Real-time detection with AdaBoost-svm combination in various face orientation

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Abstract. Most of the research has used algorithm AdaBoost-SVM for face detection. However, to our knowledge so far there is no research has been facing detection on real-time data with various orientations using the combination of AdaBoost and Support Vector Machine (SVM). Characteristics of complex and diverse face variations and real-time data in various orientations, and with a very complex application will slow down the performance of the face detection system this becomes a challenge in this research. Face orientation performed on the detection system, that is 90⁰, 45⁰, 0⁰, -45⁰, and -90⁰. This combination method is expected to be an effective and efficient solution in various face orientations. The results showed that the highest average detection rate is on the face detection oriented 0⁰ and the lowest detection rate is in the face orientation 90⁰.

Keywords: face detection, AdaBoost-SVM, real-time, face orientations.

1. Introduction
Detection and recognition of objects are widely used in our daily lives for the purposes of inspection, registration, and manipulation [1]. Face detection, in particular, is probably one of the most interesting object detection that allows the machine to interact with human beings in face recognition. The face is a distinguishing feature that is often used as a key to get to know one’s identity [2]. The Face detection system is complicated due to the level in various of the face are complex, so real-time system [9], the application of the approach so complex will slow system performance, and instead the application of an approach that is not so complex will affect the level of accuracy in the detection of the face. To date more than 150 approaches that have been applied to building a system of detection of the face.

There are several approaches to the problem of recognition of facial expression classification [3] and gender [4] which uses Support Vector Machine (SVM), which the SVM showed better results in terms of the level of truth but requires more intensive computing, while on a research [5]. AdaBoost is much faster with a little more accuracy level decreased. Boosting is a common method to improve the accuracy of the algorithm learning and designed to deal with the problem of classification. The most popular Boosting algorithms based on Freund and Schapire [4] is AdaBoost.

In research conducted by [1] have tried to combine the methods of AdaBoost-SVM to detect faces and this method proved to be able to have a higher detection rate and a lower error rate, and reducing
the time calculation in training. But the facial data detected with image data, not in real-time and face
detection system conducted in this study only detect the orientation of 0°.
Based on the above research, this time, researchers tried to use a combination of methods
AdaBoost and Support Vector Machine (SVM) in real-time data and tries to detect the face at the
various orientations, that is the orientation of the faces of the 90°, 45°, 0°, -45°, and -90°. The
combination of this method is expected to be the most efficient and effective method for face detection
in real-time in a variety of orientations of the face.

2. Face Detection
There are a number of approaches that have been done by some researchers in building a system of
detection of the face. In general, the methods applied on the face detection system can be classified
into [6].
- **Knowledge-based Method**, this method uses the basic rules that are commonly used by humans
to determine what form a face. On this approach, the face detection method developed based on
rules (rule) obtained from the knowledge of the researchers about the human face.
- **Featured Invariant Approach**, algorithm in this method aims to find the structural features of
the face that still exist, although there are variations in pose, viewpoints, and light conditions.
On this approach, the researchers tried to find the features that do not change (invariant) on the
face.
- **Template Matching**, this method will be kept in several standard patterns to describe the face as
a whole nor its parts. At the time of detection will be calculated the correlation between the
input image with the image patterns stored earlier.
- **Appearance-Based Method**, in this method, the model face learned through the process of
training by using a set of training data that contains instances of the face. Then the results of this
training are used to detect faces. In general, this method use techniques of statistical analysis
and machine learning to discover the characteristics of the relevant characteristics of the face.
The challenge facing the problem of face detection caused the following factors [7] the position
of the face. The position of the faces in the image can vary because of the positions may be
upright, tilting, turning, or viewed from the side.
1. The components of the face can exist or not exist, for example, a mustache, beard, and
glasses.
2. Facial expression. The facial appearance is strongly affected by a facial expression, such as
smiling, laughing, sad, talk and so on.
3. Obstructed by other objects. The image of a face can be deterred in part by an object or
another face, for example on the image contains a group of people.
4. Image retrieval Conditions. The image obtained is highly influenced by factors such as light
intensity, a direction of the light source, and the characteristics of the sensor and the quality
of the camera.

