SinkrOn : Jurnal dan Penelitian Teknik Informatika
Volume 5, Number 1, October 2020
DOI : https://doi.org/10.33395/sinkron.v5i1.10612
e-ISSN : 2541-2019
p-ISSN : 2541-044X

Facial Recognition Implementation using K–NN and PCA Feature Extraction in Attendance System

Juliansyah Putra Tanjung[1)*], Bayu Angga Wijaya[2)]
[1)2)]Univesitas Prima Indonesia, Indonesia
[1)]juliansyahputratanjung@unprimdn.ac.id , [2)]bayuanggawijaya@unprimdn.ac.id

Submitted : Sept 4, 2020 | **Accepted** : Oct 1, 2020| **Published** : Oct 6, 2020

Abstract— Attendance is the fact that someone is present at an event or goes regularly to an institution, or attendance at an event is the number of people present at that time. The Saifiatul Amaliyah school itself is one of the many schools in Indonesia where the attendance of students or attendance is still done manually. This can cause problems, namely allowing fraud when filling in attendance and errors in data recapitulation. Therefore, in this study a computerized face attendance was created, which was formed using the K-Nearest Neighbor (K-NN) method and combined with the extraction of the Principal Component Analysis (PCA) feature where the attendance process can be done with a person's face. The face attendance system using the K-NN and PCA methods has an accuracy of 82%.

Keywords— Face; K-Nearest Neighbor (K – NN); Principal Component Analysis (PCA); Attendance; School;

INTRODUCTION

According (Patel, 2014) *Cobuild learners dictionary*, Attendance is the fact that someone is present at an event or goes regularly to an institution, or attendance at an event is the number of people present at that time (Patel, 2014). The Shafiatul Amaliyah school itself is one of the many schools in Indonesia that in regulating the attendance of their students or attendance, it is still done manually by hand writing, using the attendance sheet provided by the teacher in class, it is an ineffective and time-consuming way. Additionally, it is very difficult to individually verify students in large classroom environments with distributed branches whether authenticated students (Nirmalya Kar, Mrinal Kanti Debbarma, Ashim Saha, 2012) attend or not. It took some time to record attendance.

Human face recognition technology is a detection technology that has received a lot of attention from researchers (Rizal & HS, 2019). The method is to peek at a special opening so that the facial image can be imaged by a computer. However, in its development, there are still several kinds of problems, apart from computation and data storage capacity problems, the condition of the human face image that becomes the system input is also an important problem. (Aini & Irmawati, 2017). One of the solutions is biometric technology, which is used for automatic identification and verification based on the behavior (behavioral) or physical traits of a person. (Pratniko, 2013),

The biometric system to identify a person with body parts that already exist in a person is an interesting thing to study. This system can identify a person's identity by their physiological characteristics (Sulistiyo et al., 2014). Biometric identification techniques are based on natural human characteristics, namely physiological characteristics and behavioral characteristics such as face, fingerprints, voice, palms, iris and eye retina, DNA, and signatures. (Rahman et al., 2015). Biometrics based on behavioral characteristics reflect more on individual psychological conditions, for example: gait, signature and speech patterns (Pratniko, 2013). Facial recognition has many benefits over other biometric methods. Most of the other forms of biometrics require some action by the user. However, facial recognition can be performed without user involvement due to the fact that facial images can be obtained from a distance by the camera (Okokpujie et al., 2017).

Facial recognition technique is one of the most efficient biometric techniques for human identification (Rizal, Gulo, Sihombing, Napitupulu, Gultom, & Siagian, 2019). We can use it in education to manage student attendance (Wagh et al., 2016). Face is a person's identity. The method for making use of these physical features has seen major changes since the advent of image processing techniques (Patil & Shukla, 2014) (Muhathir, 2018). Facial recognition techniques have now made significant advances (Kurniawan et al., 2014). Recent advances in these areas, especially

*Corresponding Author

SinkrOn : Jurnal dan Penelitian Teknik Informatika
Volume 5, Number 1, October 2020
DOI : https://doi.org/10.33395/sinkron.v5i1.10612
e-ISSN : 2541-2019
p-ISSN : 2541-044X

in deep learning, provide the possibility to use this method to find practical solutions. This solution can be more flexible and can reduce errors that may occur (Arsenovic et al., 2017). In this study, the face attendance system was formed using the K-Nearest Neighbor (K-NN) method and combined with the Principal Component Analysis (PCA) feature extraction where the attendance process can be done with a person's face. (Muliawan et al., 2015).

