Remember, this number is just representative of when the filter is at the top left of the image. This process is repeated for every location on the input volume. Every unique location on the input volume produces a number. After sliding the filter over all the locations, it will be found out that what is left with is a  $28 \times 28 \times 1$  array of feature map.

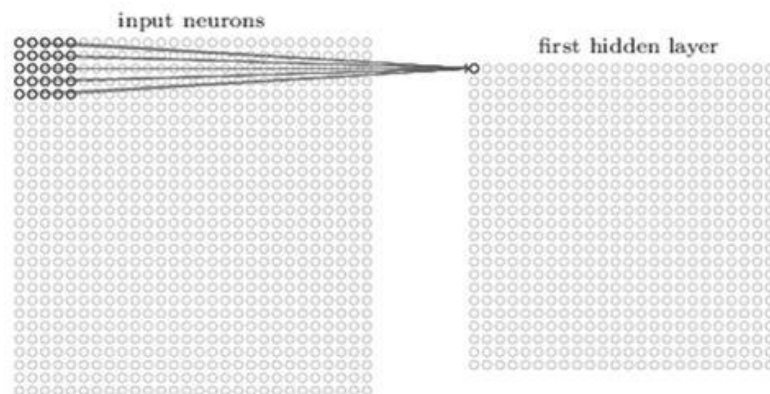


Figure 3. Analogy On How Convolutional Network Works

Now, let's take a look at padding. Before getting into that, let's think about a scenario. What happens when you apply three 5 x 5 x 3 filters to a 32 x 32 x 3 input volume? The output volume would be 28 x 28 x 3. Notice that the spatial dimensions decrease. As we keep applying conv layers, the size of the volume will decrease faster than we would like. In the early layers of our network, we want to preserve as much information about the original input volume so that we can extract those low level features. Let's say we want to apply the same conv layer but we want the output volume to remain 32 x 32 x 3. To do this, we can apply a zero padding of size 2 to that layer. Zero padding pads the input volume with zeros around the border. Thinking about a zero padding of two, then this would result in a 36 x 36 x 3 input volume.

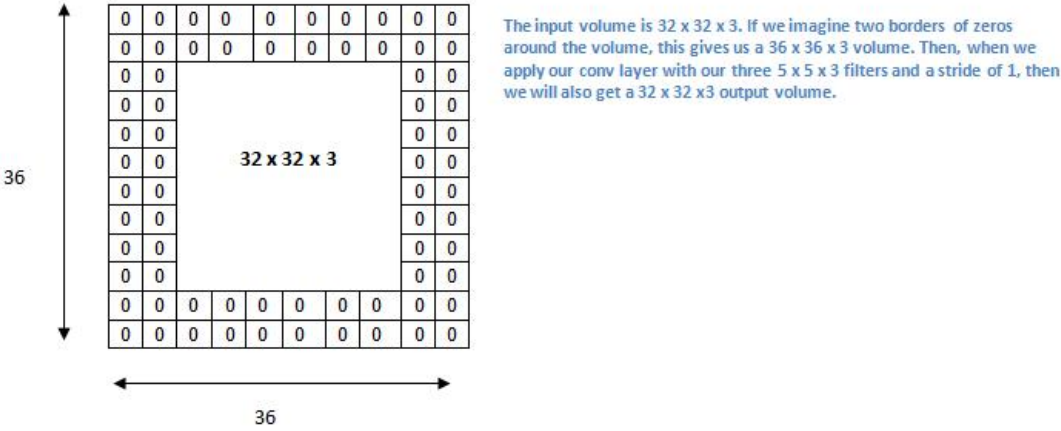


Figure 4. Paddle with 32 x32x 3 dimension

With a stride of 1 and set the size of zero padding to

$$Zero\ Padding = \frac{(K - 1)}{2} \tag{3}$$



where  $K$  is the filter size, then the input and output volume will always have the same spatial dimensions. The formula for calculating the output size for any given conv layer is

$$O = \frac{(W - K + 2P)}{S} + 1 \quad (4)$$

where  $O$  is the output height/length,  $W$  is the input height/length,  $K$  is the filter size,  $P$  is the padding, and  $S$  is the stride.

## 8. Image Classification

Image classification is the task of taking an input image and outputting a class or a probability of classes that best describes the image. For humans, this task of recognition is one of the first skills learnt from the moment human born and is one that comes naturally and effortlessly as adults. When human see an image or just when they look at the world around them, most of the time they are able to immediately characterize the scene and give each object a label, all without even consciously noticing. These skills of being able to recently quickly recognize patterns, generalize from prior knowledge, and adapt to different image environments are ones that human do not share with machines, just like illustrated in figure 4.



What We See



What Computers See

Figure 4. The Difference in Image Recognition of Human And Computer

What people want the computer to do is to be able to differentiate between all the images it's given and figure out the unique features that make a dog a dog or that make a cat a cat. In a similar way, the computer is able perform image classification by looking for low level features such as edges and curves, and then building up to more abstract concepts through a series of convolutional layers. This is a general overview of what a CNN does. Let's get into the specifics .Each of filters can be thought of as feature identifiers. When the writer says features, the writer is talking about things like straight edges, simple colors, and curves. Let's say the first filter is 7 x 7 x 3 and is going to be a curve detector. (In this section, let's ignore the fact that the filter is 3 units deep and only consider the top depth slice of the filter and the image, for simplicity). Figure 5 explain the outline of computer vision representation.

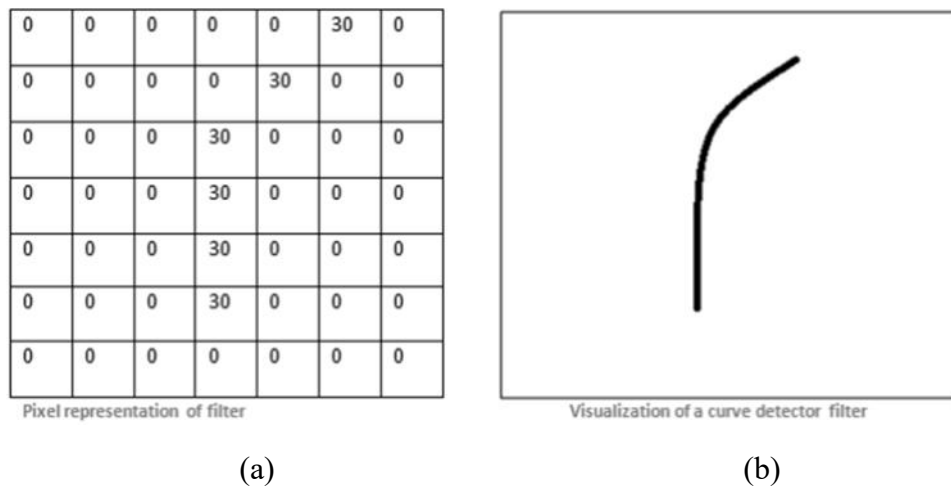


Figure 5. Perspective Of Curve Line (a) Pixel Representation And (b) The Visualization Of Curve Detector Line

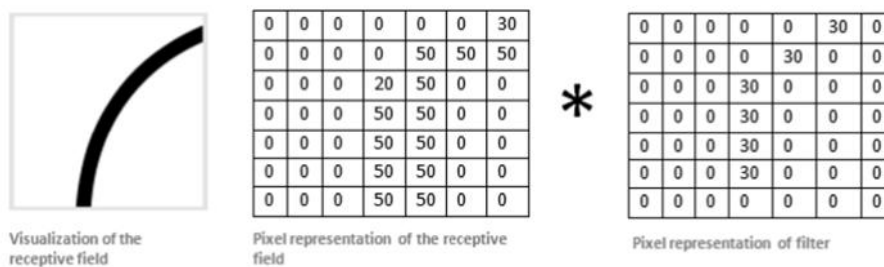


Figure 6. Matrix Multiplications And It's Visualization

Multiplication and Summation =  $(50 \times 30) + (50 \times 30) + (50 \times 30) + (20 \times 30) + (50 \times 30) = 6600$ . Now let's see figure 7 as to what happens when the filter move. When this filter is at the top left corner of the input volume, it is computing matrixes multiplications between the filter and pixel values at that region as can be seen in figure 6. This is because there wasn't anything in the image section that responded to the curve detector filter. Now that it can detect these high level features as shown in figure 8, the icing on the cake is attaching a fully connected layer to the end of the network. Basically, a FC layer looks at

what high level features most strongly correlate to a particular class and has particular weights so that when the program compute the products between the weights and the previous layer, the program get the correct probabilities for the different classes.

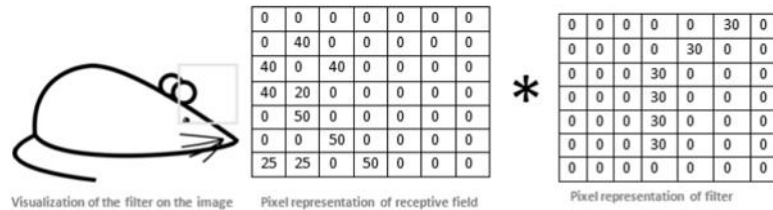


Figure 7. More Complex Example Of Matrix Perception On Curve Line

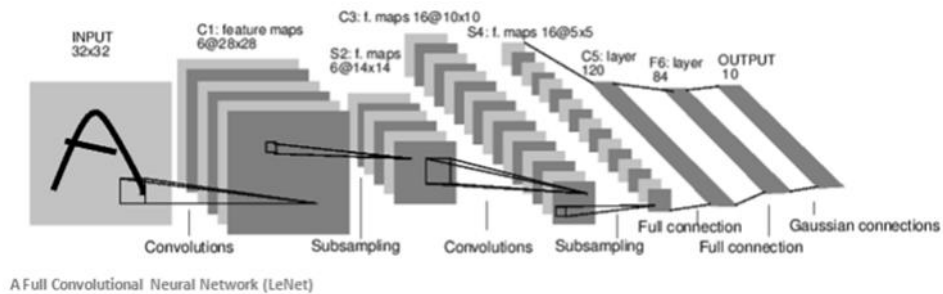


Figure 8. Visualization On Convolutional Network

## 9. Euclidian Distance

To make the software more efficient the writer commit an image transformation referred to as Standardizing Transform. It infers that Euclidian Distance are closely related to image smoothing (Wangy, Zhangy and Fengy 2005). All the M by N images are easily discussed in an MN dimensional Euclidean space, called image space.

Among all the image metrics, Euclidean distance is one of the most commonly used due to its simplicity. Let  $x$  and  $y$  be two  $M$  by  $N$  images,  $x = (x^1; x^2; \dots; x^{MN})$ ,  $y = (y^1; y^2; \dots; y^{MN})$ , where  $x^{kN+1}; y^{kN+1}$  are the gray levels at location  $(k; 1)$ . The Euclidean distance  $d_E(x; y)$  is given by

$$d_E^2(x, y) = \sum_{k=1}^{MN} (x^k - y^k)^2 \quad (1)$$

(Wangy, Zhangy and Fengy 2005).

However, this distance measure suffers from a high sensitivity even to small deformation. A reasonable image metric in figure 9 should present smaller distance between (a), (b) than that of (a), (c). But the Euclidean distance gives counter intuitive result. For simplicity, let the gray levels be one at the black pixels and zero elsewhere.

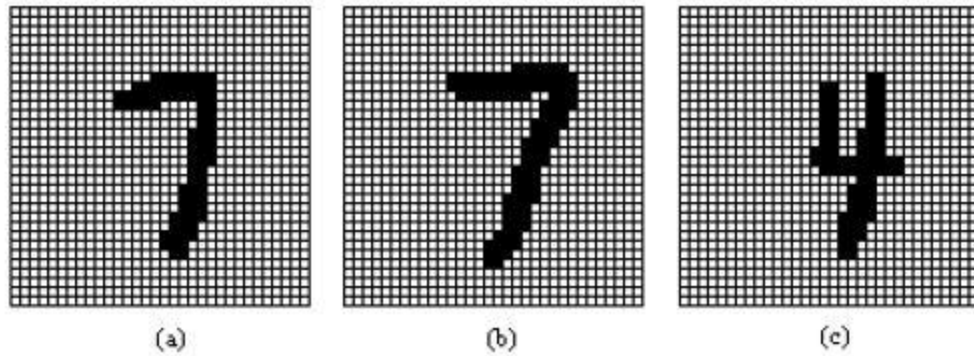


Figure 9. Similar and Dissimilar Images

Computing the Euclidean distances yields  $d_E(a; b) = 54$  and  $d_E(a; c) = 49$ . It can be seen that the pair with more similarity has a larger Euclidean distance. This phenomenon is caused by the fact that the Euclidean distance defined in Formula (1) does not take into account that  $x; y$  are images,  $x^k; y^k$  are gray levels on pixels. Minimizing an arbitrary function is generally very difficult, but if the objective function to be minimized is convex then things become simpler (Smola and Vishwanathan 2010). For images, there are spatial relationships between pixels. The traditional Euclidean distance is only a summation of the pixel-wise intensity differences, and consequently small deformation may result in a large Euclidean distance. The key advantages of this metric can be further derived into three main points which can be used to formulate a solution for one of the research problem. These advantages include:

- 1) Relative insensitivity to small perturbation (deformation),
- 2) Simplicity of computation,
- 3) It can be efficiently embedded in most of the powerful image recognition techniques.

## 10. Computer Logic

Computer logic is a concept of design concerning how computer recognize operation and structures of the world. Computers usually uses numerical system of base 10, base 2, base 8, or base 16, while the latter three were regularly used because it's easy of use when designing a computer system.

## 11. Fuzzy Logic

Sometimes a dichotomous logic, which is yes or no type logic, is inadequate to solve problems which reflected human reasoning. Fuzzy logic solved such problems by providing more humanly approach.

Essentially, a fuzzy rule is obtained through replacing intervals by fuzzy intervals, namely fuzzy sets with trapezoidal membership function as shown in figure 10. A fuzzy interval of that kind is specified by four parameters and will be written (Hühn and Hüllermeier 2009)

$$IF = (\varphi_{s,L}, \varphi_{c,L}, \varphi_{c,U}, \varphi_{s,U}):$$

$$IF(v) \stackrel{\text{df}}{=} \begin{cases} 1 & \varphi^{c,L} \leq v \leq \varphi^{c,U} \\ \frac{v - \varphi^{s,L}}{\varphi^{c,L} - \varphi^{s,L}} & \varphi^{s,L} < v < \varphi^{c,L} \\ \frac{\varphi^{s,U} - v}{\varphi^{s,U} - \varphi^{c,U}} & \varphi^{c,U} < v < \varphi^{s,U} \\ 0 & \text{else} \end{cases} \quad (5)$$

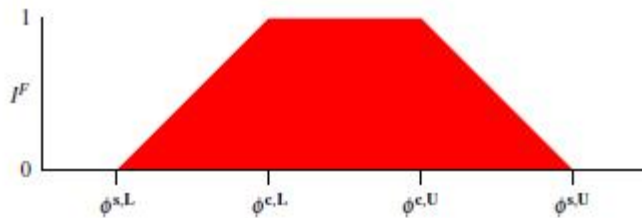


Figure 10. A Fuzzy Interval

## 12. FURIA Fuzzy Logic

A novel fuzzy rule-based classification method called FURIA, which is short for Fuzzy Unordered Rule Induction Algorithm. FURIA extends the well-known RIPPER algorithm, a state-of-the-art rule learner, while preserving its advantages, which is a modification and extension of the state-of-the-art rule learner RIPPER. In particular, FURIA learns fuzzy rules instead of conventional rules and unordered rule sets instead of rule lists. Moreover, to deal with uncovered examples, it makes use of an efficient rule stretching method.

Fuzzy rules are more general than conventional rules and have a number of advantages. For example, conventional (non-fuzzy) rules produce models with “sharp” decision boundaries and, correspondingly, abrupt transitions between different classes. This property is questionable and not very intuitive. Instead, one would expect the support for a class provided by a rule to decrease from “full” (inside the core of the rule) to “zero” (near the boundary) in a gradual rather than an abrupt way. Fuzzy rules have “soft” boundaries, which is one of their main characteristics (Hühn and Hüllermeier 2009). Admittedly, if a definite classification decision has to be made; soft boundaries have again to be turned into crisp boundaries. Interestingly, however, these boundaries are potentially more flexible in the fuzzy case. For example, by using suitable aggregation operators for combining fuzzy rules, they are not necessarily axis-parallel.

The result of most conventional rule learners is a decision list. To produce such a list, rules are learned for each class in turn, starting with the smallest (in terms of relative



frequency of occurrence) and ending with the second largest one. Finally, a default rule is added for the majority class. A new query instance is then classified by the first rule in the list by which it is covered.