3. AdaBoost
AdaBoost short for Adaptive Boosting is a machine learning algorithm that was created from a
collection of a weak classifier which formed into being strong classifier [4]. AdaBoost by Freund and
Schapire in 1995 [8]. Called adaptive because this algorithm can confirm with the data and the method
of classifying. Named after boosting algorithms because it can reduce errors of a weak classifier and
increase the accuracy of any given learning algorithm [12]. This is because basically, AdaBoost
appears to be able to reduce errors in the process of learning[5]. AdaBoost algorithm for feature
selection in large quantities, with only select certain features.
Boosting is a meta-algorithm in machine learning to perform the supervised learning. AdaBoost function to look for features that have a high level of distinction [10]. This is done by evaluating every feature against the training data by using the value of the feature. The features that have the biggest limit between objects and non-object is considered the best features [11].

4. Support Vector Machine (SVM)
Support Vector Machine (SVM) is a technique of performing a prediction which could only distinguish two classes, techniques using a formula which would later form a hyper plane that separates a data into two classes. In General, SVM linear in nature, due to a nonlinear SVM is the result of the modification to include the functions of the kernel. This technique was very tough, but the disadvantage SVM classification in the process still doesn’t have rapid performance [3].

Support Vector Machine (SVM) is a learning system using space hypothesis in the form of linear functions in a space feature (feature space) high-dimensional, trained with the learning algorithm based on optimization theory by implementing learning bias derived from statistical learning theory [1].

5. Research purposes
The purpose of this research is to measure the performance of the combination method of AdaBoost-SVM using real-time data in a variety of orientations of the face.

5.1 AdaBoost-SVM
For AdaBoost-SVM later begins with the selection of a single trait, after each selection process with each error, the smallest error is selected to be used as ingredients for classification SVM training data. The process of AdaBoost-SVM can be described in described below:

- Input sample
- Initiation of weights for each sample
  \[ D_i = \frac{1}{n} \quad (i = 1, 2, ... n) \]  
- For \( t = 1 \ldots T \):
  - For each \( h(x_i) \), calculate the weighted error
    \[ \varepsilon_t^{(i)} = \sum_{j=1}^{n} D_j |h(x_j - y_{(j)})|\pi r^2 \]  
  - Then do the calculation of the weighted error in weak classifier AdaBoost
    \[ a_t = \frac{1}{2} \ln \left( \frac{1 - \varepsilon_t}{\varepsilon_t} \right) \]  
  - After calculating the weighted error above, then done updated on weights for the next iteration process error
    \[ D_{t+1}(i) = D_t(i) \frac{-a y_i h_t(x_i)}{\varepsilon_t} \]  
- Sort the data from lowest to highest error.
- Take the number of data selection as much as.
- At this point, enter the SVM classification which should determine the initial value of initiation, i.e. alpha, maximum iterations, C, epsilon, lambda, and gamma.
- Calculate the value of a linear function of the Kernel
  \[ K(x, y) = x, y \]  
- Calculate The Hessian Matrix
  \[ D_{ij} = y_i y_j \left( K(x_i, x_j + \lambda^2) \right) \]
• Do as muchIteration n times

\[ E_n = \sum_{j=1}^{1} a_i D_{ij} \]  

(7)

• Calculate the maximum value of an alpha,

\[ \delta a_j = \min\{\max[\gamma(1 - E_i) - a_j], c - a_j]\} \]  

(8)

If the maximum value \( |\delta a_j| \) more than epsilon, then iteration continues. However, if the maximum value \( |\delta a_j| \) less than epsilon, then the iteration will stop. After getting the process of AdaBoost-SVM above obtained the data model will be tested with data testing.