By utilizing a pattern of physical characteristics, this study is used to identify a student, namely by facial recognition (Rizal, Girsang, & Prasetiyo, 2019). In the application of face recognition itself is to use a camera to capture an image of a person's face, then the image is compared with the face that was previously stored in a database containing data on the faces of other students. Facial recognition requires many variables, for example, source image, image processing result, extracted image, person's profile data and a camera sensor is also needed as a sensing tool to classify the image captured by a human face webcam or not. (Muliawan et al., 2015).

The K-Nearest Neighbor (K–NN) is a statistical learning algorithm that has been studied as a pattern recognition approach for more than four decades. (Al-Shalabi et al., 2006). K-Nearest Neighbor works by classifying objects based on learning data that is the closest distance to the object. The K-NN algorithm is a method that uses a supervised algorithm. K-NN is a group of instance base learning. K-NN is also a lazy learning (Mustakim, 2016) technique. The way K-NN works is by looking for groups of k objects in the training data that are closest (similar) to the objects in the new data or the input testing data. In general, to define the distance between two objects x and y, the Euclidean distance formula is used in the equation (Mustakim, 2016)(Mejdoub & Ben Amar, 2013)(Kuang & Zhao, 2009) (Pariyandani, Larasati, Wanti, & Muhathir, 2019).

Principal Component Analysis (PCA) is a basic transformation for diagonalizing the approximate covariance matrix data x*, $k = 1, \dots, \ell, \mathrm{X_k} \in \mathrm{R^N}, \sum_{\mathrm{k}=1}^{\ell} \mathrm{X_k} = 0$, defined as (SchSlkopf, B., Smola, A., & Muller, K.L., 2011):

$$C = \frac{1}{\ell} \sum_{j=1}^{\ell} X_{\mathrm{j}} X_j^T \quad (1)$$

According (Ismawan, 2015) Principal Component Analysis (PCA) is a technique for extracting the structure of a data set that is reliable and reliable with a large number of dimensions. The problem in PCA is finding the eigenvalues and eigenvectors. PCA is an orthogonal (perpendicular) transformation of the coordinate system in which data is described. With the new coordinates the data described is called a principal component or PC. The coordinates are selected based on the variance of the data reaching the maximum (Ismawan, 2015).

The basic principle of the PCA algorithm is by projecting an image into its eigenvector space by looking for the eigenvector that each image has and then projecting it into the eigen-space obtained. (Ismawan, 2015). By using these two methods, the face attendance system is expected to be accurate in recognizing and classifying a person's face. Can help Saifiatul Amaliyah school in improving student data collection and avoiding mistakes or mistakes in inputting attendance data.

LITERATURE REVIEW

Pattern Recognition

Pattern is a form where each pattern has its characteristics. These characteristics are used to distinguish one pattern from another. Good characteristics are characteristics that have high distinguishing power, so that grouping patterns based on their characteristics can be done with high accuracy (Muliawan et al., 2015). Pattern recognition uses the similarity method in viewing information content extracted from low-level features (Antani, S., Kasturi, R., & Jain, R., 2002). Various pattern recognition models, namely statistical techniques, structural techniques, model adjustments, neural network-based techniques, fuzzy models and hybrid models (Asht et al., 2013).

Face Recognition

Facial recognition is a biometric technology that has been widely applied in security systems in addition to recognition of the retina, fingerprint and iris recognition (Rizal, Girsang, & Prasetiyo, 2019). In the application itself, face recognition uses a camera to capture a person's face and then compare it with faces that have previously been stored in a certain database (Muliawan et al., 2015). In general, facial recognition is carried out from the front side with the lighting evenly across the face. However, several problems arise, such as face position, face scale or distance, orientation, age, facial expressions and the tools used around the face that allow for error detection. (Tanjung & Muhathir, 2020) (Indra et al., 2019).