A selector constraining a numerical attribute  $A_i$  (with domain  $D_i = \mathbb{R}$ ) in a RIPPER rule can obviously be expressed in the form  $(A_i \in I)$ , where  $I \subseteq \mathbb{R}$  is an interval:

$I = (-\infty, v]$  if the rule contains a selector  $(A_i \leq v)$ ,  $I = [u, \infty)$  if it contains a selector  $(A_i \geq u)$ , and  $I = [u, v]$  if it contains both (in the last case, two selectors are combined). Essentially, a fuzzy rule is obtained through replacing intervals by fuzzy intervals, namely fuzzy sets with trapezoidal membership function. A fuzzy interval of that kind is specified by four parameters and will be written  $IF = (\varphi_s, L, \varphi_c, L, \varphi_c, U, \varphi_s, U)$ : (Hühn and Hüllermeier 2009)

$$IF(v) \stackrel{\text{df}}{=} \begin{cases} 1 & \varphi^{c,L} \leq v \leq \varphi^{c,U} \\ \frac{v - \varphi^{s,L}}{\varphi^{c,L} - \varphi^{s,L}} & \varphi^{s,L} < v < \varphi^{c,L} \\ \frac{\varphi^{s,U} - v}{\varphi^{s,U} - \varphi^{c,U}} & \varphi^{c,U} < v < \varphi^{s,U} \\ 0 & \text{else} \end{cases} \quad (6)$$

$\varphi^{c,L}$  and  $\varphi^{c,U}$  are, respectively, the lower and upper bound of the core (elements with membership 1) of the fuzzy set; likewise,  $\varphi^{s,L}$  and  $\varphi^{s,U}$  are, respectively, the lower and upper bound of the support (elements with membership  $> 0$ ),

### 13. Outline of RIPPER Logic

RIPPER was introduced by Cohen (1995) as a successor of the IREP algorithm for rule induction (Fürnkranz and Widmer 1994). Even though the key principles remained

unchanged, RIPPER improves IREP in many details and is also able to cope with multi-class problems. Looking at formula 2, consider a polychotomous classification problem with  $m$  classes  $L = \text{df } \{\lambda_1, \dots, \lambda_m\}$ . Suppose instances to be represented in terms of attributes  $A_i, i = 1, \dots, n$ , which are either numerical (real-valued) or nominal, and let  $D_i$  denote the corresponding domains. Thus, an instance is represented as an  $n$ -dimensional attribute vector

$$\mathbf{x} = (x_1, \dots, x_n) \square \mathbf{D} = \text{df } D_1 \times \dots \times D_n \quad .(7)$$

## B. Relevant Research

There are several cases of study which is subtly similar with this research. Even though the concept of facial expression recognition remain the same, but the method and theory which used to reach the research purpose were vastly varies. How this research is different and distinct from previous research will be explained in this part.

### 1. Geometric Displacement to Detect Facial Feature

Yadan Lv et al. derived an effective facial representation from original face image as a vital step for successful facial expression recognition (Lv, Feng and Xu 2014). In image sequences, the facial movements qualified by measuring geometrical displacement of facial feature points between current frame and initial frame just like what shown in figure 11. However in this research, the detection was constricted on static image only according to the research method conducted.

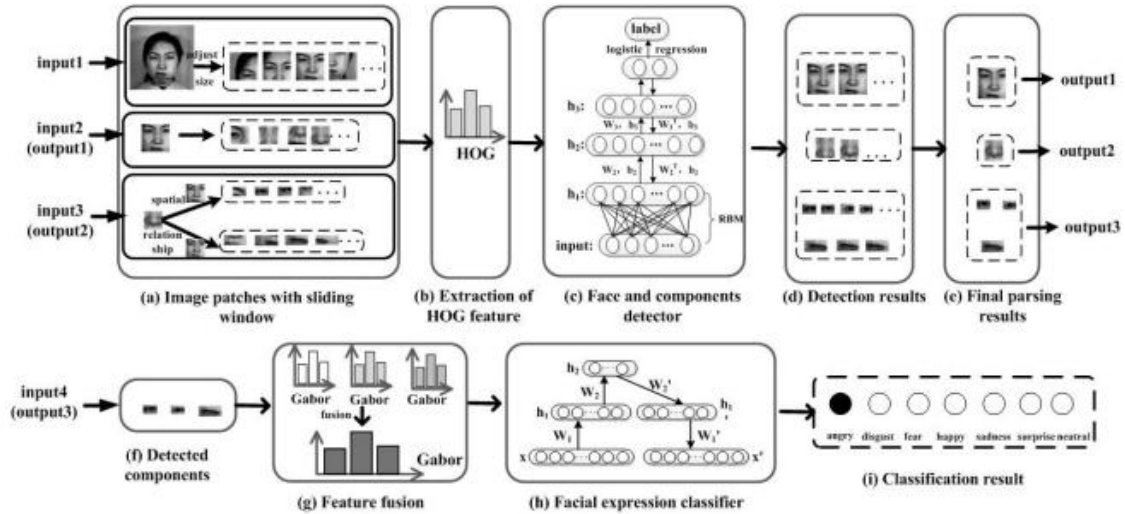


Figure 11. Yadan's Facial Recognition System Design (Lv, Feng and Xu 2014) by measuring geometrical displacement

## 2. 3D Models for Facial Expression Recognition

In 2008, Soyel and Demirel proposes an unconventional method to analyze facial image using Face and Body Animation (FBA) International Standard (Soyel and Demirel 2008) introduces the methods of extracting information from 3D models for facial expression recognition. The 3D distributions of the facial feature points and the estimation of characteristic distances in order to represent the facial expressions are explained by using a rich collection of illustrations including graphs, charts and face images. The second part of the chapter introduces 3D distance-vector based facial expression recognition.

## 3. Facial Emotions Classification through K-Means Method

Jun Ou believes that facial expression constitutes 55% of the effect of a communicated message while language and voice constitute 7% and 38% respectively (Ou

2012). He tried to adopt one of the most primitive classification algorithms on his automatic facial emotion recognition. Jun Ou state that his program's accuracy are descent, even though K-Means are no longer feasible for image classification in a facial expression recognition department. K-Means are far more effective when the images are pre-processed to become numerical data to make them feasible to be trained.

In this research, the writer is trying to make a system where the acquired image's facial features could be extracted and classified based on 7 basic human emotions. Furthermore, in this research, the writer attempted to decrease the system's requirement by applying Euclidian Distance to landmarking and FURIA fuzzy logic for emotion classification phase.

### **C. Mindset**

Human facial expression is one or more motion or positions of the muscles beneath the skin of human face. These movements, according to some theories, convey the emotional state of an individual. Some psychologists are able to use facial expression to discern and deduct indirect information from a person's facial expression. Facial expression could be adopted voluntarily or involuntarily.

There is an increase in virtual schools worldwide (Sathik and Jonathan 2013) and it is suggested that education mediated by computer is considered very important for the future. Different researchers suggest that the visual representation of the participant in a virtual environment, possibly in a virtual classroom, increases the potential for person-to-person collaboration and interaction.

Implementing artificial intelligence to recognize human facial expression can be a complex and difficult task. High quality datasets are hard to found, and there are various pitfalls to avoid when designing such system.

It is proved that facial expression could help lecturers to identify the involvement and comprehension of the student (Sathik and Jonathan 2013). The conclusion of the research conducted by Sathik and Jonathan leads the writer to the hypothesis that student's academic performance in a classroom could be elevated in a way if the teacher could monitored their student's facial expression.

#### **D. Research Question**

While the system built and the instruments being prepared, the writer is under the impression that facial expression recognition system will allow the teacher to control the class tension and mood to some degree. However there are many elementary students who act uniquely as an individual, and their nature would naturally vary. In this research, the writer would try to find out how much, students in the classroom would lean toward the mood brought by the teacher. This leads to the following questions of this research:

1. Can the facial expression recognition is able to properly detect facial emotion, given the system will run on mid-end computer specification?
2. Will the facial expression recognition able to achieve desirable accuracy?
3. Can the teachers handle the situation in the classroom by monitoring student's mood when using facial expression recognition system?

## **CHAPTER III**

### **RESEARCH METHOD**

#### **A. Type of Research**

This research combined the research and development model and simple descriptive quantitative research which use statistically simple research variables. The descriptive research method will be used to answer research question. To be able to fulfill the expected system to work and able to give satisfying result, the research ultimately required to built a system that able to detect human facial feature, track it to a certain degree, and analyze it so that it would show the correct emotions. Along the way, there is a process where the system is interconnected via LAN connection, which will be omitted in this documentation due to the scope of this research that is not including networking system as the requirements to answer the research question.

There is several popular ways to detect human emotion, be it speech recognition, handwriting pattern, or lingual distortion. However, considering available resources and research goal, the writer chooses to go with facial emotion recognition. The first challenge to tackle in this research is to make the system able to monitor student's head pose, detecting their facial layout and tracking it, detecting facial landmark and able to extract numerical information so that these information possible to be processed. The second challenge is to make the system work real-time, this is deducted from the fact that there is a need to monitor student's mood while the class activity is in motion.

## **B. Population and Sample**

Choosing the population for this research is not done randomly, instead the writer purposely choose fifth elementary students as the subject due to their basic competence to operate computer and their ability to handle their emotion and limit their stress level on their own unique way (Krisch 2018). This is important because one of the main objectives in this research is to find out the relation of class activity while the teacher monitored them with the facial expression recognition system and the student's stress rate.

Prior to research conduct in school, a research proposal was requested to university board. After 3 days, the proposal granted and ready to be forwarded to the school board, which is *SDN Percobaan 2* Yogyakarta. The research proposal was submitted to Institutional Board and approved by the headmaster. Participant's selection began by consulting with supervisor and the school's teacher. The writer is looking for students, who are capable of basic computer operation and can be left by themselves to do their work. Another criterion is the subject shouldn't be burdened by external variables, such as the approaching National Exam, which could be applied to all of the sixth grade students. This narrowed the choice to fourth grader and fifth grader. After further discussion, the writer choose to pick students from fifth grade A class as test subjects due to their relatively docile nature compared to other classes on their grade or fourth grader.

This research will be conducted in two phases; the first phase would be the research on computer specification and environment involved to build the system. The second phase

would be the implementation of the actual system to school's computer and execute the system to see how well it actually worked when implemented in school.

Real-time facial emotion recognition, in general, is divided by 2 phases. The first phase would be detecting general area of human face, this process include tracking system which require the hardware to monitor the general movement of facial layout. Second phase would be Facial landmarking, which pointing out more accurate facial point to be extracted. Of course, there is a need to choose the most efficient way to compute and doing facial analysis to prevent school computer from memory overload. On the other hand the system still need a feature which is able to extract the student's facial expression and then further processed it into the emotion as the result.

### **C. Research Procedure**

To gather the research data, a particular device to capture images of each student is needed, in this case it would be USB webcam. The writer needs to be sure the computer able to properly do image acquisition, facial extraction, facial landmarking, and logic computation to get the emotion from the subject. In short, the research needs a working webcam, and sufficient computation power on the subjected computer.

To reduce the computing resource requirement, the writer designed this system using Euclidean Distance and applying FURIA fuzzy rules to compute the emotion displayed which detected on webcam. The end-user, in this case is the corresponding school which will use the system, will decide how they will use or utilize the facial expression recognition system. It will then be left entirely to the corresponding



teachers how to deal with the classroom situation, whether the class is intended to be tense or the teacher want to use easy-going approach.

After consulting with the headmaster and IT teacher, it is confirmed that even though they have 20 computers in their lab, only 4 computers for student use that were installed with working webcam (installed by default on monitor display). Like that, there are four client computer and one server computer as a working system (see figure 11 for reference) prepared by the school.

#### **D. Development Model**

Software development model is an expression of the whole process of software development, which defines the main activities clearly to instruct the working tasks on software development that to be completed. It is the structural framework of all the work and tasks which are implemented by system development, running and maintenance to across the entire software life cycle, and the relationship between the various phases of software development activities are also given.

Waterfall model is a traditional software development model, but the framework of the model is much simple. The model consists of development phases of requirements analysis, designing, coding, testing, and maintenance, but each phase must be executed in queue, and requirements must be known up front. But, it's difficult to imagine every detail in advance in reality. Most projects start out with some uncertainty, and more details are learned as the project progresses. The major disadvantage of model is that problems in system aren't discovered until late in process (testing phase).

Prototype model was used in this research. This technique offers a useful method of exploring ideas and getting customer feedback for each of them. In this model, there is a first step to create a rough design or prototype, test it and rework as necessary until an acceptable prototype is finally achieved by which a complete product can be developed. Hence it is a trial and error process that takes place between the developer and the user. This type of system development method is employed when it is difficult to obtain the exact requirements from the customer. In this model, a prototype acts as a sample to test the process (Saxena and Upadhyay 2016).

A requirements specification is an important document normally produced at the initial (problem definition) stage. It defines the functionality, scope, and constraints of the software. It also serves as a basis for contracts as well as communication between the software developer and the user. If the development is based on an incomplete and incorrect specification, then even with well written code, the software will still be unsatisfactory and unable to fulfill user requirements. In addition, defects in a vague specification will be propagated to subsequent phases of the development.

Naturally a test plan initiated early in the product development cycle must keep pace with the application being developed as seen in figure 12. As the application progresses through the design, develop, test, change, re-release, and re-test cycle new areas for system level tests will be exposed.

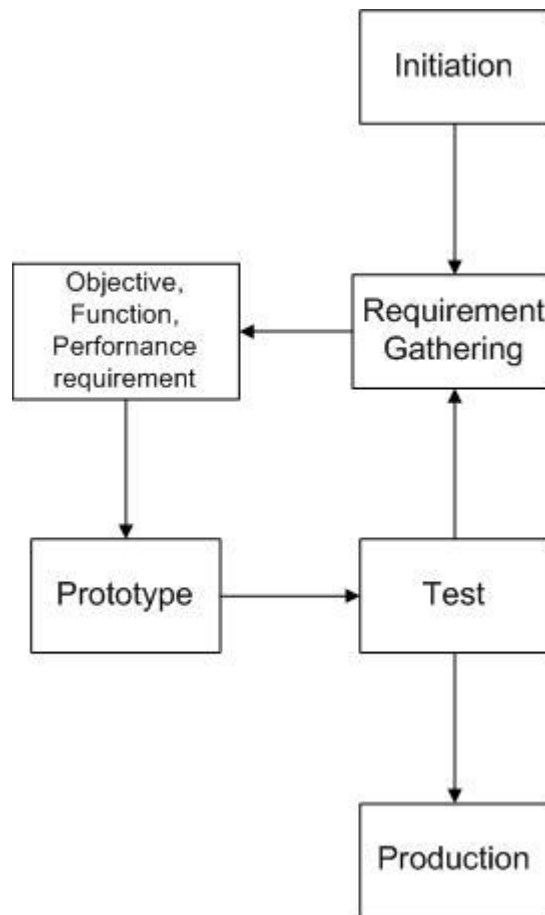


Figure 12. Prototype Development Model Life Cycle

Testing of a software application need not wait until the application is actually functioning. Part of the test plan created during the analysis phase, may have items to be tested during each of the following phases. Requirements, specifications, and application design are all testable even from documentation (Nindel-Edwards and Steinke 2007).

## E. System Design

### 1. Facial Landmarking

The location of facial features can be represented as landmarks on the face. The image acquisition of human face can be represented as coordinated vector landmark and Action Units (AU). Hence, facial feature offered geometric information of each and overall shape of particular object. Facial expression extraction and localization has become pivotal point among image analyst. The flow of this process could be seen in figure 13.

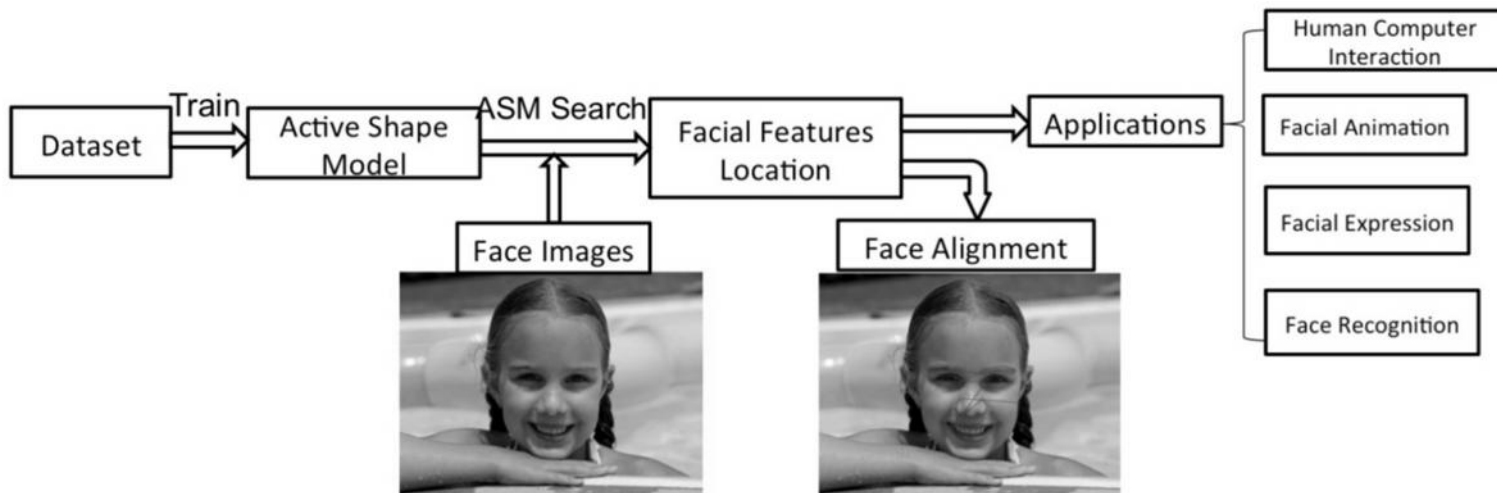


Figure 13. Facial Feature Localization And Applications (Li 2017)

## 2. Facial Expression Recognition System Design

Human facial expression conveys much rich, complex, emotional information as a bridge in the communication relation. Automatic facial emotion recognition by itself had become a challenging problem and has potential to be used in a plethora of applications. Figure 14 represented the process of emotion acquisition in the facial expression recognition system. As an example of how to implement the system, the system may acquire image from student's computer, extracting information, classifying the image, then, relaying the result to teacher's computer which is shown in figure 15.