6. Research Methodology

Training process

Real time Face Input \( \rightarrow \) Greyscale \( \rightarrow \) Sobel Edge Detection \( \rightarrow \) Face Pattern Model \( \rightarrow \) Face Location Detection Output

Real time Face Input \( \rightarrow \) Greyscale \( \rightarrow \) Sobel Edge Detection \( \rightarrow \) Matching Face Detection Model with AdaBoost-SVM

Testing process

Figure 1. The Scheme Research

Figure 1 describes the research scheme, where there are two processes, namely the process of training and testing process, training process on the input image done pre-processing with Greyscale and Sobel operator using edge detection and continued localized patterns as a model that will be detected at the stage of testing data, and at the stage of testing, the input image done pre-processing with using edge detection of Greyscale and Sobel operator and forwarded to the stages using pattern matching AdaBoost-SVM method. If the pattern is similarly or close to the pattern of training then the pattern will be in blocking as an output location detection is a face.

7. Results and Discussion

Face detection system scheme that was built using a combination of AdaBoost-SVM in this study are illustrated in the following figure:
Figure 2. The Overall Scheme of the System Face Detection

Face detection system performance based on the parameters of the true and false detection. Table 1 illustrates some of the results of measurement performance AdaBoost-combination method of SVM on face detection in real-time in a variety of orientations.

| The number of training | The number of testing | True detection real-time face detection with Adaboost-SVM combination in orientation (orientation) | The average detection rate |
|------------------------|-----------------------|------------------------------------------------------------------------------------------------|---------------------------|
|                        |                       | 90° | 45° | 0° | -45° | -90° | true detection | false detection |
| 10                     | 20                    | 5   | 25  | 40 | 20   | 2   | 50%            | 50%            |
| 20                     | 40                    | 9   | 32  | 55 | 40   | 7   | 62%            | 38%            |
| 40                     | 60                    | 15  | 45  | 75 | 44   | 16  | 78%            | 22%            |
| 60                     | 70                    | 23  | 53  | 87 | 67   | 22  | 89%            | 13%            |
| 80                     | 100                   | 25  | 64  | 92 | 72   | 28  | 95%            | 5%             |

Figure 3a. Training Processing  Figure 3b. Testing Processing (0°) and (90°)
Table 1 describes the results of research in which the detection rate of the highest average in the detection of facial orientated $0^\circ$ is the position of the front view and the detection rate is the lowest in the orientation of the faces of $90^\circ$. True the detection rate reached 95% on 100 test data.

![Real-Time Face Detection With AdaBoost-SVM Combination In Orientation](image)

**Figure 4.** Graph of AdaBoost-SVM performance

Based on Figure 4 graphs illustrates the measurement of performance the work done after 20 sample faces are trained to face pattern characteristics using a combination of methods AdaBoost-SVM. The number of samples testing as many as 100 patterns done gradually in real-time on the orientation $90^\circ$, $45^\circ$, $0^\circ$, $-45^\circ$, and $-90^\circ$, in the early stages of testing done detection system that has trained 10 facial samples taken in real-time in a variety of combinations using the method of face orientation AdaBoost-SVM and obtained results as has been described previously on the table and look at the graph of AdaBoost-SVM performance. The highest detection of the orientation of $0^\circ$ is the orientation of the face position looks ahead to reach 95% the level of accuracy of detection.

8. Conclusion and Future Work

On the research of detection system face trying to build in real-time using a combination of methods AdaBoost-SVM in various orientations to the face. The results of the evaluation of the system show that the increased detection rate is highly associated with an increased amount of training. Based on the results of detection rate face detection in real-time using a combination of methods AdaBoost-SVM in various orientation accuracy rate reaches 95%. There is still room for improvement and some recommendations by adding specific feature extraction and recognition of facial characteristics as complex detail in order to facilitate the detection of the face either in real time or not, it can also combines the methods of AdaBoost with other classification methods.

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