K-Nearest Neighbor (K-NN)

K-Nearest Neighbor is an algorithm for classifying objects based on learning data that is closest to the object (Fatoni & Noviandha, 2018)(Rivki & Bachtiar, 2017)(Noviana et al., 2019)(Muhathir , Sibarani, & Al-Khowarizmi,2020). K-NN is a method for finding cases by calculating the closeness between new cases and old cases. The K-NN algorithm is one of the methods used for classification analysis, but the k-NN method is also used for prediction (Noviana et al., 2019). The K-Nearest Neighbor (K-NN) algorithm is a method that uses a supervised

SinkrOn : Jurnal dan Penelitian Teknik Informatika
Volume 5, Number 1, October 2020
DOI : https://doi.org/10.33395/sinkron.v5i1.10612
e-ISSN : 2541-2019
p-ISSN : 2541-044X

algorithm (Mustakim, 2016) (Sandi, Siahaan, Permana, & Muhathir, 2019). The K-Nearest Neighbor (K-NN) algorithm is one of the simplest algorithms (Al-Shalabi et al., 2006) to solve classification problems and often produce significant and competitive results (Nikmatun & Waspada, 2019).

The KNN algorithm is a widely applied method for machine learning classification and pattern recognition. However, we cannot get satisfactory performance in many applications, because the K-NN algorithm has a high computational complexity (Kuang & Zhao, 2009). The K-Nearest Neighbor (K-NN) classification is an instance-based learning algorithm (Deng et al., 2016) which is very suitable for use when classifying images described by local features (Mejdoub & Ben Amar, 2013). K-NN statistical learning algorithm (Alkhatib et al., 2013) which has been studied as a pattern recognition approach for over four decades (Al-Shalabi et al., 2006).

K - Nearest Neighbor (NN) is one of the most popular classification methods and is included in the lazy learner classification. (Mustakim, 2016) because it delays the training process until there is test data that the class label wants to know, the new method will run the algorithm (Sanim R., R., Zeniarja, J. & Luthfiarta, A., 2016). The previous K-NN method first selects the k closest training sample for the test sample, and then predicts the test sample with the main class among the k closest training sample. However, K-NN needs to calculate the distance (or similarity) of all training samples for each test sample in the process of choosing k to approximate neighbors t (Deng et al., 2016)(Al-Shalabi et al., 2006)(Wang & Wang, 2007). In general, the k value uses an odd number so that there are not the same distances in the classification process. Far or near neighbor is calculated using Euclidean distance (Fatoni & Noviandha, 2018).

The special case in which the classification is predicted based on the closest learning data (in other words, k = 1) is called the K - Nearest Neighbor algorithm. The formula for calculating similarity weight with K-Nearest Neighbor is shown in equation (1) (Fatoni & Noviandha, 2018).

$$Similarity(T,S) = \frac{\sum_{i=1}^{n} f(T_i,S_i)\times W_i}{W_i} \qquad (2)$$

Information:

T : A new case
S : The case is in storage
n : The number of attributes in each case
i : Individual attributes between 1 to 1 n
f : The i attribute similarity function between case T and case S
w : The weight given between the to-1 attribute

The distance between two points on the training data and points on the testing data can be defined by the Euclidean formula, as follows (Fatoni & Noviandha, 2018):

$$d = \sqrt{\sum_{i=1}^{p}(x_{21} - x_{1i})^2} \qquad (3)$$

With :

d : Euclidean distance
x_{2i} : The value in the testig data - i
x_{1i} : Value in the training data - i
p : The number of attributes

Data Normalization

The Min-Max Normalization formula is as follows (Fatoni & Noviandha, 2018).

$$X^* = \frac{X - \min(X)}{\max(X) - \min(X)} \qquad (4)$$

With :

X^* : New data
X : Old data
Min(X) : The minimum value of data per column
Max(X) : The maximum value of data per column

Principal Component Analysis (PCA)

The basic principle of Principal Component Analysis (PCA) is the projection of the image into its eigen space / face space (Suryadi, 2015). According to the article (Kusnadi & Ranny, 2017) PCA is a linear transformation