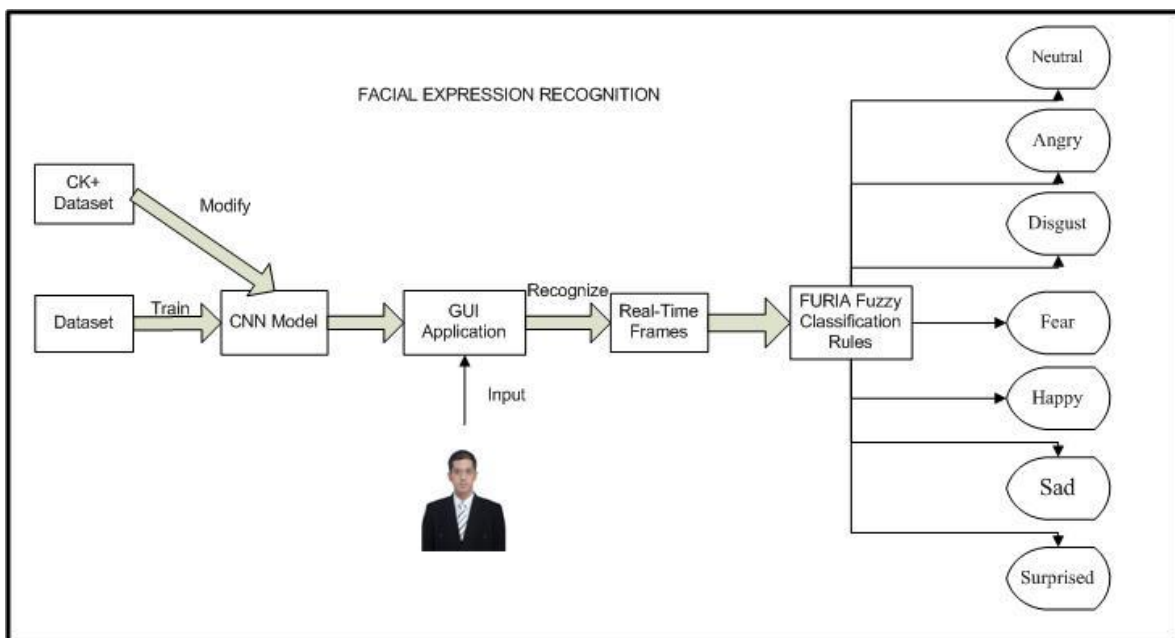


Figure 14. System Design

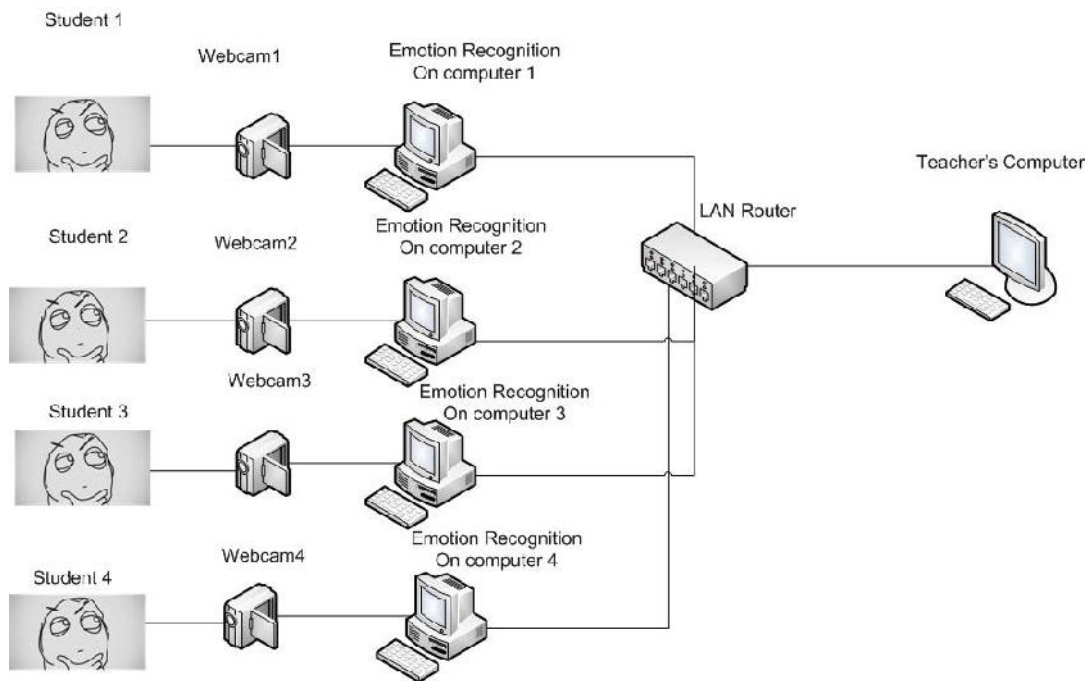


Figure 15. An Example of Environment Design as System's Implementation

The system uses a pre-trained dataset as its base. The writer will build the system with prototype development model which is divided into three main activities. First, the writer will do preliminary research on what the school need, this will resulted on the research theme itself. Second, the writer will develop the product based on the resource available and feasible for school computers. Third, the writer will test the system using a specific image set to check the accuracy of the system used on this research.

The image captured from the webcam will be processed with the dataset and Euclidian Distance to get and track the information of human face coordinate which displayed in monitor. While tracking the face, the system will extract the necessary information of human facial features by implementing Euclidian Distance theory. From the

extracted information about human facial features, the system will apply FURIA fuzzy rules to decide the classification of an expression from one of the seven possible emotions.

The data will be taken, naturally, unconsciously by the students themselves as to guarantee there is no fabricated emotion and expressions would be made. The students will conduct their class activity using a computer with a webcam installed. Prior to the class, the environment is set by teachers, where the student's computer will be turned on and the system will be turned on beforehand. The teacher then will be able to observe the displayed information.

## **F. System Implementation**

The implementation of the system requires the computer to have an ability to process image data analysis. The development environment also demanded to support machine learning data processing and do data analysis from processed images.

### **1. Facial Landmarking**

Although a lot of ways are proposed as a way to detect human emotions, but facial recognition remains as a challenge until today. Many factors such as, illumination, deformed environment, head pose, body pose could contribute to the complexity of the computations (Chen, et al. 2014). Facial landmarks is defined as the detection and localization of certain key points on the face which have an impact on subsequent tasks focused on the face, like animation, face recognition, gaze detection, face tracking, expression recognition, gesture understanding as shown in figure 16 and 17.

```

    /// Faces
    g.DrawRectangle(
        new Pen(new SolidBrush(Color.Black)),
        new Rectangle(kvp.Key.Left, kvp.Key.Top, kvp.Key.Right - kvp.Key.Left, kvp.Key.Bottom -
kvp.Key.Top));
    /// Face Id
    g.DrawString(
        String.Format("Face_{0}", cnt++),
        new Font(FontFamily.GenericSansSerif, 10.0f, FontStyle.Bold),
        new SolidBrush(Color.Yellow),
        new PointF(kvp.Key.Left, kvp.Key.Top));
    /// Angles.
    foreach (EmotionDetectionAsset.POINT vector in eda.Vectors)
    {
        g.DrawLine(new Pen(
            new SolidBrush(Color.Blue)),
            kvp.Value[vector.X].X, kvp.Value[vector.X].Y,
            kvp.Value[vector.Y].X, kvp.Value[vector.Y].Y);
    }
    /// Landmarks.
    foreach (EmotionDetectionAsset.POINT p in kvp.Value)
    {
        g.FillRectangle(new SolidBrush(Color.Red), new Rectangle(p.X - 2, p.Y - 2, 5, 5));
        //g.FillRectangle(new SolidBrush(Color.Red), new Rectangle(p.X - 1, p.Y - 1, 3, 3));
    }
    }
    }
    this.Refresh();
}

```

Figure 16.Drawing Facial Landmark Algorithm

From the coordinate vector result from landmarking process, the system will capture the image which tracked from the rectangle. This captured image will then processed as designated 'human face' which facial features will be extracted.

```

private void webCamCapture1_ImageCaptured(object source, WebCam_Capture.WebcamEventArgs e)
{
    this.pictureBox1.Image = e.WebCamImage;

    ProcessImageIntoEmotions(this.pictureBox1.Image, true);

    //this.webCamCapture1.Stop();
}

```

Figure 17.CapturingImage



## 2. Facial Extraction

Machine learning systems can be trained to recognize human emotional expressions from a series of human faces, with a particular high degree of accuracy in many cases.

Figure 18 explain part of the process taken from the algorithm.

```
    //! Face Id
    // .
    g.DrawString(
        String.Format("Face_{0}", cnt++),
        new Font(FontFamily.GenericSansSerif, 10.0f, FontStyle.Bold),
        new SolidBrush(Color.Yellow),
        new PointF(kvp.Key.Left, kvp.Key.Top));

    //! Angles.
    //
    foreach (EmotionDetectionAsset.POINT vector in eda.Vectors)
    {
        g.DrawLine(new Pen(
            new SolidBrush(Color.Blue)),
            kvp.Value[vector.X].X, kvp.Value[vector.X].Y,
            kvp.Value[vector.Y].X, kvp.Value[vector.Y].Y);
    }

    //! Landmarks.
    //
    foreach (EmotionDetectionAsset.POINT p in kvp.Value)
    {
        g.FillRectangle(new SolidBrush(Color.Red), new Rectangle(p.X - 2, p.Y - 2, 5, 5));
        //g.FillRectangle(new SolidBrush(Color.Red), new Rectangle(p.X - 1, p.Y - 1, 3, 3));
    }
}
```

Figure 18. Extracting Facial Feature

## 3. Emotion Classification

Facial emotion classification intended to recognize human emotions as a given text. (Zhu, et al. 2016). A region of interest is determined by the result of face detection by Cascade Classifier. Then the region is cropped to 48 by 48 pixels and converted to grayscale. The choice of cropped image size is based on the balance of accuracy and speed, as convolutions can be prohibitively expensive. The pixel data is zero-centered and

normalized, so the range changes from [0, 255] to [-1, 1]. For another, the training images are converted to the idx3-ubyte format for convenient parsing. Figure 19 served as an example taken by the actual code used to build the system.

```
private static string CK2Emotion(Int32 emo)
{
    switch (emo)
    {
        case 0:
            return "Neutral";
        case 1:
            return "Anger";
        case 2:
            return "Contempt"; //not included in calculation
        case 3:
            return "Disgust";
        case 4:
            return "Fear";
        case 5:
            return "Happy";
        case 6:
            return "Sad"; //Sadness in CK+ documentation
        case 7:
            return "Surprise";
    }
}
```

Figure 19. Emotion Classification Structure

Figure 20 explicitly explain how the writer will apply FURIA fuzzy rules and Euclidian distance formula to formulate the coordinate which will be ruled to give the desired emotion based on fuzzy rules. Note that this is also taken from the code used in the system.

```

public Boolean DetectEmotionsInLandmarks()
{
    Int32 ndx = 0;
    foreach (DetectedFace kvp in Faces)
    {
        //
        foreach (POINT p in Vectors)
        {
            EuclideanDistances.Add(EuclideanDistance(kvp.Value[p.X], kvp.Value[p.Y]));
        }
        //! 2) Calculate Cosines from Euclidean Distances.
        //
        for (Int32 i = 0; i < EuclideanDistances.Count; i += 3)
        {
            Cosines.Add(Cosine(EuclideanDistances[i + 0], EuclideanDistances[i + 1], EuclideanDistances[i + 2]));
            Cosines.Add(Cosine(EuclideanDistances[i + 1], EuclideanDistances[i + 2], EuclideanDistances[i + 0]));
            Cosines.Add(Cosine(EuclideanDistances[i + 2], EuclideanDistances[i + 0], EuclideanDistances[i + 1]));
        }
        //! Calculate ArcCosines from Cosines.
        for (Int32 i = 0; i < Cosines.Count; i++)
        {
            ArcCosines.Add(ArcCosine(Cosines[i]));
        }
        //! Evaluate FURIA Fuzzy Rules with ArCosines as Input.
        foreach (IGrouping<String, FuzzyExpression> emotion in Expressions.GroupBy(p => p.Emotion))
        {
            Double orresult = 0; //! Classic Fuzzy Logic: Double.MinValue;
            foreach (FuzzyExpression expression in emotion)
            {
                Double andresult = Double.NaN; //! Classic Fuzzy Logic: Double.MaxValue;
                foreach (FuzzyPart part in expression)
                {
                    //! Normal Fuzzy And is just take the min of both operands.
                    andresult = Double.IsNaN(andresult) ? part.Result(ArcCosines) : andresult * part.Result(ArcCosines); //! Classic
                    Fuzzy Logic: Math.Min(andresult, part.Result(ArcCosines));
                }

                //! Normal Fuzzy Or is just take the max of the operands.
                //! We multiply the part first with the Certainty Factor (CF)
                orresult += expression.CF * andresult; //! Classic Fuzzy Logic: orresult = Math.Max(orresult, expression.CF *
                andresult);
            }
            DetectedEmotions[emotion.Key] = orresult;
        }
    }
}

```

Figure 20. EmotionClassification By Applying FURIA Fuzzy Rules

## **G. Measuring Student's Stress**

The students will be given pre-test questionnaire just like in table 1 to measure their initial stress value refers to symptoms mentioned by Diah Krisnatuti Pranadji and Nurlaela (2009). After some class activity with the teacher using the system, their stress level will be re-evaluated with post-test questionnaire which hold same content as the questionnaire in pre-test. The data acquired from the questionnaire will be analyzed using simple t-test to analyze the significance of this research data.

The original set of question to measure the rate of student's stress was consisted of 18 items. However, amongst them, some items were deemed invalid as the condition is not suitable to be applied on active classroom such as question of whether the students had nightmare or their eating behavior, such questions were removed.

Table 1. Student's Questionnaire

<b>Nomor</b>	<b>Gejala</b>	<b>Ya</b>	<b>Tidak</b>
1	Merasa pusing/sakit kepala tanpa alasan yang jelas?		
2	Merasa pegal-pegal pada leher/punggung/bahu ?		
3	Perut terasa mual/kembung/mulas/diare pada saat akan melakukan kegiatan tertentu?		
4	Mengalami tangan gemeteran?		
5	Sering menjatuhkan/memecahkan barang/tersandung/terjatuh?		
6	Jantung berdebar kencang dan keras?		
7	Merasa tidak tenang/tegang/cemas/terancam?		
8	Merasa sukar berkonsentrasi pada saat melakukan kegiatan?		
9	Mudah tersinggung?		
10	Merasa sangat lelah/lesu/lemas/tidak memiliki tenaga?		
11	Merasa tidak sabar atau cepat marah tanpa sebab?		
12	Merasa tidak memiliki harapan/putus asa?		
13	Merasa bingung/takut bila bertemu dengan orang lain?		
14	Merasa sedih sekali dan ingin menangis?		
15	Merasa dipaksa dengan sangat oleh orang lain (tertekan)?		

## **H. Measuring System Functionality**

In functional (black-box) testing, test cases are designed from an examination of the input/output values only and no knowledge of design or code is required. It is an external view of the test object and verifies the functional behavior of the test object in the software product to ensure that system does what its “Expected “ to do. Another definition of requirements is offered by requirements engineering authors Dorfman and Thayer (1990) in two parts:

1. A software capability needed by the user to solve a problem to achieve an objective.
2. A software capability that must be met or possessed by a system or system component to satisfy a contract, standard, specification, or other formally imposed documentation (Saini and Rai 2013).

Test the survey concept to evaluate the preliminary design or approach, particularly for complex surveys. For example, researcher wishes to answer the following:

1. How well does the interface support the way respondents think about and answer the survey questions?
2. Are the questions asked chronologically from past to present, and do respondents prefer to answer from present to past?
3. Does the organizational structure of the survey support how respondents think about the task?

4. Should you ask participants to recall a series of specific events and then ask questions about each event, or should you ask the follow-up questions immediately after asking about each event? (Geisen and Bergstorm 2017)

The questionnaire consisted of 15 questions, in which each of it was provided with 5 answers. Each of the answer will be given scale depended on the teacher's responses.

Table 2. Teacher's Questionnaire

No	Indikator	Skor				
		SS	S	TB	KS	TS
<b>A</b>	<b>Penggunaan system pengenalan wajah</b>					
1	Sistem pengenalan wajah mudah untuk dijalankan					
2	Sistem pengenalan wajah mudah untuk digunakan					
3	Sistem pengenalan wajah berjalan dengan baik					
4	Sistem pengenalan wajah memberikan data yang tepat					
5	Informasi yang diberikan Sistem pengenalan wajah mudah dibaca					
6	Tombol di sistem pengenalan wajah berjalan dengan lancar					
7	Guru bisa belajar menggunakan Sistem pengenalan wajah dengan cepat					
<b>B</b>	<b>Pemanfaatan sistem pengenalan wajah</b>					
8	Sistem pengenalan wajah dapat membuat guru menjadi lebih interaktif dengan siswa					
9	Sistem pengenalan wajah membantu guru memantau situasi kelas					
10	Sistem pengenalan wajah membantu guru mengendalikan perilaku siswa					
11	Sistem pengenalan wajah membantu guru dalam menyampaikan materi					
12	Sistem pengenalan wajah membantu meningkatkan performa siswa di kelas					
13	Sistem pengenalan wajah membantu siswa menjadi lebih aktif					
14	Sistem pengenalan wajah dapat digunakan dengan infrastruktur sekolah yang ada					
15	Sistem pengenalan wajah dapat dimanfaatkan untuk meningkatkan layanan sekolah					

## **CHAPTER IV**

### **RESULT AND ANALYSIS**

#### **A. System Implementation Result**

The facial expression recognition tool produced systematical processes which allowed the teacher to monitor their student's mood through the class activity by using computer's webcam to acquire the image real-time. This research used a pre-made library to acquire image(s) from a webcam. The process to determine facial feature from the acquired image will utilize pre-trained dataset, which is trained using convolutional neural network model. While trying some method to recognize facial feature, The writer stumbled at some problems such as:

- a. Difficulty to combine the metric with powerful image recognition technique such as SVM, LDA, PPA, etc is particularly high.
- b. The measurement computation is very complicated.
- c. The distance does not obey triangle inequality. So sometime two similar images can be both similar to a completely unknown object.

