

Face pattern recognition using Expectation-Maximization (EM) algorithm

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ABSTRACT

This paper discusses the use of face pattern recognition which is nowadays become popular, especially on smartphone lock screen systems. The method used in this research is the Expectation-Maximization (EM) Algorithm. EM Algorithm is an iterative optimization method for the estimation of Maximum Likelihood (ML) which is used in incomplete data problems. there are 2 stages, namely the Expectation stage E (E-step) and the Maximization stage M (M-step). These two stages will continue to be carried out until they reach a convergent value. The result of the research shows that EM Algorithm produces high accuracy, it's about 95% on the data training and 83% accuracy in the data testing.

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Introduction

Pattern recognition is a field in machine learning and can be defined as the act of taking raw data and acting on the classification of the data. Thus, pattern recognition is a set of rules for supervised learning (Duda *et al.*, 2001; Schuermann, 1996). Several other definitions of pattern recognition, including: (1) Determination of a physical object or event into one or several categories, (2) Science that focuses on the description and classification (recognition) of a measurement, (3) An automatic recognition of a form, nature, state, condition, arrangement without active human participation in the termination process (Yang *et al.*, 2002; Rujirakul *et al.*, 2014). One of the applications is speech recognition, document text classification into categories (e.g. spam/non-spam e-mails), handwriting recognition, automatic recognition of postal codes on letter covers, or human facial recognition systems (Balafar, 2013). This application mostly uses image analysis for pattern recognition concerning digital images as input into the pattern recognition system.

The problem to be studied is to find out how Expectation-Maximization (EM) plays a role in pattern recognition, especially in face recognition. While the specific purpose of this research is to apply the Expectation-Maximization (EM) Algorithm. The urgency/priority of this research is that facial pattern recognition which is currently used for the security of smartphone devices makes

pattern recognition a very risky thing, due to personal data contained in smartphone devices. One How the Expectation-Maximization (EM) algorithm plays a role in pattern recognition will be studied for its accuracy and speed in this study. The target of this research is to produce new theories, methods, or policy principles that are used for scientific development and can support applied research so that this research is included in the basic research scheme.

Method

Facial pattern recognition is included in the study of the soft clustering method, which theoretically will form a certain distribution pattern, for example in the Mixture Model distribution. The soft clustering method modeling the number of grayscale intensities at each intensity level will form several distribution groups so that each distribution group is represented as a cluster. The type of distribution used for clustering, in general, is the Gaussian distribution or often known as the Normal distribution. Segmentation has been done using the Gaussian Mixture Model (GMM) method, but the results are not good, because this intensity data does not follow the Normal distribution (Zarpak & Rahman, 2008). To overcome these problems, GMM for image segmentation must be optimized to get better results. The optimization method used is Expectation-Ma (EM). Research conducted by Tito (2014) suggests that this EM-GMM method provides a fairly high average accuracy result of 80% in CT Scan image segmentation.

The expectation-maximization Algorithm was first introduced by Dempster *et al.* (1977). EM Algorithm is an iterative optimization method for the estimation of Maximum Likelihood (ML) which is used in incomplete data problems. In each iteration of the EM Algorithm, there are 2 stages, namely the Expectation stage E (E-step) and the Maximization stage M (M-step). In the E-step, the expected value of the data parameter is calculated, and the M-step calculates the estimated parameter value using the expected value found in the previous step. The two stages will continue to be carried out until they reach a convergent value.

The basic idea of the EM Algorithm is to associate a complete data problem with an incomplete data problem to make it computationally easier. This stage is in the E-step, where a surrogate function will be built which involves a kind of 24 unobserved variables to be expected. In MM, the surrogate function is Minorize which will be maximized at the M-step stage. In the E-step stage, conditional expectations will be searched for missing data, provided that the data is known for its value (observed) and its parameter estimator, then the expected value obtained is substituted for the missing data (Sianipar, 2017). The missing data in question is a function of the missing observations (Y_{MISS}) that appear in the complete data loglikelihood, namely $\ell(\theta|Y)$, then, M steps in EM determine the value of $\theta^{(\theta+1)}$.