SinkrOn : Jurnal dan Penelitian Teknik Informatika
Volume 5, Number 1, October 2020
DOI : https://doi.org/10.33395/sinkron.v5i1.10612
e-ISSN : 2541-2019
p-ISSN : 2541-044X

commonly used in data compression. PCA is also a commonly used technique to pull features from data at a high-dimensional scale (Kusnadi & Ranny, 2017). The PCA method basically rotates a set of points around the mean in order to match the main component, this method mobilizes as much variance as possible by using linear transformations into several dimensions. (Husein et al., 2017). Eigenfaces PCA is used to reduce the dimensions of a set or drawing space so that the new base or coordinate system can better describe the typical model of the set. (Zein, 2018).

Principal Component Analysis (PCA) algorithm is a method that can be used to manipulate a person's facial image so that the system will automatically recognize a person's face through its main characteristics such as eyes, nose, lips, eyebrows as identity. (Nugrahney, D., 2000). PCA can be used to represent samples with a smaller number of variables, visualize samples and genes, and detect dominant patterns of gene expression. (Ringnér, 2008). PCA is one of the most important and powerful methods of chemometry and is popularly used in many fields (Bro & Smilde, 2014).

Principal Component Analysis (PCA) is a standard tool in modern data analysis in fields ranging from neuroscience to computer graphics, as it is a simple non-parametric method for extracting relevant information from confusing data sets. (Shlens, 2014). Principal Component Analysis (PCA) data analysis and processing techniques are widely implemented, but not based on probability models (Michael E. Tipping & Christopher M. Bishop., 1999). Principal Component Analysis (PCA) is a basic transformation for diagonalizing the approximate covariance matrix data x*, $k = 1, \dots, \ell, \mathrm{X_k} \in \mathrm{R^N}, \sum_{\mathrm{k=1}}^{\ell} \mathrm{X_k} = 0$, didefinisikan sebagai (SchSlkopf, B., Smola, A., & Muller, K.L., 2011):

$$C = \frac{1}{l}\sum_{j=1}^{l} X_j X_j^T \qquad (5)$$

The new coordinates in the base of the Eigenvector, i.e. orthogonal projections to the Eigenvectors, are called principal components. In this study, we generalize this arrangement to a nonlinear one of the following types. Suppose we first map data nonlinearly into the feature space F with (SchSlkopf, B., Smola, A., & Muller, K.L., 2011):

$$\emptyset : R^N \rightarrow F, \; X \mapsto X \quad (6)$$

We will show that even if F has arbitrary large dimensions, definitely choice ¢, we can still perform PCA on F. This is done using known kernel functions from Support Vector Machines (SchSlkopf, B., Smola, A., & Muller, K.L., 2011).

PROPOSED METHOD

Dataset

In this study, the dataset was taken directly using SLR cameras in shafiatul amaliyah high school class with the number of students 10 people, for each student face sample was taken as many as 30 face images from various angles. The total sample used in this study was 300 samples.

Research schemes

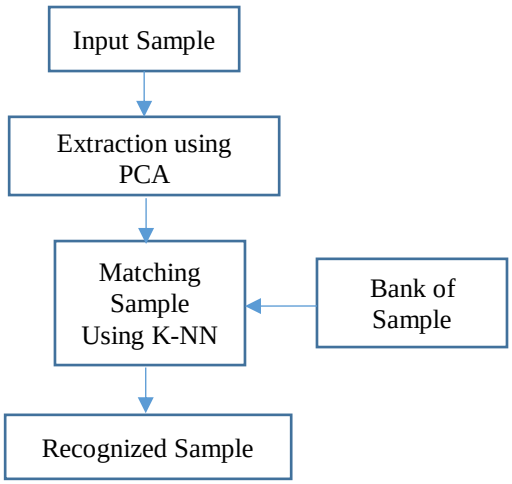

Figure 1. Research schemes

SinkrOn : Jurnal dan Penelitian Teknik Informatika
Volume 5, Number 1, October 2020
DOI : https://doi.org/10.33395/sinkron.v5i1.10612
e-ISSN : 2541-2019
p-ISSN : 2541-044X

In figure 1 illustrating how the introduction of absentee facial samples using the K-NN and PCA classification methods as extraction work, the way this study works by giving facial input into the system will automatically extract with PCA and will be classified with K-NN algorithm based on the data bank that has been provided.