With these points all covered, This research will simplify the Euclidean Distance computation. Standardizing Transform to do domain smoothing is being used. This directly relates image to smoothing and indicates that smoothing noiseless images can still increase image recognition rate.



The system that successfully built can be seen in the figure 21 and 22. The dots on image 21 represent captured facial features that would be calculated in the system. The bug which may happen if the program closed then re-opened is affected by computer's hardware capabilities (webcam, or video card's clock speed).

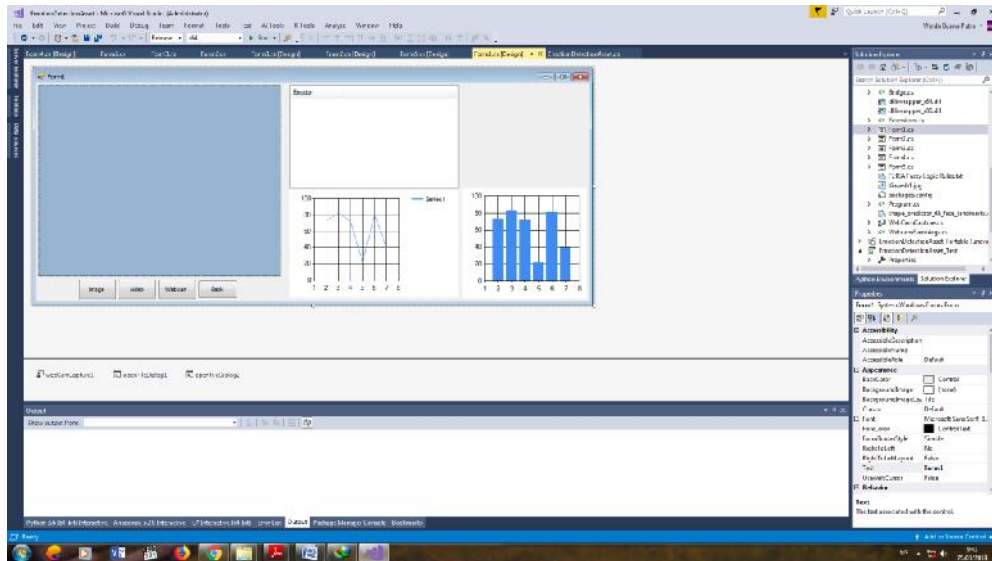


Figure 21. Main Form On the System Development

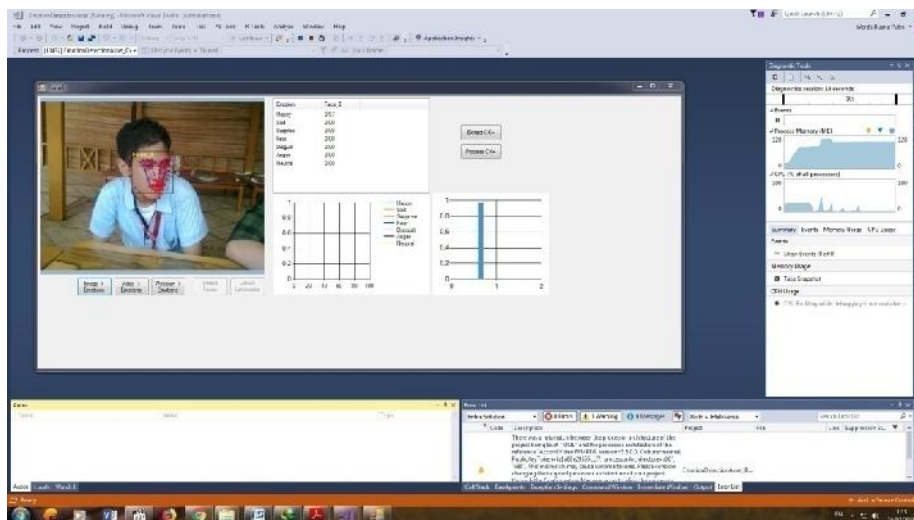


Figure 22. System Testing Run

## B. System Testing and Analysis

Before the system would be used for the research at school, the system's accuracy has to be measured. JAFFE image set will be used, which is already classified based on specific emotions by experts. The measurement brought by the system will be compared, with the classification from the image set.

### 1. Data set testing

Next, CK+ image set will be used and had some manual interpretation to the analysis result. Table 3 through table 5 shows confusion matrix for pre-trained dataset that being used to build the system. The score that written in the table informs the reader how many image that represented an emotion that fit with the comparison.

Table 3 is the comparison from the original database with the normalized shape feature benchmark. In table 4, the dataset will be tested on Canonical Appearances benchmark. In table 5, the dataset will be tested with the combination of both benchmarking system. This test is usually the most reliable of the three and the result often be made for the validity of the dataset.

On the table 3 through table 5, the significant results were shown in bold font. In table 3 the comparison between sad and surprised expression were greatly alleviated, hence it's become a reference for the next confusion matrix. On table 4 and table 5, the test results were balanced and there is no big difference to the accuracy benchmark.

Table 3. Confusion Matrix Of Emotion Detection For The Similarity Normalized Shape (SPTS) Features (Kim, Joo and Park 2015)

	An	Di	Fe	Ha	Sa	Su	Co
An	<b>35.0</b>	40.0	0.0	5.0	5.0	15.0	0.0
Di	7.9	<b>68.4</b>	0.0	15.8	5.3	0.0	2.6
Fe	8.7	0.0	<b>21.7</b>	21.7	8.7	26.1	13.0
Ha	0.0	0.0	0.0	<b>98.4</b>	1.6	0.0	0.0
Sa	28.0	4.0	12.0	0.0	4.0	<b>28.0</b>	24.0
Su	0.0	0.0	0.0	0.0	0.0	<b>100.0</b>	0.0
Co	15.6	3.1	6.3	0.0	15.6	34.4	<b>25.0</b>

Table 4. Confusion Matrix Of Emotion Detection For The Canonical Appearance (Kim, Joo and Park 2015)

	An	Di	Fe	Ha	Sa	Su	Co
An	<b>70.0</b>	5.0	5.0	0.0	10.0	5.0	5.0
Di	5.3	<b>94.7</b>	0.0	0.0	0.0	0.0	0.0
Fe	8.7	0.0	<b>21.7</b>	21.7	8.7	26.1	13.0
Ha	0.0	0.0	0.0	<b>100.0</b>	0.0	0.0	0.0
Sa	16.0	4.0	8.0	0.0	<b>60.0</b>	4.0	8.0
Su	0.0	0.0	1.3	0.0	0.0	<b>98.7</b>	0.0
Co	12.5	12.5	3.1	0.0	28.1	21.9	<b>21.9</b>

Table 5. Confusion Matrix Of Emotion Detection For The Combination Of Features (SPTS+CAPP). The Fusion Of Both Systems Were Performed By Summing Up The Probabilities From Output Of The Multi-Class SVM. (Kim, Joo and Park 2015)

	An	Di	Fe	Ha	Sa	Su	Co
An	<b>75.0</b>	7.5	5.0	0.0	5.0	2.5	5.0
Di	5.3	<b>94.7</b>	0.0	0.0	0.0	0.0	0.0
Fe	4.4	0.0	<b>65.2</b>	8.7	0.0	13.0	8.7
Ha	0.0	0.0	0.0	<b>100.0</b>	0.0	0.0	0.0
Sa	12.0	4.0	4.0	0.0	<b>68.0</b>	4.0	8.0
Su	0.0	0.0	0.0	0.0	4.0	<b>96.0</b>	0.0
Co	3.1	3.1	0.0	6.3	3.1	0.0	<b>84.4</b>

Index for table 3, 4, and 5:

- An : Angry
- Di : Disgust
- Fe : Fear
- Ha : Happy
- Sa : Sad
- Su: Surprised
- Co : Confused

The results given in Table 5 seem to be in line with recent perceptual studies. In a validation study conducted on the Karolinska Directed Emotional Faces (KDEF) database, results for the 6 basic emotions (i.e. all emotions in CK+ except Contempt) plus neutral (Lucey, et al. 2010), were similar to the ones presented here. In this study they used 490 images (i.e. 70 per emotion) and the hit rates for each emotion were: Angry - 78.81% (75.00%), Disgust - 72.17% (94.74%), Fear - 43.03% (65.22%), Happy - 92.65% (100%), Sadness - 76.70% (68.00%), Surprised - 96.00% (77.09%), Neutral - 62.64% (100%).

## 2. System testing

JAFFE image set consisted of 213 images of Japanese female frontal facial pictures, classified by 7 basic emotions just like the classification used by the system. Compare the result that got from analyzing each of these 213 images using the system will be compared, with the default classification from JAFFE image set. In figure 21, the system started to see how the emotion recognition algorithm could detect facial features. The system proved to be able distinct emotion features of human expressions; this will be further tested using a specific expert-arranged image set which shown on table 6. The test shows that the system able to reach more than 90% when tested using JAFFE image set.

This result of system testing using JAFFE image set, combined with data set testing, suggests that an automated system can do just as a good job, if not better as a naive human observer and suffer from the same confusions due to the perceived ambiguity between subtle emotions. Human observation is still possible to be done. However, observer ratings need to be performed on the CK+ database and automated results need to be conducted on the JAFFE database to test out the validity of the claims of the mentioned human observation and benchmarking.

Table 6. System Analysis By Comparing Its Performance With Default Classification Of JAFFE Image Set

Expression presented	System classification								Total	Accuracy
	N	A	D	F	H	S	Su	Z		
Neutral	32								32	100.00%
Angry		25	1			3		1	30	83.33%
Disgust		2	17	2		1		2	24	70.83%
Fear			1	26	7				34	76.47%
Happy					31				31	100.00%
Sad						30			30	100.00%
Surprised							32		32	100.00%
Total	32	27	19	28	38	34	32	3	213	90.09%

Index :

N: Neutral

A: Angry

D: Disgust

F: Fear

H: Happy

S: Sad

Su: Surprised

Z: All Zero (no classification)

### C. Teacher's Questionnaire Analysis to Determine System's Functionality

The result of teacher's questionnaire will be processed with a simple formula, mainly because this questionnaire is only has two respondents, which is the IT teachers. The formula is simply required the total score collected, which ranged from 0 to 20, from the questionnaire with maximum value possible for the questionnaire on the question. This method of data analysis is called SUS (System Usability Scale).

Originally created by John Brooke, it allows an evaluation of vast variety of products, be it hardware, software, operating system, mobile devices, and websites. SUS has been used in more than 1300 science article and publications, or product quality assurance. There are 15 questions for each teacher, the score for each question will ranged from -2 to 2. The result is as follows:

Number of Questions	:	15
Number of Respondent	:	2
Score	:	50
Maximum Score	:	60

According to the acquired data which can be seen in Appendix I, the system achieved score of 50 out of 60. In percentage it means the system achieved 83,33% of total functionality. This proved the system can fulfilled its role as a tool to collect emotional information and monitor student's mood in a classroom activity.

#### **D. Student's Mood Analysis through Questionnaire Result**

When using the system, the teacher is supposedly interact more with students and able to adapt with classroom situation to create a less stressful atmosphere for the students. This way, the writer tried to reduce stress residue from the students by letting the teacher able to monitor their student's mood condition. This research will monitor specifically 4 class's activity which will be conducted consecutively in four days. In the first two days, the teacher will teach as they usually do without the help of the system. On the last two activities, the teacher will use the system so they can monitor their student's emotion state. The questionnaire consisted of fifteen questions which ask the students about their general state of mind and body. In the questionnaire, the writer divides the question into four categories. Each category is connected to a more specific student's condition; either it's their health condition, their physiology and psychology state, and their direct emotion state.

The questionnaire will be delivered to each and every student after each class session. The result from these questionnaire will be then compared to pinpoint whether the system able to help the teacher increased the class overall mood or not. After collecting all the questionnaire results, simple statistical calculation to make an average stress level of the class will be done. Then, the result will be compared between the calculation result from the first two questionnaire results and the last two questionnaire results as shown in table 7. The table implies that in the last two sessions, students' stress level has significantly reduced. It can be seen how much their stress level reduced by subtracting the average stress level of two last sessions with the former two sessions. The complete result can be seen in appendix C through appendix F.



**Table 7. Questionnaire Result From Class Activities About Subject's Stress**

Student's ID	Pre-test1	Pre-test2	Post-test 1	Post-test 2	avgpretest	avgposttest
1	40.00%	40.00%	46.67%	40.00%	40,00%	43,33%
2	60.00%	53.33%	33.33%	26.67%	56,67%	30,00%
3	66.67%	60.00%	40.00%	40.00%	63,33%	40,00%
4	40.00%	40.00%	26.67%	20.00%	40,00%	23,33%
5	53.33%	53.33%	6.67%	13.33%	53,33%	10,00%
6	40.00%	40.00%	26.67%	26.67%	40,00%	26,67%
7	53.33%	53.33%	6.67%	6.67%	53,33%	6,67%
8	53.33%	53.33%	26.67%	20.00%	53,33%	23,33%
9	66.67%	66.67%	20.00%	20.00%	66,67%	20,00%
10	40.00%	40.00%	20.00%	13.33%	40,00%	16,67%
11	33.33%	33.33%	26.67%	33.33%	33,33%	30,00%
12	33.33%	33.33%	33.33%	33.33%	33,33%	33,33%
13	53.33%	53.33%	33.33%	26.67%	53,33%	30,00%
14	46.67%	46.67%	20.00%	20.00%	46,67%	20,00%
15	53.33%	53.33%	0.00%	0.00%	53,33%	0,00%
16	66.67%	60.00%	33.33%	26.67%	63,33%	30,00%
17	40.00%	46.67%	20.00%	20.00%	43,33%	20,00%
18	53.33%	53.33%	33.33%	33.33%	53,33%	33,33%
19	53.33%	46.67%	20.00%	20.00%	50,00%	20,00%
20	46.67%	33.33%	13.33%	13.33%	40,00%	13,33%
21	46.67%	53.33%	46.67%	40.00%	50,00%	43,33%
22	40.00%	33.33%	33.33%	33.33%	36,67%	33,33%
23	60.00%	53.33%	26.67%	20.00%	56,67%	23,33%
24	46.67%	40.00%	33.33%	33.33%	43,33%	33,33%
25	53.33%	53.33%	13.33%	6.67%	53,33%	10,00%
26	46.67%	53.33%	26.67%	26.67%	50,00%	26,67%
27	40.00%	46.67%	13.33%	13.33%	43,33%	13,33%
28	33.33%	33.33%	20.00%	20.00%	33,33%	20,00%
29	53.33%	66.67%	13.33%	13.33%	60,00%	13,33%
30	40.00%	40.00%	33.33%	26.67%	40,00%	30,00%
31	60.00%	60.00%	33.33%	33.33%	60,00%	33,33%
32	40.00%	46.67%	13.33%	13.33%	43,33%	13,33%
33	46.67%	53.33%	40.00%	40.00%	50,00%	40,00%
<b>Average of Total</b>	<b>48.48%</b>	<b>48.28%</b>	<b>25.25%</b>	<b>23.43%</b>	<b>48,38%</b>	<b>24,34%</b>

To estimate the confidence, calculate t-value, and then lookup the inverse of CDF of Student's t-distribution with  $(N_a - 1) + (N_b - 1)$  degrees of freedom.  $N_a$  is the size of sample A and  $N_b$  is the size of sample B. To find t-value you start from calculating the mean  $M_x$  and sum of squared deviations, or sum of squares  $SS = \sum (X_i - M_x)^2$  for each sample. Then, estimate the variance of the source population as  $\{s_p^2\} = \frac{SS_a + SS_b}{(N_a - 1) + (N_b - 1)}$ . This estimation is called pooled variance, a method for estimating variance of several different populations when the mean of each population may be different, but one may assume that the variance of each population is the same.

The writer estimate the standard error of  $M_{X_a} - M_{X_b}$  as

$$est.\sigma_{M-M} = \sqrt{\frac{\{s_p^2\}}{N_a} + \frac{\{s_p^2\}}{N_b}} \quad (\text{Shafer and Zhang 2012}).$$

Finally, calculate t as

$$t = \frac{M_{X_a} - M_{X_b}}{est.\sigma_{M-M}} .$$

- Index :
- $t_x$  : Size of the difference relative to the variation in sample data x
  - $SS_x$  : Sum of Squares of x
  - $N_x$  : Size of sample x
  - $M_x$  : Sum of squared deviations from sample x

Here is the result from the two sample that run by testing the average of pre-test results and the average of post-test results as follows:

- Mean of samples a : 0.5
- Mean of samples b : 0.2
- t-value : 10
- Level of Confidence for one and two tail test of significance : 100%

It could be seen that there was significance from the samples, which in this context is the pre-test and post-test result. From the data, It's clear that the post-test, which resulted from the data after the teacher using the system, has remarkable significance. From this test, it can be safely concluded that by using the facial expression recognition system, the teacher able to reduce student's stress level.

An educational program with a pre- and post-test method has better chances of being effective (Shivaraju, et al. 2017). The application of a pretest was observed to be a feasible tool to shape group specific education programs. In planning and pre- and post-test based learning method, the student will be actively involved in education.

#### **E. Research Limitation**

Due to the research method and the nature of the system implementation, this research has some limitations as well. Some of which connected with the flow of the research while other is the limitation of the research prospect and potential. Some noticeable limitations are:

1. The writer wasn't involved on the classroom settings and how the system would be implemented, such as LAN connection setting, teacher's act and treatment toward students.
2. The writer doesn't train the dataset that will be used on the system. Instead, the system will use pre-trained dataset.
3. The system usage is intended for research purpose.