In summary, the EM Algorithm is given:

- (1) E-step: estimate the sufficient statistic for Y_t by calculating the expected value.
- (2) M-step: find $\theta^{(\theta+1)}$ from Y_t by using the Maximum Likelihood Estimation method
- (3) Iterate until the value $\theta^{(t)}$ convergent, or $|\theta^{(\theta+1)} - \theta^{(t)}| < \epsilon$ where ϵ is a very small value close to 0.

Results and Discussion

The research that has been carried out for several months has done several things, firstly searching the literature that is relevant to the research that has been done and obtaining several studies, research conducted by Yang (2002), it was found that EM algorithms can accurately detect facial patterns with multiple poses and lighting conditions. The data obtained in this study took a dataset from Kaggle by taking data in the form of facial images and a total dataset of 600MB in size. From

the data, there are 8 face classification classes, including: {'Ariel Sharon', 'Colin Powell', 'Donald Rumsfeld', 'George W Bush', 'Gerhard Schroeder', 'Hugo Chavez', 'Junichiro Koizumi', 'Tony Blair'}. The class of the face recognition of the data is shown in Figure 1.



Figure 1. Face Classification Target

Before the EM Algorithm is applied, dimension reduction is first performed on the dataset, using PCA (Principal Component Analysis). From the PCA process it calculated the results of dimension reduction PCA (Rujirakul *et al.*, 2014), the result is obtained in Figure 2.

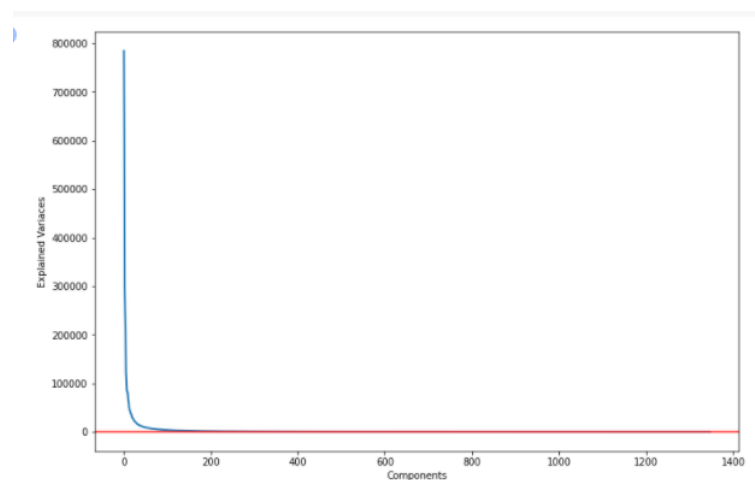


Figure 2. Dimensional reduction using PCA

Based on Figure 2, it is found that the PCA reduction component has converged to the 180 component, which means that the maximum reduction value of PCA is reduced to 180 components. The next step is to divide the datasets into data training and data test with a comparison of 70% data testing and 30% data training and the classification results are obtained in Figure 3.

Based on Figure 3, the classification results show that the highest precision value is in the 4th class, at 90%, which means that the ratio of correctly predicted observations is 90%. The 4th class precision value is supported by a recall value of 85%, which means that the precision and recall values are high, which means that predictions made using the EM algorithm give good results. Both the E steps and M steps also the iteration are done and integrated by the software Python.

	precision	recall	f1-score	support
Ariel Sharon	0.71	0.80	0.75	15
Colin Powell	0.79	0.84	0.81	68
Donald Rumsfeld	0.79	0.74	0.77	31
George W Bush	0.90	0.85	0.87	126
Gerhard Schroeder	0.77	0.74	0.76	23
Hugo Chavez	0.82	0.70	0.76	20
Junichiro Koizumi	0.86	1.00	0.92	12
Tony Blair	0.77	0.86	0.81	42
accuracy			0.82	337
macro avg	0.80	0.82	0.81	337
weighted avg	0.83	0.82	0.82	337

Figure 3. Classification Report EM Algorithm

The results of the overall analysis resulted in an accuracy value of 95% for the training data and an accuracy of 83% for the data test, which means that the EM Algorithm accuracy value for the dimension reduction process in the classification is optimal.

Conclusion

The result shows that the EM Algorithm surely can be used to solve Pattern Recognition, especially in face recognition. Combining the EM Algorithm dan PCA produces an accuracy value on 95% of the training data and 83% accuracy on the testing data.

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