RESULT

Facial samples

In this study the sample used was a sample of the face of a high school student at shafiyyatul amaliyyah school, here are some facial samples.

Figure 2. Facial samples

Facial attendance recognition results

The results of facial attendance research using K-NN and PCA assistance as the extraction of its features can be seen in table 1.

Table 1
Facial attendance recognition results

	Subj 1	**Subj 2**	**Subj 3**	**Subj 4**	**Subj 5**	**Subj 6**	**Subj 7**	**Subj 8**	**Subj 9**	**Subj 10**
Subject 1	**10**	0	0	0	0	0	0	0	0	0
Subject 2	0	**10**	0	0	0	0	0	0	0	0
Subject 3	0	0	**8**	1	0	1	0	1	2	0
Subject 4	0	0	0	**9**	2	1	1	1	1	1
Subject 5	0	0	0	0	**7**	0	0	0	0	0
Subject 6	0	0	1	0	0	**8**	0	0	1	1
Subject 7	0	0	1	0	1	0	**9**	0	0	1
Subject 8	0	0	0	0	0	0	0	**8**	0	0
Subject 9	0	0	0	0	0	0	0	0	**6**	0
Subject 10	0	0	0	0	0	0	0	0	0	**7**

In table 1, the results of facial attendance recognition are visible. In this study, facial samples tested 10 tests for each subject, subject 1 and subject 2 out of 10 tests were successfully identified all, in subject 4 and subject 7 the test was successfully identified 9 samples and 1 sample was incorrect in its introduction, on subject 3, subject 6 and subject 8 tested successfully as many as 8 samples and erroneously 2 samples , in subject 5 and subject 10 samples can be correctly identified as many as 7 samples and 3 samples are mistaken in recognizing them, and in subject 9 tests that were successfully identified only 6 samples while the wrong one reached 4 samples.

Based on the tests that have been done facial attendance testing the best introduction is found in subject 1 and subject 2, while the results of facial attendance test on subject 9 get the worst test results.

The results of facial attendance recognition are illustrated in figure 3.

SinkrOn : Jurnal dan Penelitian Teknik Informatika
Volume 5, Number 1, October 2020
DOI : https://doi.org/10.33395/sinkron.v5i1.10612
e-ISSN : 2541-2019
p-ISSN : 2541-044X

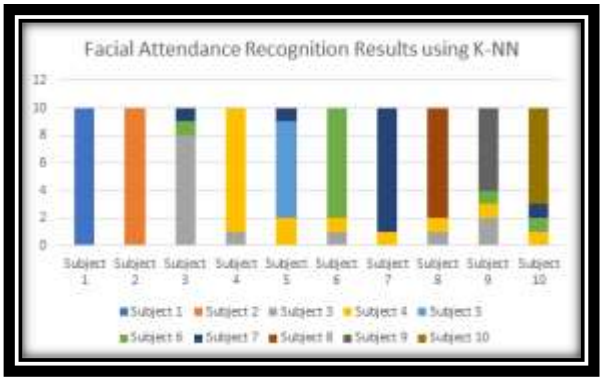

Figure 3. Facial attendance recognition using KNN

CONCLUSION

The results of the introduction of facial absenteeism in the school Shafiyyatul Amaliyyah using the classification method K-NN and the PCA feature extraction method obtained an accuracy rate of absenteeism as much as 82%, so the K-NN and PCA methods have not been optimal to be implemented as facial absenteeism in Shafiatul Amaliyah school.

ACKNOWLEDGMENT

Our thanks go to the Directorate of Research and Community Service, Directorate General of Research and Development Strengthening of the Ministry of Research, Technology and Higher Education for funding the Penelitian Dosen Pemula (PDP) in the year of implementation 2020.