# CHAPTER V

## CONCLUSION

### A. Conclusion

From the result collected in Data result and analysis, the research can be concluded to be able to answer the research purpose and research question while conducted in the area of problem limitation and research limitation. The conclusion can be summed as follows:

1. The Facial Expression recognition tools provided desirable results on the scanning and image analysis, which could detect, and determine human expression that contained in captured image. This contributes greatly on this research mainly because this research is quite focused on the accuracy of the system. The system also successfully implemented Euclidian Distance formula and FURIA fuzzy rules to extract necessary information from the acquired image or image sequence into one of 7 basic human emotions.
2. The measurement on the tools and pre-trained dataset is also shown satisfying results. By comparing the result when the system detect the emotion from JAFFE image set, with the one that already classified by experts, the system able to reached the accuracy of 90%.With this fact, the teacher would be able to monitor object's emotion using facial expression recognition system while preparing counter-measure of unexpected mood change. Then, the user of the system can adapt according to the result shown by the system.

3. It can be seen that when used in a classroom activity, the system could make a significant difference to student's mood. This result could greatly vary from school to school, not to mention when used on different grades. Because there will be many other external variable that could affected the state of the students. However, from this research, the writer concluded that it is possible to have a scientific measurement toward student's stress level by using a system which could detect human emotions.

## **B. Research Implications**

This research could be used for reference when people want to further inspect how facial emotion recognition detect, extract, and classified human facial emotions real-time when the objects varied in age or races. The tools developed using open-source library and code, so it could be used by other researchers to conduct their research. There is much room for improvement in this research and deeper analysis can easily derived, such as connecting student's emotion and their daily behavior going to canteen and many others.

## **C. Research Advices**

While using facial expression analysis tool built in classroom activity, it would be better if each user individually operate their computer. The reason is to increase data reliability. By doing this, teacher would be able to understand better the condition each of their student. The ideal time to monitor the student's mood is when their position is fixed, like in an exam or class assignment. The fuzzy rules, though difficult, may improved in the future research to recognize age, gender, even individual person.

## Bibliography

- Acosta-Gómez, María Guadalupe, et al. "Stress in High School Students: A Descriptive Study." *JOURNAL OF COGNITIVE BEHAVIORAL THERAPY*, 2018: 1-10.
- Ahmed, Wondimu, Greetje van der Werf, Hans Kuype, and Alexander Minnaert. "Emotions, Self-Regulated Learning, and Achievement in Mathematics: A Growth Curve Analysis." *Journal of Educational Psychology*, 2013: 150–161.
- Babis, Katarzyna. <http://beibis.tumblr.com>. 2014. (accessed 2018).
- Baumeister, Roy F., and Brad J. Bushman. *Social Psychology and Human Nature 2nd Edition*. Belmont: Wadsworth, Cengage Learning, 2011.
- Bedewy, Dalia, and Adel Gabriel. "Examining perceptions of academic stress and its sources among university students: The Perception of Academic Stress Scale." *Health Psychology Open*, 2015: 1-9.
- Beesdo, Katja, et al. "Incidence of Social Anxiety Disorder and The Consistent Risk For Secondary Depression In The First Three Decades of Life." *Archives of general psychiatry*, 2007: 903-912.
- Chen, Junkai, Zenghai Chen, Zheru Chi, and Hong Fu. "Facial Expression Recognition Based on Facial." *Scientific Cooperations International Workshops on Electrical and Computer Engineering Subfields*, 2014: 22-23.
- Cohen, William W. "Fast, Effective Rule Induction." *Machine Learning Proceedings of the Twelfth International Conference*. Morgan Kaufmann, 1995. 115--123.
- Costello, E. Jane, Sarah Mustillo, Alaattin Erkanl, Gordon Keeler, and Adrian Angold. "Prevalence and Development of Psychiatric Disorders in Childhood and Adolescence." *Arch Gen Psychiatry*, 2003: 837–844.
- Ekman, Paul, and Wallace Friesen. *PaulEkmanGroup*. 1993. <https://www.paulekman.com/product/pictures-of-facial-affect-pofa/> (accessed December 14, 2018).
- Fauzie, Yuli Yanna. *Bank Dunia: Kualitas Pendidikan Indonesia Masih Rendah*. CNN Indonesia, 2018.
- Geisen, Emily, and Jennifer Romaro Bergstorm. *Usability Testing for Survey Research*. United State: Elsevier, 2017.
- Hanifah, Abu, and Nunung Unayah. "MENCEGAH DAN MENANGGULANGI PENYALAHGUNAAN NAPZA." *Informasi (Kompas)*, 2011: 33-46.
- Horikawa, Masami, and Akihiro Yagi. "The Relationships among Trait Anxiety, State Anxiety and the Goal Performance of Penalty Shoot-Out by University Soccer Players." *PLoS One*, 2012: 1-5.
- Indonesian Financial Ministry. *Ini Alokasi Subsidi Pada RAPBN 2018*. 2018. <https://www.kemenkeu.go.id/publikasi/berita/ini-alokasi-subsidi-pada-rapbn-2018/>.
- Kessler, Ronald C, Patricia Berglund, Olga Demler, Robert Jin, Kathleen R Merikangas, and Ellen E Walters. "Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication." *Archives of general psychiatry*, 2005: 593-602.

- Khurshid, Shumaila, Qaisara Parveen, M. Imran Yousuf, and Abid Ghafoor Chaudhry. "EFFECTS OF DEPRESSION ON STUDENTS' ACADEMIC PERFORMANCE." *Sci.int.(Lahore)*, 2015: 27(2).
- Kim, Moon Hwan, Young Hoon Joo, and Jin Bae Park. "Emotion Detection Algorithm Using Frontal Face Image." *ICCAS2005*, 2015: 2373-2378.
- Krisch, Joshua A. *Fatherly*. February 15, 2018. <https://www.fatherly.com/health-science/science-kids-love-stuffed-animals-teddy-bears/> (accessed February 15, 2019).
- Lampi, Andrea Ruth. *TEACHER-STUDENT INTERACTIONS: DIFFERENCE BETWEEN STUDENTS WITH AND WITHOUT BEHAVIOUR PROBLEM*. FLORIDA: GRADUATE SCHOOL OF THE UNIVERSITY OF FLORIDA, 2006.
- Li, Zeming. *Automated Face Analysis by Feature Tracking and Expression Recognition*. 2017. [http://www.dsp.utoronto.ca/projects/face\\_analysis/](http://www.dsp.utoronto.ca/projects/face_analysis/) (accessed March 12, 2019).
- Lucey, Patrick, Jeffrey F. Cohn, Takeo Kanade, Jason Saragih, Zara Ambadar, and Iain Matthews. "The Extended Cohn-Kanade Dataset (CK+): A complete dataset for action unit and emotion-specified expression." *IEEE*, 2010: 94-101.
- Lv, Yadan, Zhiyong Feng, and Chao Xu. "Facial expression recognition via deep learning." *International Conference on Smart Computing*, 2014: 303-308.
- Marroquín, Brett, Chloe C. Boyle, and Susan Nolen-Hoeksema. "Using Emotion as Information in Future-Oriented Cognition: Individual Differences in the Context of State Negative Affect." *Pers Individ Dif*, 2016: 121-126.
- Ministry of Health Republic of Indonesia. *PERAN KELUARGA DUKUNG KESEHATAN JIWA MASYARAKAT*. October 6, 2016. <http://www.depkes.go.id/article/print/16100700005/peran-keluarga-dukung-kesehatan-jiwa-masyarakat.html> (accessed February 2, 2018).
- Mordor Intelligence. *Mordor Intelligence*. September 2018. <https://www.mordorintelligence.com/industry-reports/facial-recognition-market> (accessed November 14, 2018).
- NIH. *The National Institute of Mental Health (NIMH)*. January 28, 2014. <https://www.nimh.nih.gov/about/index.shtml> (accessed January 2019, 28).
- Nindel-Edwards, Jim, and Gerhard Steinke. "The Development of a Thorough Test Plan in the Analysis Phase leading to more Successful Software Development Projects." *Journal of International Technology and Information Management*, 2007: 65-32.
- Ou, Jun. "Classification Algorithms Research on Facial Expression." *International Conference on Solid State Devices and Materials Science*. Physics Procedia, 2012. 1241 – 1244.
- Pennings, Helena J.M., Jan van Tartwijk, Theo Wubbels, and Luce C.A. Claessens. "Real-time teacherstudent interactions: A Dynamic Systems." *Elsevier Teaching and Teacher Education*, 2014: 183-193.
- Pranadji, Diah Krisnatuti, and Nurlaela. "Affected Factors of Stress Level in Busy and Unbusy School Age Children." *Jurnal Ilmu Keluarga dan Konsumen*, 2009: 57-63.

- Saini, Gaurav, and Kestina Rai. "An Analysis on Objectives, Importance and Types of Software Testing." *International Journal of Computer Science and Mobile Computing*, 2013: 18-23.
- Sathik, Mohamed, and G.Sofia Jonathan. "Effect of facial expressions on student's comprehension recognition in virtual." *SpringerPlus*, 2013: 1-9.
- Saxena, Aayushi, and Priya Upadhyay. "Waterfall vs. Prototype: Comparative Study of SDLC." *Imperial Journal of Interdisciplinary Research (IJIR)*, 2016: 1012-1015.
- Shafer, Douglas S., and Zhiyi Zhang. *Beginning Statistics*. Charlotte: Creative Commons-licensed, 2012.
- Shivaraju, Padmanabha Thiruganahalli, Gangadhar Manu, Vinaya M, and Madhav K Savkar. "Evaluating the effectiveness of pre- and post-test model of learning in a medical school." *National Journal of Physiology, Pharmacy and Pharmacology*, 2017: 947-951.
- Smola, Alex, and S.V.N. Vishwanathan. *Introduction to Machine Learning*. New York: Cambridge University Press, 2010.
- Soyel, Hamit, and Hasan Demirel. "Facial Expression Recognition Using 3D Facial Feature Distances." *Affective Computing, Focus on Emotion Expression, Synthesis and Recognition*, 2008: 831-838.
- Statistik, Badan Pusat. *Badan Pusat Statistik*. May 5, 2005. <https://www.bps.go.id/publication/2014/05/05/8d2c08d9d41aa8c02fad22e7/statistik-indonesia-2014.html> (accessed January 5, 2019).
- Thorat, Suryakant B., Sunilnayak K. Nayak, and Jyoti .P Dandale. "Facial Recognition Technology: An analysis With Scope In India." *(IJCSIS) International Journal of Computer Science and Information Security*, 2010: 325-330.
- Valiente, Carlos, Jodi Swanson, and Nancy Eisenberg. "Linking Students' Emotions and Academic Achievement: When and Why Emotions Matter." *Child Development Perspectives*, 2012: 1-7.
- Wangy, Liwei, Yan Zhangy, and Jufu Fengy. "On the Euclidean Distance of Images." *IEEE Transactions on Pattern Analysis and Machine*, 2005: 1334 - 1339.
- Writer, Staff. *Tech Trends : Facial Recognition – History And Privacy*. 2017. <https://themtnear.com/2017/12/tech-trends-facial-recognition-history-and-privacy/> (accessed 2019).
- XimenaFranco, Lissette M. Saavedra, and Wendy K. Silverman. "External validation of comorbid patterns of anxiety disorders in children and adolescents." *Journal of Anxiety Disorders*, 2007: 717-729.
- Zhu, Suyang, Shoushan Li, Ying Chen, and Guodong Zhou Zhou. "Corpus Fusion for Emotion Classification." *COLING* , 2016: 3287–3297.



## Appendix

### A. Image Facial Emotion Recognition Source Code's Clip

```
namespace AssetPackage
{
using System;
using System.Collections.Generic;
using System.Drawing;
using System.Drawing.Imaging;
using System.Globalization;
using System.IO;
using System.Linq;
using System.Runtime.InteropServices;
using System.Text.RegularExpressions;
using AssetManagerPackage;
    /// <summary>
    /// The detected emotions.
    ///
    /// The Key is the name of the emotion.
    ///
```

```

    /// The Value is the fuzzy outcome for the emotion.
    /// </summary>
using DetectedEmotions = System.Collections.Generic.Dictionary<System.String, System.Double>;

    /// <summary>
    /// The detected face.
    ///
    /// The Key is the detection rectangle.
    ///
    /// The Value is a list of 68 landmark points.
    /// </summary>
using DetectedFace=System.Collections.Generic.KeyValuePair<EmotionDetectionAsset.RECT,System.Collections.Generic.List<EmotionD
nDetectionAsset.POINT>>;
    /// <summary>
    /// The detected faces.
    ///
    /// The Key is the detection rectangle.
    ///
    /// The Value is a list of 68 landmark points.
    /// </summary>
using DetectedFaces=System.Collections.Generic.Dictionary<EmotionDetectionAsset.RECT,System.Collections.Generic.List<EmotionD
etectionAsset.POINT>>;
    /// <summary>
    /// An asset.
    /// </summary>
public class EmotionDetectionAsset : BaseAsset
{
    #region Fields

    /// <summary>
    /// The names of detectable Emotions.
    /// </summary>
public List<String> Emotions = new List<String>();

    /// <summary>
    /// The list of Fuzzy expressions parsed.
    /// </summary>
    ///
    /// <remarks>
    /// Each expression is a single line from the FURIA output.
    /// </remarks>
private FuzzyExpressions Expressions = new FuzzyExpressions();

    /// <summary>
    /// The detected faces and their landmarks.
    /// </summary>
public DetectedFaces Faces = new DetectedFaces();

    /// <summary>
    /// The vectors used to calculate the angles.
    ///
    /// <remark>This need to be read from a config file</remark>
    /// </summary>
public List<POINT> Vectors = new List<POINT>()
{
    /// Left eyebrow to the left eye.
    ///
    new POINT(17,36), // 0
    new POINT(17,39), // 1
    new POINT(36,39), // 2

    new POINT(19,36), // 3
    new POINT(19,39), // 4
    new POINT(36,39), //! equal to [2]

    new POINT(21,36), // 5

```

```

new POINT(21,39), // 6
new POINT(36,39), //! equal to [2]

    //! Right eyebrow to the right eye.
    //
new POINT(22,42), // 7
new POINT(22,45), // 8
new POINT(42,45), // 9

new POINT(24,42), // 10
new POINT(24,45), // 11
new POINT(24,45), //! equal to [11]

new POINT(26,42), // 13
new POINT(26,45), // 14
new POINT(24,45), //! equal to [11]

    //! Left eye.
    //
new POINT(37,40), // 16
new POINT(37,41), // 17
new POINT(40,41), // 20

new POINT(38,40), // 21
new POINT(38,41), // 22
new POINT(40,41), //! equal to [20]

    //! Right eye?
    //
new POINT(43,46), // 24
new POINT(43,47), // 25
new POINT(46,47), // 26

new POINT(44,46), // 27
new POINT(44,47), // 28
new POINT(46,47), //! equal to [26]

    //! Top of the mouth.
    //
new POINT(48,51), // 30
new POINT(51,54), // 31
new POINT(48,54), // 32

    //! Bottom of the mouth.
    //
new POINT(48,57), // 33
new POINT(54,57), // 34
new POINT(48,54), //! equal to [32]

    //! Left eyebrow.
    //
new POINT(17,19), // 36
new POINT(19,21), // 37
new POINT(17,21), // 38

    //! Right eyebrow.
    //
new POINT(22,24), // 39
new POINT(24,26), // 40
new POINT(22,26), // 41

    //! Eyebrows to the top nose.
    //
new POINT(21,27), // 42
new POINT(22,27), // 43
new POINT(21,22), // 44

```

```

        /// Left eye to the mouth.
        //
new POINT(36,60), // 45
new POINT(48,60), // 46
new POINT(36,48), // 47

        /// Right eye to the mouth.
        //
new POINT(45,64), // 48
new POINT(54,64), // 49
new POINT(45,54), // 50

        /// Mouth to eyes.
        //
new POINT(39,51), // 51
new POINT(42,51), // 52
new POINT(39,42), // 53
    };

    /// <summary>
    /// The 64 bits wrapper.
    /// </summary>
public static String wrapper64 = @"dlibwrapper_x64.dll";

    /// <summary>
    /// The 32 bits wrapper.
    /// </summary>
public static String wrapper32 = @"dlibwrapper_x86.dll";

    private static Regex rg1 = new Regex(@"(?<var>[a-zA-Z][0-9]+) in \[(?<lsb>[^\w.]+), (?<lst>[^\w.]+), (?<rst>[^\w.]+), (?<rsb>[^\w.]+)]");

private static Regex rg2 = new Regex(@"Emotions=(?<emotion>[A-Za-z]*) \((CF = (?<cf>[0-9.]+))\)");
private Dictionary<Int32, List<DetectedEmotions>> EmotionsHistory = new Dictionary<Int32, List<DetectedEmotions>>();

private EmotionDetectionAssetSettings settings = null;

PixelFormat[] supported =
    {
        PixelFormat.Format1bppIndexed,
        PixelFormat.Format4bppIndexed,
        PixelFormat.Format8bppIndexed,

        /// Dlib lack support for Format16bppRgb is missing.

        PixelFormat.Format24bppRgb

        /// Dlib lack support for Format32bppRgb (my webcam's default).
    };
    /// <summary>
    /// Detect emotions in landmarks.
    /// </summary>
public Boolean DetectEmotionsInLandmarks()
    {Int32 ndx = 0;
foreach (DetectedFace kvp in Faces)
    {DetectedEmotions DetectedEmotions = new DetectedEmotions();
    List<Double> EuclideanDistances = new List<Double>();
    List<Double> Cosines = new List<Double>();
    List<Double> ArcCosines = new List<Double>();
    /// 1) Calculate Euclidean Distances from Landmarks.
    //
foreach (POINT p in Vectors)
    {EuclideanDistances.Add(EuclideanDistance(kvp.Value[p.X], kvp.Value[p.Y]));}
for (Int32 i = 0; i < EuclideanDistances.Count; i += 3)

```

```

        {Cosines.Add(Cosine(EuclideanDistances[i + 0], EuclideanDistances[i + 1], EuclideanDistances[i + 2]));
Cosines.Add(Cosine(EuclideanDistances[i + 1], EuclideanDistances[i + 2], EuclideanDistances[i + 0]));
Cosines.Add(Cosine(EuclideanDistances[i + 2], EuclideanDistances[i + 0], EuclideanDistances[i + 1]));}
for (Int32 i = 0; i < Cosines.Count; i++)
    {ArcCosines.Add(ArcCosine(Cosines[i]));}
    /// Evaluate FURIA Fuzzy Rules with ArcCosines as Input.
foreach (IGrouping<String, FuzzyExpression> emotion in Expressions.GroupBy(p => p.Emotion))
    {Double orresult = 0; /// Classic Fuzzy Logic: Double.MinValue;
foreach (FuzzyExpression expression in emotion)
    {Double andresult = Double.NaN; /// Classic Fuzzy Logic: Double.MaxValue;
foreach (FuzzyPart part in expression)
    {/// Normal Fuzzy And is just take the min of both operands.
andresult = Double.IsNaN(andresult) ? part.Result(ArcCosines) : andresult * part.Result(ArcCosines); /// Classic Fuzzy Logic:
Math.Min(andresult, part.Result(ArcCosines));
    /// Normal Fuzzy Or is just take the max of the operands.
    /// We multiply the part first with the Certainty Factor (CF).
orresult += expression.CF * andresult; /// Classic Fuzzy Logic: orresult = Math.Max(orresult, expression.CF * andresult);}
DetectedEmotions[emotion.Key] = orresult;}
    /// Build some history so we can average.
if (!EmotionsHistory.ContainsKey(ndx))
    {EmotionsHistory.Add(ndx, new List<DetectedEmotions>());}
if (settings.SuppressSpikes && EmotionsHistory[ndx].Count >= settings.Average + 2)
    {Double SpikeAmplitude = settings.SpikeAmplitude;
    Double v;
    Double lv;
    Double nv;
    //foreach (Int32 face in EmotionsHistory.Keys)
    //{
    Int32 cnt = EmotionsHistory[ndx].Count;
foreach (String emotion in Emotions)
    {
lv = EmotionsHistory[ndx][cnt - 2][emotion];
v = EmotionsHistory[ndx][cnt - 1][emotion];
nv = DetectedEmotions[emotion];
if (((v >= lv + SpikeAmplitude) && (v >= nv + SpikeAmplitude)) ||
((v <= lv - SpikeAmplitude) && (v <= nv - SpikeAmplitude)))
    {EmotionsHistory[ndx][cnt - 1][emotion] = (lv + nv) / 2; }}
EmotionsHistory[ndx].Add(DetectedEmotions);
if (EmotionsHistory[ndx].Count > settings.Average + (settings.SuppressSpikes ? 2 : 0))
    {EmotionsHistory[ndx].RemoveAt(0); }
    /// Broadcast Emotions.
foreach (String emotion in Emotions)
    {Messages.broadcast(emotion, new EmotionEventArgs()
    {face = ndx,
value = this[ndx, emotion]
});}
ndx++;}
return ndx != 0;}
public void Initialize(String dllPath, String database)

    /// Load the appropriate dll (x86 or x64) depending on the CPU/OS version.

    /// <summary>
    /// Parse a FURIA Fuzzy Rule.
    /// </summary>
public Boolean ParseRule(String rule)
    {if (!String.IsNullOrEmpty(rule.Trim()))
    {FuzzyExpression expression = new FuzzyExpression();
String[] fsplit = rule
    .Split(new string[] { "=>" }, StringSplitOptions.RemoveEmptyEntries)
    .Select(p => p.Trim())
    .ToArray();
if (fsplit.Length == 2)
    {String logic = fsplit[0];
String score = fsplit[1];
if (rg2.IsMatch(score))

```

```

        {foreach (Match m in rg2.Matches(score))
            {if (m.Success)
                {expression.Emotion = m.Groups["emotion"].Value;
                 expression.CF = Double.Parse(m.Groups["cf"].Value, CultureInfo.InvariantCulture);
                } }}
String[] parts = logic
    .Split(new string[] { "and" }, StringSplitOptions.RemoveEmptyEntries)
    .Select(p => p.Trim())
    .ToArray();
foreach (String part in parts)
    {if (rg1.IsMatch(part))
        {foreach (Match m in rg1.Matches(part))
            {if (m.Success)
                {FuzzyPart fuzzy = new FuzzyPart();
                 // lsb is Left Shoulder Bottom Location
                 // lst is Left Shoulder Top Location
                 // rst is Right Shoulder Top Location
                 // rsb is Right Shoulder Bottom Location
                 //! ____/---\____
                 fuzzy.var = Int32.Parse(m.Groups["var"].Value.TrimStart("V"), CultureInfo.InvariantCulture);
                 fuzzy.lsb = ParseNumber(m, "lsb", Double.NegativeInfinity);
                 fuzzy.lst = ParseNumber(m, "lst", Double.NegativeInfinity);
                 fuzzy.rst = ParseNumber(m, "rst", Double.PositiveInfinity);
                 fuzzy.rsb = ParseNumber(m, "rsb", Double.PositiveInfinity);

                expression.Add(fuzzy);}}
            else
                {return false; }}
        else
            {return false; }
        Expressions.Add(expression);
        return true;}
return false;}
/// <summary>
/// Parse rules.
/// true if it succeeds, false if it fails.
/// </returns>
public Boolean ParseRules(String[] rules)
    {Expressions.Clear();
     Emotions.Clear();
     foreach (String rule in rules)
         {if (!ParseRule(rule) && rule.StartsWith("(V"))
             {return false; }}
         Emotions = Expressions.Select(p => p.Emotion).Distinct().ToList();
     foreach (String emotion in Emotions)
         {if (!Messages.define(emotion))
             {Log(Severity.Warning, "Error defining {0} message", emotion); }}
     return true; }
public Boolean ProcessFaces()
    {DetectLandmarksInFaces();
     foreach (KeyValuePair<RECT, List<POINT>> kvp in Faces)
         {if (kvp.Value.Count != 0)
             {return true;}}
     return false; }
public Boolean ProcessImage(Byte[] bmp, Int32 width, Int32 height, Boolean flip = false)
    {Faces.Clear();
     #warning add additional checks on format & size.
     if (DlibWrapper.SetImageToRGBA(bmp, width, height, flip))
         {DetectFacesInImage();}
     return Faces.Count != 0;}
public Boolean ProcessImage(Image bmp)
    {Faces.Clear();
     if (!supported.Contains(bmp.PixelFormat))
         {Log(Severity.Warning, "Unsupported PixelFormat {0}, will need conversion", bmp.PixelFormat);}
         //Bitmap clone = new Bitmap(pictureBox1.Image.Width, pictureBox1.Image.Height,
     System.Drawing.Imaging.PixelFormat.Format24bppRgb);

```

```

        //using (Graphics gr = Graphics.FromImage(clone))
        //{gr.DrawImage(pictureBox1.Image, new Rectangle(0, 0, clone.Width, clone.Height));}
        //! This is code to make sure dlib accepts the image.
        //! Dlib's image_load.h / load_bmp() only supports 1,4,8 or 24 bits images (so no 16 or 32 bit ones).
        Boolean gray = ((EmotionDetectionAssetSettings)settings).GrayScale;
        // GrayScale() returns PixelFormat.Format32bppArgb
        bmp = gray ? bmp.GrayScale() : bmp;
        Byte[] raw = !supported.Contains(bmp.PixelFormat)
            ? ((Bitmap)bmp).Clone(
                new Rectangle(0, 0, bmp.Width, bmp.Height),
                PixelFormat.Format24bppRgb).ToArray()
            : ((Bitmap)bmp).ToArray();
        //Dlib Wrapper.SetImageToBmp(raw, raw.Length);
#warning This code must be more versatile to support more formats
        // See https://msdn.microsoft.com/en-us/library/system.drawing.imaging.pixelformat(v=vs.110).aspx
        //! No need to test pixelformat any further as raw contains either a supported pixel depth or is a 24 bits converted image.
        if (DlibWrapper.SetImageToBmp(raw, raw.Length))
        {
            DetectFacesInImage();
            //if (bmp.PixelFormat == PixelFormat.Format32bppPArgb || bmp.PixelFormat == PixelFormat.Format32bppArgb)
            //!No need to flip Image.
            //if (DlibWrapper.SetImageToRGBA(raw, bmp.Width, bmp.Height, false)
            //    DlibWrapper.SetImageToBmp(raw, raw.Length))
            //!DetectFacesInImage();} else
            //!No need to flip Image.
            //    if (DlibWrapper.SetImageToRGB(raw, bmp.Width, bmp.Height, false))
            //        {DetectFacesInImage();}
        }
        return Faces.Count != 0; }
    /// true if it succeeds, false if it fails.
    /// </returns>
    public Boolean ProcessLandmarks()
    {return DetectEmotionsInLandmarks();}
    private static Double ParseNumber(Match m, String grp, Double def)
    {return m.Groups[grp].Value.EndsWith("inf") ? def : Double.Parse(m.Groups[grp].Value, CultureInfo.InvariantCulture);}
    /// <summary>
    /// To solve three sides of the triangle (called an SSS triangle) : Use The Law of Cosines first
    /// to calculate one of the angles then use The Law of Cosines again to find another angle and
    /// finally use angles of a triangle add to 180° to find the last angle.
    /// We use the "angle" version of the Law of Cosines :
    ///  $\cos(C) = (a^2 + b^2 - c^2) / 2ab$ 
    ///  $\cos(A) = (b^2 + c^2 - a^2) / 2bc$ 
    ///  $\cos(B) = (c^2 + a^2 - b^2) / 2ca$ .
    /// </summary>
    private double ArcCosine(double a)
    {return (Math.Acos(a) * 180.0 / Math.PI);}
    private double Cosine(double a, double b, double c)
    {#warning Possibility of a divide by zero!
        return ((Math.Pow(a, 2) + Math.Pow(b, 2) - Math.Pow(c, 2)) / (2 * a * b));}
    private void DetectFacesInImage()
    {int facecount = 0;
        IntPtr faces = IntPtr.Zero;
        DlibWrapper.DetectFaces(out faces, out facecount);
        Faces.Clear();
        if (facecount != 0)
            {IntPtr[] pIntPtrArray = new IntPtr[facecount];
            Marshal.Copy(faces, pIntPtrArray, 0, facecount);
            for (Int32 i = 0; i < facecount; i++)
                {Faces.Add((RECT)Marshal.PtrToStructure(pIntPtrArray[i], typeof(RECT)), new List<POINT>());}
            Marshal.FreeCoTaskMem(pIntPtrArray[i]);}
        Marshal.FreeCoTaskMem(faces); }
    private double EuclideanDistance(POINT a, POINT b)
    {return (Math.Sqrt(
        Math.Pow(a.X - b.X, 2) +
        Math.Pow(a.Y - b.Y, 2)); }
    #endregion Methods
    #region Nested Types
    [StructLayout(LayoutKind.Sequential)]

```

```

public struct POINT
    {public int X;
      public int Y;
      #region Constructors
public POINT(int x, int y)
    {this.X = x;
      this.Y = y;}
public override string ToString()
    {return string.Format("{X={0},Y={1}}", X, Y);}
    [StructLayout(LayoutKind.Sequential)]
public struct RECT
    {public int Left;
      public int Top;
      public int Right;
      public int Bottom;
      #region Constructors
public RECT(int left, int top, int right, int bottom)
    {Left = left;
      Top = top;
      Right = right;
      Bottom = bottom;}
      #endregion Constructors
      #region Methods
public override string ToString()
    {return string.Format("{Left={0},Top={1},Right={2},Bottom={3}}", Left, Top, Right, Bottom);}
      #endregion Methods}
public String Emotion;
      #endregion Fields}
public class FuzzyExpressions : List<FuzzyExpression>
    {public Double Result(List<Double> Input)
      {Double value = Input[var];
      if (value >= lsb && value <= rsb) {
      if (value < lst)
          {return (value - lsb) / (lst - lsb);}
      else if (value >= lst && value <= rst)
          {return 1;}
      else if (value > rst)
          { (rsb - rst);}
          (value < lsb) or (value > rsb)
      return 0;}
    }

```

## B. FURIA Fuzzy Rules

“(V30 in [159.608, 160.424, inf, inf]) and (V35 in [30.0655, 30.2536, inf, inf]) => Emotions=Happy (CF = 0.97)  
(V31 in [-inf, -inf, 9.85016, 9.96286]) and (V51 in [35.5078, 35.5856, inf, inf]) and (V10 in [22.9748, 23.0757, inf, inf]) and (V0 in [-inf, -inf, 24.8358, 24.9599]) => Emotions=Happy (CF = 0.98)  
(V32 in [-inf, -inf, 13.8022, 14.6793]) and (V34 in [25.1647, 25.4542, inf, inf]) and (V50 in [3.7724, 3.79234, inf, inf]) and (V48 in [64.551, 66.8476, inf, inf]) => Emotions=Happy (CF = 0.9)  
(V31 in [-inf, -inf, 12.4074, 16.2636]) and (V35 in [25.6426, 27.0878, inf, inf]) and (V37 in [21.4168, 21.5797, inf, inf]) and (V0 in [-inf, -inf, 21.1748, 21.9187]) => Emotions=Happy (CF = 0.95)  
(V32 in [-inf, -inf, 5.15255, 5.16574]) and (V32 in [4.97626, 5.05265, inf, inf]) => Emotions=Happy (CF = 0.66)  
(V34 in [-inf, -inf, 15.1591, 15.3646]) and (V42 in [-inf, -inf, 73.6283, 74.5163]) and (V32 in [17.9646, 17.9917, inf, inf]) and (V13 in [68.61, 70.3929, inf, inf]) and (V37 in [-inf, -inf, 22.5483, 22.8643]) => Emotions=Sad (CF = 0.94)  
(V33 in [142.341, 142.606, inf, inf]) and (V44 in [51.9081, 52.9607, inf, inf]) and (V50 in [-inf, -inf, 3.15842, 3.18719]) and (V31 in [14.1431, 14.4425, inf, inf]) => Emotions=Sad (CF = 0.82)  
(V46 in [-inf, -inf, 84.9609, 85.074]) and (V51 in [36.248, 36.6846, inf, inf]) => Emotions=Sad (CF = 0.81)  
(V42 in [-inf, -inf, 54.362, 54.4623]) and (V3 in [49.4672, 53.9726, inf, inf]) and (V18 in [48.7314, 48.7806, inf, inf]) => Emotions=Sad (CF = 0.84)  
(V1 in [-inf, -inf, 6.82602, 7.03498]) and (V15 in [14.5889, 15.0512, inf, inf]) => Emotions=Sad (CF = 0.53)



(V30 in [-inf, -inf, 126.304, 149.554]) and (V34 in [33.9611, 34.0477, inf, inf]) => Emotions=Surprise (CF = 0.99)  
(V8 in [40.2461, 40.3331, inf, inf]) and (V12 in [-inf, -inf, 45.1865, 45.2721]) => Emotions=Surprise (CF = 0.98)  
(V17 in [17.0409, 17.0477, inf, inf]) and (V17 in [-inf, -inf, 17.1027, 17.1054]) => Emotions=Surprise (CF = 0.68)  
(V48 in [-inf, -inf, 42.3974, 43.2472]) => Emotions=Surprise (CF = 0.6)  
(V26 in [38.6598, 40.2364, inf, inf]) and (V50 in [3.61388, 3.62035, inf, inf]) and (V19 in [86.8202, 87.1376, inf, inf]) and (V32 in [-inf, -inf, 22.3228, 22.4199]) and (V44 in [48.7314, 48.8141, inf, inf]) => Emotions=Fear (CF = 0.9)  
(V49 in [-inf, -inf, 95.8395, 96.2791]) and (V49 in [93.3419, 94.0108, inf, inf]) and (V8 in [35.0195, 35.6748, inf, inf]) and (V30 in [112.548, 127.911, inf, inf]) => Emotions=Fear (CF = 0.84)

(V33 in [113.647, 120.77, inf, inf]) and (V35 in [19.8265, 20.2393, inf, inf]) and (V22 in [41.6335, 41.8665, inf, inf]) and (V51 in [34.8844, 35.0913, inf, inf]) and (V12 in [-inf, -inf, 56.658, 56.7193]) => Emotions=Fear (CF = 0.87)  
(V26 in [-inf, -inf, 26.9489, 27.5973]) and (V8 in [-inf, -inf, 25.3267, 26.1046]) and (V21 in [59.7436, 60.0864, inf, inf]) => Emotions=Disgust (CF = 0.96)  
(V26 in [-inf, -inf, 35.8377, 36.2538]) and (V30 in [-inf, -inf, 151.318, 151.76]) and (V35 in [18.6981, 18.7149, inf, inf]) and (V8 in [-inf, -inf, 25.9913, 26.0754]) and (V50 in [3.1012, 3.21448, inf, inf]) and (V51 in [-inf, -inf, 40.4826, 40.6054]) => Emotions=Disgust (CF = 0.96)