REFERENCES

Aini, N., & Irmawati. (2017). Implementasi Metode Fisherface pada Absensi Wajah Karyawan Studi Kasus PT . Illuminati Metamorphosis Makassar. *Seminar Nasional Teknologi Informasi Dan Multimedia*, 109–114.

Al-Shalabi, R., Kanaan, G., & Gharaibeh, M. H. (2006). Arabic Text Categorization Using kNN Algorithm. *Proceedings of The 4th International Multiconference on Computer Science and Information Technology*, 5–7.

Alkhatib, K., Najadat, H., Hmeidi, I., & Shatnawi, M. K. A. (2013). Stock Price Prediction Using K-Nearest Neighbor Algorithm. *International Journal of Business, Humanities and Technology*, *3*(3), 32–44.

Antani, S., Kasturi, R., & Jain, R., (2002). A survey on the use of pattern recognition methods for. *Pattern Recognition*, *35*, 945–965.

Arsenovic, M., Sladojevic, S., Anderla, A., & Stefanovic, D. (2017). FaceTime - Deep learning based face recognition attendance system. *SISY 2017 - IEEE 15th International Symposium on Intelligent Systems and Informatics, Proceedings*, 53–57. https://doi.org/10.1109/SISY.2017.8080587

Asht, S., Dass, R., Fallis, A. ., Dn, T. Y., Yyepg, T., Cambria, E., Huang, G.-B., Kasun, L. L. C., Zhou, H., Vong, C. M., Lin, J., Yin, J., Cai, Z., Liu, Q., Li, K., Leung, V. C. M., Feng, L., Ong, Y.-S., Lim, M.-H., … Liu, J. (2013). Pattern Recognition Techniques: A Review. *Journal of Chemical Information and Modeling*, *53*(9), 1689–1699. https://doi.org/10.1017/CBO9781107415324.004

Bro, R., & Smilde, A. K. (2014). Principal component analysis. *Analytical Methods*, *6*(9), 2812–2831. https://doi.org/10.1039/c3ay41907j

Deng, Z., Zhu, X., Cheng, D., Zong, M., & Zhang, S. (2016). Efficient kNN classification algorithm for big data. *Neurocomputing*, *195*, 143–148. https://doi.org/10.1016/j.neucom.2015.08.112

Fatoni, C. S., & Noviandha, F. D. (2018). Case Based Reasoning Diagnosis Penyakit Difteri dengan Algoritma K-Nearest Neighbor. *Creative Information Technology Journal*, *4*(3), 220. https://doi.org/10.24076/citec.2017v4i3.112

Husein, A. M., Harahap, M.,(2017). Pengenalan Multi Wajah Berdasarkan Klasifikasi Kohonen SOM Dioptimalkan dengan Algoritma Discriminant Analysis PCA. *QUERY : Jurnal Sistem Informasi Volume : . 5341*(October), 33–39.

Indra, E., Batubara, M. D., Yasir, M., & Chau, S. (2019). Desain dan Implementasi Sistem Absensi Mahasiswa Berdasarkan Fitur Pengenalan Wajah dengan Menggunakan Metode Haar-Like Feature. *Jurnal Teknologi Dan Ilmu Komputer Prima (JUTIKOMP)*, *2*(2), 11. https://doi.org/10.34012/jutikomp.v3i1.637

Ismawan, F. (2015). Hasil Ekstraksi Algoritma Principal Component. *Jurnal Sisfotek Global*, *5*(1), 26–30.

Kuang, Q., & Zhao, L. (2009). A practical GPU based kNN algorithm. *International Symposium on Computer*