(V26 in [-inf, -inf, 35.4509, 35.8195]) and (V30 in [-inf, -inf, 160.168, 160.675]) and (V42 in [91.4652, 91.8476, inf, inf]) and (V9 in [28.8713, 31.4661, inf, inf]) and (V16 in [-inf, -inf, 151.557, 151.794]) => Emotions=Disgust (CF = 0.94)  
(V28 in [-inf, -inf, 38.1572, 38.3107]) and (V31 in [7.43669, 10.1433, inf, inf]) and (V26 in [-inf, -inf, 30.9638, 31.4521]) and (V4 in [-inf, -inf, 46.4321, 46.5831]) and (V45 in [74.4759, 75.0686, inf, inf]) => Emotions=Disgust (CF = 0.94)  
(V28 in [-inf, -inf, 38.1572, 38.3782]) and (V32 in [8.70181, 8.71473, inf, inf]) and (V9 in [35.9909, 36.1861, inf, inf]) and (V8 in [-inf, -inf, 27.817, 27.929]) and (V14 in [-inf, -inf, 46.8177, 47.5595]) and (V8 in [17.2892, 18.9069, inf, inf]) => Emotions=Disgust (CF = 0.93)

(V28 in [-inf, -inf, 38.1572, 39.6233]) and (V32 in [15.3773, 15.6442, inf, inf]) and (V23 in [-inf, -inf, 90, 92.4002]) and (V6 in [34.6599, 35.2154, inf, inf]) and (V2 in [144.482, 144.492, inf, inf]) => Emotions=Disgust (CF = 0.9)  
(V10 in [-inf, -inf, 26.4547, 27.2133]) and (V17 in [13.8931, 14.1754, inf, inf]) and (V11 in [-inf, -inf, 117.723, 118.822]) and (V7 in [112.807, 113.395, inf, inf]) and (V0 in [-inf, -inf, 24.2531, 28.1416]) => Emotions=Disgust (CF = 0.86)  
(V7 in [115.258, 117.446, inf, inf]) and (V34 in [-inf, -inf, 17.2653, 19.2307]) and (V30 in [152.184, 152.257, inf, inf]) and (V36 in [141.526, 141.77, inf, inf]) => Emotions=Anger (CF = 0.93)

(V11 in [122.859, 124.442, inf, inf]) and (V22 in [33.0558, 33.6901, inf, inf]) and (V8 in [-inf, -inf, 21.139, 21.5363]) => Emotions=Anger (CF = 0.9)  
(V11 in [114.76, 115.918, inf, inf]) and (V34 in [-inf, -inf, 17.0449, 17.049]) and (V39 in [-inf, -inf, 137.883, 138.125]) and (V19 in [86.0353, 86.1859, inf, inf]) => Emotions=Anger (CF = 0.82)

(V11 in [123.048, 124.509, inf, inf]) and (V51 in [-inf, -inf, 33.6707, 33.6995]) and (V18 in [52.6819, 53.231, inf, inf]) => Emotions=Anger (CF = 0.83)  
(V34 in [-inf, -inf, 22.8636, 23.1986]) and (V31 in [-inf, -inf, 10.1964, 10.3628]) and (V46 in [-inf, -inf, 107.21, 107.447]) and (V47 in [-inf, -inf, 3.29176, 3.4244]) => Emotions=Anger (CF = 0.82)  
(V5 in [-inf, -inf, 68.4986, 68.8774]) and (V35 in [-inf, -inf, 18.6981, 18.7149]) and (V13 in [-inf, -inf, 66.8664, 67.7345]) and (V51 in [-inf, -inf, 39.3543, 39.4115]) => Emotions=Anger (CF = 0.92)

(V34 in [-inf, -inf, 26.5651, 26.7055]) and (V20 in [39.2894, 39.6233, inf, inf]) and (V45 in [-inf, -inf, 78.9618, 78.9745]) and (V38 in [19.9831, 20.0674, inf, inf]) and (V8 in [-inf, -inf, 35.4327, 36.92]) and (V30 in [-inf, -inf, 156.633, 157.079]) and (V44 in [38.5527, 38.6598, inf, inf]) => Emotions=Neutral (CF = 0.98)  
(V35 in [-inf, -inf, 27.2363, 27.3464]) and (V28 in [38.1572, 38.6598, inf, inf]) and (V6 in [38.9806, 39.1219, inf, inf]) and (V50 in [-inf, -inf, 3.61388, 3.64164]) and (V45 in [-inf, -inf, 79.5199, 79.6952]) => Emotions=Neutral (CF = 0.95)  
(V34 in [-inf, -inf, 28.1313, 28.9551]) and (V28 in [38.1572, 38.4537, inf, inf]) and (V9 in [39.7376, 39.8419, inf, inf]) and (V19 in [-inf, -inf, 86.6335, 87.0364]) and (V50 in [-inf, -inf, 3.61207, 3.62575]) => Emotions=Neutral (CF = 0.93)

(V34 in [-inf, -inf, 26.8913, 26.9486]) and (V20 in [33.6901, 35.8195, inf, inf]) and (V12 in [-inf, -inf, 58.3317, 58.6666]) and (V22 in [-inf, -inf, 38.7933, 39.0939]) and (V33 in [-inf, -inf, 152.969, 152.971]) and (V43 in [50.7021, 50.8786, inf, inf]) => Emotions=Neutral (CF = 0.94)

(V33 in [88.1516, 121.909, inf, inf]) and (V28 in [38.1572, 38.6238, inf, inf]) and (V51 in [-inf, -inf, 35.422, 36.0181]) and (V43 in [-inf, -inf, 51.481, 51.6839]) and (V32 in [13.4486, 13.6831, inf, inf]) and (V26 in [-inf, -inf, 43.2643, 43.3844]) and (V36 in [-inf, -inf, 146.691, 146.723]) => Emotions=Neutral (CF = 0.97)  
(V35 in [-inf, -inf, 29.0332, 32.685]) and (V8 in [26.5308, 26.5651, inf, inf]) and (V29 in [-inf, -inf, 85.6013, 85.9144]) and (V44 in [-inf, -inf, 51.953, 52.0023]) and (V5 in [-inf, -inf, 75.7986, 76.0875]) and (V18 in [-inf, -inf, 61.0736, 64.9831]) => Emotions=Neutral (CF = 0.95)  
(V33 in [118.764, 120.426, inf, inf]) and (V27 in [-inf, -inf, 57.0948, 64.7327]) and (V49 in [104.517, 104.534, inf, inf]) and (V51 in [-inf, -inf, 33.918, 34.2595]) and (V5 in [73.3444, 73.7261, inf, inf]) and (V33 in [-inf, -inf, 136.4, 149.673]) => Emotions=Neutral (CF = 0.96)

Number of Rules : 37"

### C. Pre-test 1 Results

No siswa	SOAL 1	SOAL 2	SOAL 3	SOAL 4	SOAL 5	SOAL 6	SOAL 7	SOAL 8	SOAL 9	SOAL 10	SOAL 11	SOAL 12	SOAL 13	SOAL 14	SOAL 15	Skor	Persentase tingkat Stress
1	Y	T	T	Y	Y	T	Y	Y	T	Y	T	T	T	T	T	6	40,00%
2	Y	Y	T	Y	T	T	Y	Y	T	Y	T	T	Y	Y	Y	9	60,00%
3	Y	Y	Y	Y	Y	T	Y	Y	T	Y	T	T	Y	T	Y	10	66,67%
4	T	Y	T	T	Y	T	Y	Y	T	Y	T	T	T	T	Y	6	40,00%
5	Y	Y	Y	Y	T	T	Y	Y	T	Y	T	T	Y	T	T	8	53,33%
6	Y	T	Y	Y	T	T	Y	T	T	Y	T	T	Y	T	T	6	40,00%
7	T	Y	T	Y	Y	T	Y	Y	T	Y	T	T	Y	T	Y	8	53,33%
8	Y	Y	T	Y	T	T	Y	Y	T	Y	Y	T	T	T	Y	8	53,33%
9	Y	Y	T	Y	Y	T	Y	Y	T	Y	T	T	Y	Y	Y	10	66,67%
10	T	Y	T	T	Y	T	Y	T	Y	Y	T	T	Y	T	T	6	40,00%
11	Y	T	T	Y	T	T	Y	Y	T	Y	T	T	T	T	T	5	33,33%
12	T	Y	T	Y	T	T	T	Y	T	Y	T	T	T	T	Y	5	33,33%
13	Y	Y	T	Y	T	T	T	Y	T	Y	Y	T	Y	T	Y	8	53,33%
14	Y	T	T	Y	Y	T	T	Y	T	Y	T	T	Y	T	Y	7	46,67%
15	Y	Y	T	Y	Y	T	Y	Y	T	Y	T	T	Y	T	T	8	53,33%
16	Y	Y	Y	Y	Y	Y	Y	Y	T	Y	T	T	T	Y	T	10	66,67%
17	T	Y	Y	T	T	Y	Y	T	T	Y	T	T	T	T	Y	6	40,00%
18	Y	Y	T	Y	T	T	Y	Y	T	Y	T	T	Y	T	Y	8	53,33%
19	T	Y	T	Y	Y	T	Y	Y	T	Y	T	T	Y	T	Y	8	53,33%
20	Y	T	T	Y	Y	T	Y	Y	T	Y	T	T	Y	T	T	7	46,67%
21	Y	T	Y	Y	Y	T	Y	Y	T	Y	T	T	T	T	T	7	46,67%
22	T	T	T	Y	T	T	Y	Y	T	Y	T	T	Y	T	Y	6	40,00%
23	Y	T	T	Y	T	Y	Y	Y	T	Y	Y	T	T	Y	Y	9	60,00%
24	Y	Y	T	T	T	T	Y	T	T	Y	Y	T	Y	T	Y	7	46,67%
25	Y	Y	T	Y	Y	T	Y	Y	T	Y	T	T	Y	T	T	8	53,33%
26	Y	T	T	Y	Y	T	Y	Y	T	Y	T	T	Y	T	T	7	46,67%
27	Y	T	T	Y	Y	T	Y	Y	T	Y	T	T	T	T	T	6	40,00%
28	Y	T	Y	T	T	T	Y	Y	T	Y	T	T	T	T	T	5	33,33%
29	Y	Y	Y	Y	T	T	Y	Y	T	Y	T	T	Y	T	T	8	53,33%
30	Y	Y	T	Y	Y	T	T	Y	T	Y	T	T	T	T	T	6	40,00%
31	Y	Y	Y	Y	T	T	Y	Y	T	Y	Y	T	Y	T	T	9	60,00%
32	Y	Y	T	Y	T	T	Y	Y	T	Y	T	T	T	T	T	6	40,00%
33	Y	Y	Y	Y	T	T	T	Y	T	Y	T	T	Y	T	T	7	46,67%
<b>Total</b>	<b>26</b>	<b>22</b>	<b>10</b>	<b>28</b>	<b>16</b>	<b>3</b>	<b>28</b>	<b>29</b>	<b>1</b>	<b>33</b>	<b>5</b>	<b>0</b>	<b>20</b>	<b>4</b>	<b>15</b>	<b>240</b>	<b>48,48%</b>

### D. Pre-test 2 Result

No siswa	SOAL 1	SOAL 2	SOAL 3	SOAL 4	SOAL 5	SOAL 6	SOAL 7	SOAL 8	SOAL 9	SOAL 10	SOAL 11	SOAL 12	SOAL 13	SOAL 14	SOAL 15	Skor	Persentase
1	Y	T	T	Y	Y	T	Y	Y	T	Y	T	T	T	T	T	6	40,00%
2	Y	T	T	Y	T	T	Y	Y	T	Y	T	T	Y	Y	Y	8	53,33%
3	Y	T	Y	Y	Y	T	Y	Y	T	Y	T	T	Y	T	Y	9	60,00%
4	T	Y	T	T	Y	T	Y	Y	T	Y	T	T	T	T	Y	6	40,00%
5	Y	Y	Y	Y	T	T	Y	Y	T	Y	T	T	Y	T	T	8	53,33%
6	Y	T	Y	Y	T	T	Y	T	T	Y	T	T	Y	T	T	6	40,00%
7	T	Y	T	Y	Y	T	Y	Y	T	Y	T	T	Y	T	Y	8	53,33%
8	Y	Y	T	Y	T	T	Y	Y	T	Y	Y	T	T	T	Y	8	53,33%
9	Y	Y	T	Y	Y	T	Y	Y	T	Y	T	T	Y	Y	Y	10	66,67%
10	T	Y	T	T	Y	T	Y	T	Y	Y	T	T	Y	T	T	6	40,00%
11	Y	T	T	Y	T	T	Y	Y	T	Y	T	T	T	T	T	5	33,33%
12	T	Y	T	Y	T	T	T	Y	T	Y	T	T	T	T	Y	5	33,33%
13	Y	Y	T	Y	T	T	T	Y	T	Y	Y	T	Y	T	Y	8	53,33%
14	Y	T	T	Y	Y	T	T	Y	T	Y	T	T	Y	T	Y	7	46,67%
15	Y	Y	T	Y	Y	T	Y	Y	T	Y	T	T	Y	T	T	8	53,33%
16	T	Y	Y	Y	Y	Y	Y	Y	T	Y	T	T	T	Y	T	9	60,00%
17	T	Y	Y	T	Y	Y	Y	T	T	Y	T	T	T	T	Y	7	46,67%
18	Y	Y	T	Y	T	T	Y	Y	T	Y	T	T	Y	T	Y	8	53,33%
19	T	Y	T	Y	Y	T	T	Y	T	Y	T	T	Y	T	Y	7	46,67%
20	Y	T	T	Y	Y	T	Y	T	T	T	T	T	Y	T	T	5	33,33%
21	Y	T	Y	Y	Y	T	Y	Y	T	Y	T	T	T	T	Y	8	53,33%
22	T	T	T	Y	T	T	Y	Y	T	T	T	T	Y	T	Y	5	33,33%
23	Y	T	T	Y	T	Y	Y	Y	T	Y	T	T	T	Y	Y	8	53,33%
24	Y	Y	T	T	T	T	Y	T	T	Y	T	T	Y	T	Y	6	40,00%
25	Y	Y	T	Y	Y	T	Y	Y	T	Y	T	T	Y	T	T	8	53,33%
26	Y	T	T	Y	Y	T	Y	Y	T	Y	T	T	Y	T	Y	8	53,33%
27	Y	T	T	Y	Y	T	Y	Y	T	Y	T	T	T	T	Y	7	46,67%
28	Y	T	Y	T	T	T	Y	Y	T	Y	T	T	T	T	T	5	33,33%
29	Y	Y	Y	Y	T	T	Y	Y	T	Y	T	T	Y	Y	Y	10	66,67%
30	Y	Y	T	Y	Y	T	T	Y	T	Y	T	T	T	T	T	6	40,00%
31	Y	Y	Y	Y	T	T	Y	Y	T	Y	Y	T	Y	T	T	9	60,00%
32	Y	Y	T	Y	T	T	Y	Y	T	Y	T	T	T	T	Y	7	46,67%
33	Y	Y	Y	Y	T	T	T	Y	T	Y	T	T	Y	T	Y	8	53,33%
<b>Total</b>	25	20	10	28	17	3	27	28	1	31	3	0	20	5	21	239	<b>48,28%</b>

### E. Post-test 1 Result

No siswa	SOAL 1	SOAL 2	SOAL 3	SOAL 4	SOAL 5	SOAL 6	SOAL 7	SOAL 8	SOAL 9	SOAL 10	SOAL 11	SOAL 12	SOAL 13	SOAL 14	SOAL 15	Skor	Persentase
1	Y	Y	T	T	Y	Y	T	T	T	T	Y	T	Y	T	Y	7	46,67%
2	T	Y	T	T	T	T	T	T	Y	Y	T	Y	T	Y	T	5	33,33%
3	T	Y	T	T	T	T	T	Y	T	Y	Y	T	Y	T	Y	6	40,00%
4	T	Y	T	T	Y	T	T	T	T	T	Y	T	T	T	Y	4	26,67%
5	T	Y	T	T	T	T	T	T	T	T	T	T	T	T	T	1	6,67%
6	Y	Y	Y	T	T	T	T	T	T	T	T	T	T	T	Y	4	26,67%
7	T	Y	T	T	T	T	T	T	T	T	T	T	T	T	T	1	6,67%
8	T	Y	T	T	T	T	T	Y	Y	T	T	T	T	T	Y	4	26,67%
9	T	Y	T	T	T	T	T	T	T	T	Y	T	T	T	Y	3	20,00%
10	T	T	T	T	Y	T	T	T	T	Y	T	T	T	T	Y	3	20,00%
11	Y	Y	Y	Y	T	T	T	T	T	T	T	T	T	T	T	4	26,67%
12	T	Y	T	T	T	T	T	T	T	T	Y	T	Y	Y	Y	5	33,33%
13	T	Y	T	T	Y	Y	Y	T	T	T	T	T	Y	T	T	5	33,33%
14	T	T	T	T	Y	T	T	T	T	T	Y	T	T	T	Y	3	20,00%
15	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	0	0,00%
16	Y	Y	T	T	T	Y	T	T	T	T	T	T	Y	T	Y	5	33,33%
17	T	Y	T	T	T	Y	Y	T	T	T	T	T	T	T	T	3	20,00%
18	T	Y	T	T	T	Y	T	T	T	Y	Y	T	Y	T	T	5	33,33%
19	T	Y	T	T	T	Y	Y	T	T	T	T	T	T	T	T	3	20,00%
20	T	Y	T	T	T	T	T	T	T	T	T	T	Y	T	T	2	13,33%
21	Y	Y	T	T	Y	Y	Y	T	T	T	Y	T	T	T	Y	7	46,67%
22	T	Y	T	T	T	Y	T	Y	T	Y	Y	T	T	T	T	5	33,33%
23	T	Y	T	T	T	Y	Y	T	T	T	T	T	T	T	Y	4	26,67%
24	T	Y	Y	T	T	Y	T	T	T	T	T	T	Y	T	Y	5	33,33%
25	T	Y	T	T	T	T	T	T	T	T	T	T	T	T	Y	2	13,33%
26	T	Y	T	T	T	T	Y	T	T	Y	T	T	T	T	Y	4	26,67%
27	T	Y	T	T	T	T	T	T	T	T	T	T	Y	T	T	2	13,33%
28	Y	T	T	T	T	T	T	T	T	T	T	T	Y	T	Y	3	20,00%
29	T	Y	T	T	T	T	T	T	T	T	T	T	Y	T	T	2	13,33%
30	T	Y	T	T	Y	T	T	Y	T	Y	T	T	T	T	Y	5	33,33%
31	T	Y	T	T	Y	T	T	T	T	Y	Y	T	Y	T	T	5	33,33%
32	T	Y	T	T	T	T	T	T	T	Y	T	T	T	T	T	2	13,33%
33	Y	Y	T	T	T	T	T	T	T	Y	T	Y	Y	Y	T	6	40,00%
Total	7	29	3	1	8	10	6	4	2	10	10	2	13	3	17	125	25,25%