Science and Computational Technology (ISCSCT), *7*(3), 151–155.
Kurniawan, Akuwan, A. S., & Ramadijanti, N. (2014). Aplikasi Absensi Kuliah Berbasis Identifikasi Wajah Menggunakan Metode Gabor Wavelet. *Jurnal ICT*, *Face Regocnition*, 6.
Kusnadi, A., & Ranny, R. (2017). Identifikasi Dini Kerusakan Jalan Flexible Pavement Dengan Menggunakan Algoritma PCA. *Jurnal ULTIMATICS*, *8*(2), 1–6. https://doi.org/10.31937/ti.v8i2.521
Mejdoub, M., & Ben Amar, C. (2013). Classification improvement of local feature vectors over the KNN algorithm. *Multimedia Tools and Applications*, *64*(1), 197–218. https://doi.org/10.1007/s11042-011-0900-4
Michael E. Tipping & Christopher M. Bishop., (1999). Probabilistic Principal Component Analysis. *International Journal of Pharma and Bio Sciences*, *1*(2).
Muhathir, M. (2018). KLASIFIKASI EKSPRESI WAJAH MENGGUNAKAN BAG OF VISUAL WORDS. *JITE (JOURNAL OF INFORMATICS AND TELECOMMUNICATION ENGINEERING)*, *1*(2), 73-82.
Muhathir, M., Sibarani, T. T., & Al-Khowarizmi, A.-K. (2020, May). Analysis K-Nearest Neighbors (KNN) in Identifying Tuberculosis Disease (Tb) By Utilizing Hog Feature Extraction. *Al'adzkiya International of Computer Science and Information Technology (AIoCSIT) Journal*, *1*(1).
Muliawan, M. R., Irawan, B., & Brianorman, Y. (2015). Implementasi Pengenalan Wajah Dengan Metode Eigenface Pada Sistem Absensi. *Jurnal Coding, Sistem Komputer Untan*, *03*(1), 41–50. http://jurnal.untan.ac.id/index.php/jcskommipa/article/viewFile/9727/9500
Mustakim, G. O. (2016). Algoritma K-Nearest Neighbor Classification. *Jurnal Sains, Teknologi Dan Industri*, *13*(2), 195–202. http://ejournal.uin-suska.ac.id/index.php/sitekin
Nikmatun, I. A., & Waspada, I. (2019). Implementasi Data Mining untuk Klasifikasi Masa Studi Mahasiswa Menggunakan Algoritma K-Nearest Neighbor. *Jurnal SIMETRIS*, *10*(2), 421–432.
Nirmalya Kar, Mrinal Kanti Debbarma, Ashim Saha, and D. R. P. (2012). Study of Implementing Automated Attendance System Using Face Recognition Technique. *International Journal of Computer and Communication Engineering*, *1*(2), 100–103. http://www.ijcce.org/papers/28-N010.pdf
Noviana, D., Susanti, Y., & Susanto, I. (2019). Analisis Rekomendasi Penerima Beasiswa Menggunakan Algoritma K-Nearest Neighbor (K-Nn) Dan Algoritma C4.5. *Seminar Nasional Penelitian Pendidikan Matematika (SNP2M) 2019 UMT*, 79–87.
Nugrahney, D., (2000). Hasil Ekstraksi Algoritma Principal Component Analysis (Pca) Untuk Pengenalan Wajah.
Okokpujie, K., Noma-Osaghae, E., John, S., Grace, K. A., & Okokpujie, I. P. (2017). A face recognition attendance system with GSM notification. *2017 IEEE 3rd International Conference on Electro-Technology for National Development, NIGERCON 2017*, *2018-Janua*, 239–244. https://doi.org/10.1109/NIGERCON.2017.8281895
Patel, U. A. (2014). Computer Science and Management Studies Development of a Student Attendance Management System Using RFID and Face Recognition: A Review. *International Journal of Advance Research In*, *2*(8), 109–119.
Patil, A., & Shukla, M. (2014). Implementation of Classroom Attendance System Based On Face Recognition In Class. *7*(3), 974–979.
Pariyandani, A., Larasati, D. A., Wanti, E. P., & Muhathir. (2019). Klasifikasi Citra Ikan Berformalin Menggunakan Metode k-NN dan GLCM. *(Semantika) Seminar Nasional Teknologi Informatika. 2*, pp. 42-47. Politeknik Ganesha Medan.
Pratniko, H. (2013). Sistem Absensi Berbasiskan Pengenalan Wajah Secara Realtime Menggunakan Webcam Dengan Metode Pca. STIKOM SURABAYA.
Rahman, M. A., Wasista, I. S., Kom, M., (2015). Sistem Pengenalan Wajah Menggunakan Webcam Untuk Absensi Dengan Metode Template Matching. *Elektronika*, 1–6.
Ringnér, M. (2008). What is principal component analysis?. *Nature Biotechnology*, *26*(3), 303–304. https://doi.org/10.1038/nbt0308-303
Rizal, R. A., & HS, C. (2019, October). Analysis of Facial Image Extraction on Facial Recognition using Kohonen SOM for UNPRI SIAKAD Online User Authentication. *SINKRON*, *4*(1), 171-176.
Rizal, R. A., Girsang, I. S., & Prasetiyo, S. A. (2019). Klasifikasi Wajah Menggunakan Support Vector Machine (SVM). *REMIK*, *3*(2), 1-4.
Rizal, R. A., Gulo, S., Sihombing, O. D., Napitupulu, A. B., Gultom, A. Y., & Siagian, T. J. (2019). Analisis Gray Level Co-Occurrence Matrix (Glcm) Dalam Mengenali Citra Ekspresi Wajah. *Jurnal Mantik*, *3*(2).
Rivki, M., & Bachtiar, A. M. (2017). Implementasi Algoritma K-Nearest Neighbor Dalam Pengklasifikasian Follower Twitter Yang Menggunakan Bahasa Indonesia. *Jurnal Sistem Informasi*, *13*(1), 31. https://doi.org/10.21609/jsi.v13i1.500
Sandi, B., Siahaan, J. K., Permana, P., & Muhathir. (2019). Klasifikasi Citra Wayang Dengan Menggunakan Metode k-NN & GLCM. *(Semantika) Seminar Nasional Teknologi Informatika. 2*, pp. 71-77. Politeknik Ganesha Medan.