## F. Post-test 2 Result

No siswa	SOAL 1	SOAL 2	SOAL 3	SOAL 4	SOAL 5	SOAL 6	SOAL 7	SOAL 8	SOAL 9	SOAL 10	SOAL 11	SOAL 12	SOAL 13	SOAL 14	SOAL 15	Skor	Persentase
1	Y	Y	T	Y	T	Y	T	T	T	T	Y	T	Y	T	T	6	40,00%
2	T	Y	T	T	T	T	Y	T	Y	Y	T	T	T	T	T	4	26,67%
3	T	Y	T	T	T	T	T	Y	T	Y	Y	T	Y	T	Y	6	40,00%
4	T	Y	T	T	Y	T	T	T	T	T	Y	T	T	T	T	3	20,00%
5	T	Y	T	T	T	T	Y	T	T	T	T	T	T	T	T	2	13,33%
6	Y	Y	Y	T	T	T	T	T	T	T	T	T	T	T	Y	4	26,67%
7	T	Y	T	T	T	T	T	T	T	T	T	T	T	T	T	1	6,67%
8	T	Y	T	T	T	T	T	Y	Y	T	T	T	T	T	T	3	20,00%
9	T	Y	T	T	T	T	T	T	T	T	Y	T	T	T	Y	3	20,00%
10	T	T	T	T	Y	T	T	T	T	Y	T	T	T	T	T	2	13,33%
11	Y	Y	Y	Y	T	Y	T	T	T	T	T	T	T	T	T	5	33,33%
12	T	Y	T	T	T	Y	T	T	T	T	Y	T	Y	Y	T	5	33,33%
13	T	Y	T	T	Y	T	Y	T	T	T	T	T	Y	T	T	4	26,67%
14	T	T	T	T	Y	T	T	T	T	T	Y	T	T	T	Y	3	20,00%
15	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	0	0,00%
16	Y	Y	T	T	T	Y	T	T	T	T	T	T	Y	T	T	4	26,67%
17	T	Y	T	T	T	Y	Y	T	T	T	T	T	T	T	T	3	20,00%
18	T	Y	T	T	T	Y	T	T	T	Y	Y	T	Y	T	T	5	33,33%
19	T	Y	T	T	T	Y	Y	T	T	T	T	T	T	T	T	3	20,00%
20	T	Y	T	T	T	T	T	T	T	T	T	T	Y	T	T	2	13,33%
21	Y	Y	T	T	Y	Y	Y	T	T	T	Y	T	T	T	T	6	40,00%
22	T	Y	T	T	T	Y	T	Y	T	Y	Y	T	T	T	T	5	33,33%
23	T	Y	T	T	T	Y	Y	T	T	T	T	T	T	T	T	3	20,00%
24	T	Y	Y	T	T	Y	T	T	T	T	T	T	Y	T	Y	5	33,33%
25	T	Y	T	T	T	T	T	T	T	T	T	T	T	T	T	1	6,67%
26	T	Y	T	T	T	T	Y	T	T	Y	T	T	T	T	Y	4	26,67%
27	T	Y	T	T	T	T	T	T	T	T	T	T	Y	T	T	2	13,33%
28	Y	T	T	T	T	T	T	T	T	T	T	T	Y	T	Y	3	20,00%
29	T	Y	T	T	T	T	T	T	T	T	T	T	Y	T	T	2	13,33%
30	T	Y	T	T	Y	T	T	Y	T	Y	T	T	T	T	T	4	26,67%
31	T	Y	T	T	Y	T	T	T	T	Y	Y	T	Y	T	T	5	33,33%
32	T	Y	T	T	T	T	T	T	T	Y	T	T	T	T	T	2	13,33%
33	Y	Y	T	T	T	T	T	T	T	Y	T	Y	Y	Y	T	6	40,00%
<b>Total</b>	7	29	3	2	7	11	8	4	2	10	10	1	13	2	7	116	<b>23,43%</b>

## G. Student's Questionnaire

### ANGKET TANGGAPAN SISWA DALAM PENGUNAAN SISTEM PENGENAL EMOSI

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#### A. Pengantar

Dengan segala kerendahan hati, penulis mengucapkan rasa syukur kepada Allah SWT karena hanya dengan lingkungan dan karunia-Nya penulis dapat menyelesaikan angket ini sebagai pedoman pertanyaan dalam penelitian : **“Facial Recognition System to Monitor Student’s Mood In A Classroom”**. Sehubungan dengan penelitian ini, kami mohon kesediaan kalian untuk menyisihkan sedikit waktu untuk mengisi angket ini agar penulis mendapatkan data dan informasi yang diperlukan. Atas bantuan dan kesediaan kalian menjawab pertanyaan di angket ini kami mengucapkan terima kasih.

#### B. Petunjuk

1. Mohon tuliskan nama ditempat yang disediakan.
2. Mohon beri tanda centang (✓) terhadap pertanyaan yang anggap sesuai.

Nama :  
 Usia :  
 Kelas :

Apakah selama kelas kegiatan kelas berlangsung, kalian :

Nomor	Gejala	Ya	Tidak
1	Merasa pusing/sakit kepala tanpa alasan yang jelas?		
2	Merasa pegal-pegal pada leher/punggung/bahu ?		
3	Perut terasa mual/kembung/mulas/diare pada saat akan melakukan kegiatan tertentu?		
4	Mengalami tangan gemeteran?		
5	Sering menjatuhkan/memecahkan barang/tersandung/terjatuh?		
6	Jantung berdebar kencang dan keras?		
7	Merasa tidak tenang/tegang/cemas/terancam?		
8	Merasa sukar berkonsentrasi pada saat melakukan kegiatan?		
9	Mudah tersinggung?		
10	Merasa sangat lelah/lesu/lemas/tidak memiliki tenaga?		
11	Merasa tidak sabar atau cepat marah tanpa sebab?		
12	Merasa tidak memiliki harapan/putus asa?		
13	Merasa bingung/takut bila bertemu dengan orang lain?		
14	Merasa sedih sekali dan ingin menangis?		
15	Merasa dipaksa dengan sangat oleh orang lain (tertekan)?		

**Keterangan : Untuk pengisian angket ini mohon agar Bapak/Ibu Guru mendampingi siswa saat melakukan pengisian angket.**



### **Kisi-kisi instrumen**

Jenis instrumen	Nomor soal
Gejala stress yang berhubungan dengan emosi siswa secara langsung	9, 11, 14
Gejala stress yang mempengaruhi kondisi kesehatan siswa	1, 2, 3, 12
Gejala stress yang mempengaruhi kondisi fisiologis	4, 5, 6, 11
Gejala stress yang mempengaruhi kondisi psikologis	7, 8, 13, 15
<b>Total</b>	<b>15</b>

## H. Teacher's Questionnaire

### ANGKET TANGGAPAN GURU DALAM PENGUNAAN SISTEM PENGENAL EMOSI

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#### A. Pengantar

Dengan segala kerendahan hati, penulis mengucapkan rasa syukur kepada Allah SWT karena hanya dengan lingkungan dan karunia-Nya penulis dapat menyelesaikan angket ini sebagai pedoman pertanyaan dalam penelitian : **“Pengaplikasian Facial Recognition System to Monitor Student’s Mood”**. Sehubungan dengan penelitian ini, saya mohon kesediaan Bapak/ Ibu untuk menyisihkan sedikit waktu untuk mengisi angket ini agar penulis mendapatkan data dan informasi yang diperlukan. Atas bantuan dan kesediaan Bapak/ Ibu menjawab pertanyaan di angket ini saya mengucapkan terima kasih.

#### B. Petunjuk

1. Mohon Bapak/ Ibu tuliskan nama ditempat yang disediakan.
2. Mohon Bapak/ Ibu beri tanda silang (X) terhadap pertanyaan yang Bapak/ Ibu anggap sesuai.
3. Petunjuk jawaban :

ST : Sangat Setuju  
S : Setuju  
TB : Tidak berpendapat  
KS : Kurang Setuju  
KS : Tidak Setuju

#### C. Identitas Responden

Nama Guru :  
Sekolah :

No	Indikator	Skor				
		SS	S	TB	KD	TS
<b>A</b>	<b>Penggunaan system pengenalan wajah</b>					
1	Sistem pengenalan wajah mudah untuk dimulai					
2	Sistem pengenalan wajah mudah untuk digunakan					
3	Sistem pengenalan wajah berjalan dengan baik					
4	Sistem pengenalan wajah memberikan data yang tepat					
5	Informasi yang diberikan Sistem pengenalan wajah mudah dibaca					
6	Tombol di sistem pengenalan wajah berjalan dengan lancar					
7	Guru lain bisa belajar menggunakan Sistem pengenalan wajah dengan cepat					
<b>B</b>	<b>Pemanfaatan sistem pengenalan wajah</b>					
8	Sistem pengenalan wajah dapat membuat guru menjadi lebih interaktif dengan siswa					
9	Sistem pengenalan wajah membantu guru memantau situasi kelas					
10	Sistem pengenalan wajah membantu guru mengendalikan perilaku siswa					
11	Sistem pengenalan wajah membantu guru dalam menyampaikan materi					
12	Sistem pengenalan wajah membantu meningkatkan performa siswa di kelas					
13	Sistem pengenalan wajah membantu siswa menjadi lebih aktif					
14	Sistem pengenalan wajah dapat digunakan dengan infrastruktur sekolah yang ada					
15	Sistem pengenalan wajah dapat dimanfaatkan untuk meningkatkan layanan sekolah					

## I. Teacher's Sign on Questionnaire

### ANGKET TANGGAPAN GURU DALAM PENGUNAAN SISTEM PENGENAL EMOSI

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#### A. Pengantar

Dengan segala kerendahan hati, penulis mengucapkan rasa syukur kepada Allah SWT karena hanya dengan lingkungan dan karunia-Nya penulis dapat menyelesaikan angket ini sebagai pedoman pertanyaan dalam penelitian : **"Pengaplikasian Facial Recognition System to Monitor Student's Mood"**. Sehubungan dengan penelitian ini, saya mohon kesediaan Bapak/ Ibu untuk menyisihkan sedikit waktu untuk mengisi angket ini agar penulis mendapatkan data dan informasi yang diperlukan. Atas bantuan dan kesediaan Bapak/ Ibu menjawab pertanyaan di angket ini saya mengucapkan terima kasih.

#### B. Petunjuk

1. Mohon Bapak/ Ibu tuliskan nama ditempat yang disediakan.
2. Mohon Bapak/ Ibu beri tanda silang (X) terhadap pertanyaan yang Bapak/ Ibu anggap sesuai.
3. Petunjuk jawaban :

SS : Sangat Setuju  
S : Setuju  
TB : Tidak berpendapat  
KS : Kurang Setuju  
TS : Tidak Setuju

#### C. Identitas Responden

Nama Guru : VIVI SAFIRA A. S-E  
Sekolah :



**ANGKET TANGGAPAN GURU DALAM  
PENGUNAAN SISTEM PENGENAL EMOSI**

---

**A. Pengantar**

Dengan segala kerendahan hati, penulis mengucapkan rasa syukur kepada Allah SWT karena hanya dengan lingkungan dan karunia-Nya penulis dapat menyelesaikan angket ini sebagai pedoman pertanyaan dalam penelitian : **"Pengaplikasian Facial Recognition System to Monitor Student's Mood"**. Sehubungan dengan penelitian ini, saya mohon kesediaan Bapak/ Ibu untuk menyisihkan sedikit waktu untuk mengisi angket ini agar penulis mendapatkan data dan informasi yang diperlukan. Atas bantuan dan kesediaan Bapak/ Ibu menjawab pertanyaan di angket ini saya mengucapkan terima kasih.

**B. Petunjuk**

1. Mohon Bapak/ Ibu tuliskan nama ditempat yang disediakan.
2. Mohon Bapak/ Ibu beri tanda silang (X) terhadap pertanyaan yang Bapak/ Ibu anggap sesuai.
3. Petunjuk jawaban :

SS : Sangat Setuju  
S : Setuju  
TB : Tidak berpendapat  
KS : Kurang Setuju  
TS : Tidak Setuju

**C. Identitas Responden**

Nama Guru : HALIFAH S.E  
Sekolah : SDN PERCOBAAN 2

*Hal*

## J. Validator's Signs



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UNIVERSITAS NEGERI YOGYAKARTA  
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Telepon (0274) 550835, 550836, Fax (0274) 520326  
Laman: pps.uny.ac.id E-mail: pps@uny.ac.id, humas\_pps@uny.ac.id

### SURAT KETERANGAN VALIDASI

Yang bertanda tangan di bawah ini:

Nama : Dr. Saiful Hae, Mpd, MT  
Jabatan/Pekerjaan : Lektor Kepala / Dosen  
Instansi Asal : FT UNY

Menyatakan bahwa instrumen penelitian dengan judul:

*Facial Expression Recognition To Monitor Student's Mood In Class*

dari mahasiswa:

Nama : Werda Buana Putra  
Program Studi : Pendidikan Teknik Elektronika dan Informatika  
NIM : 16720251020

(sudah siap/belum siap)\* dipergunakan untuk penelitian dengan menambahkan beberapa saran sebagai berikut:

1. *Angket sura, perbaiki petunjuk pengisian*
2. *Angket siswa, tidak jelas menanyakan gejala stress karena rumus dan alat pengukur stress tidak*

Demikian surat keterangan ini kami buat untuk dapat dipergunakan sebagaimana mestinya.

Yogyakarta, 8/3-2019

Validator,

Dr. Saiful Hae, Mpd, MT

\*) coret yang tidak perlu



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SURAT KETERANGAN VALIDASI

Yang bertanda tangan di bawah ini:

Nama : Nurkhamid, Ph. D.  
Jabatan/Pekerjaan : Dosen  
Instansi Asal : UNY

Menyatakan bahwa instrumen penelitian dengan judul:

*Facial Expression Recognition To Monitor Student's Mood In Class*

dari mahasiswa:

Nama : Werda Buana Putra  
Program Studi : Pendidikan Teknik Elektronika dan Informatika  
NIM : 16720251020

(sudah siap/~~belum siap~~)\* dipergunakan untuk penelitian dengan menambahkan beberapa saran sebagai berikut:

1. tujuan penelitian bisa disematkan dengan aspek-aspek yang diukur menggunakan angket
2. basis guru (fungsi, manfaat alat) dan angket basis siswa (tingkat stres).

Demikian surat keterangan ini kami buat untuk dapat dipergunakan sebagaimana mestinya.

- 2) Instrumen tingkat stres diturunkan secara tidak langsung dari paper Acosta-Gomez yang validasinya belum diuji.

Yogyakarta, 6/3/2019

Validator,

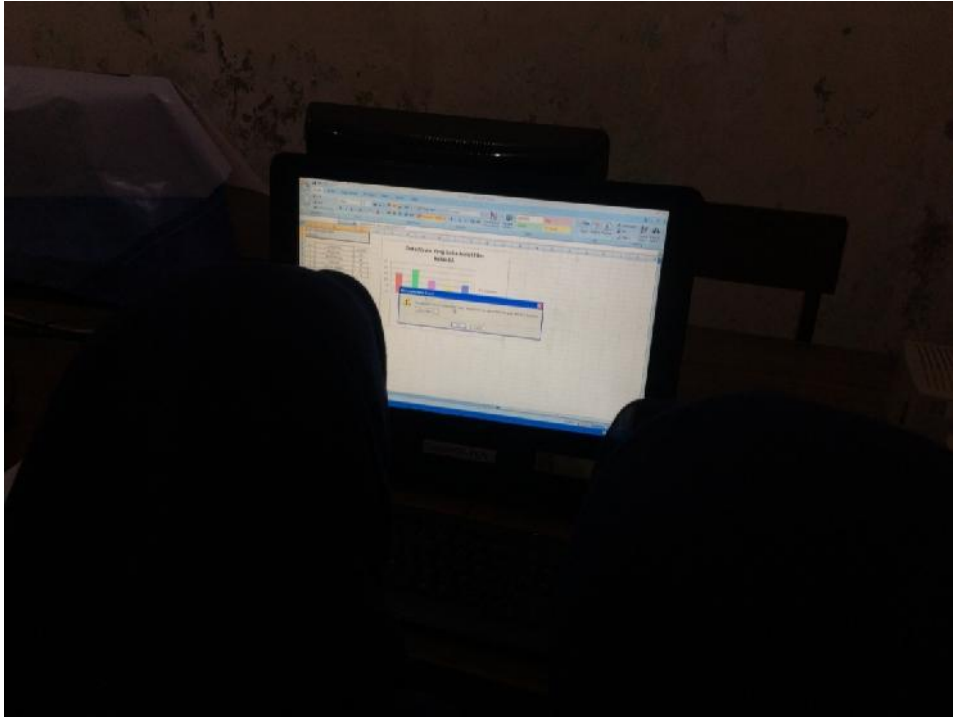
Nurkhamid, Ph. D.

\*) coret yang tidak perlu

## K. Class Activity







**L. Student's Detected Facial Expression on Webcam**