Sanim R., R., Zeniarja, J. & Luthfiarta, A., (2016). Penerapan Algoritma K-Nearest Neighbor pada Information Retrieval dalam Penentuan Topik Referensi Tugas Akhir. *Journal of Applied Intelligent System*, *1*(2), 123–133.

SchSlkopf, B., Smola, A., & Muller, K.L., (2011). Kernel Principal Component Analysis Bernhard. *583_1.Tif*. *3*, 1–6. papers://22880b5a-c3f7-4a61-9e33-ed4c97fcb3c7/Paper/p254

Shlens, J. (2014). *A Tutorial on Principal Component Analysis*. http://arxiv.org/abs/1404.1100

Sulistiyo, W., Suyanto, B., Hestiningsih, I., Mardiono, & Sukamto. (2014). Rancang Bangun Prototipe Aplikasi Pengenalan Wajah untuk Sistem Absensi Alternatif dengan Metode Haar Like Feature dan Eigenface. *Jtet*, *3*(2), 93–98. https://jurnal.polines.ac.id/index.php/jtet/article/view/180/172

Suryadi, A. (2015). Sistem Pengenalan Wajah Menggunakan Metode Principal Component Analysis (PCA) Dengan Algoritma Fuzzy C-Means (FCM). *Jurnal Pendidikan Matematika*, *4*(2), 58–65. http://e-mosharafa.org/index.php/mosharafa/article/view/mv4n2_2/194.

Tanjung, J. P., & Muhathir. (2020). Classification of facial expressions using SVM and HOG. *JITE (JOURNAL OF INFORMATICS AND TELECOMMUNICATION ENGINEERING)*, *3*(2), 210-215.

Wagh, P., Thakare, R., Chaudhari, J., & Patil, S. (2016). Attendance system based on face recognition using eigen face and PCA algorithms. *Proceedings of the 2015 International Conference on Green Computing and Internet of Things, ICGCIoT 2015*, 303–308.https://doi.org/10.1109/ICGCIoT.2015.7380478

Wang, Y., & Wang, Z. O. (2007). A fast KNN algorithm for text categorization. *Proceedings of the Sixth International Conference on Machine Learning and Cybernetics, ICMLC 2007*, *6*(August), 3436–3441. https://doi.org/10.1109/ICMLC.2007.4370742

Zein, A. (2018). Pendeteksian Multi Wajah dan Recognition Secara Real Time Menggunakan Metoda Principal Component Analysis (PCA) dan Eigenface. *Jurnal Teknologi Informasi ESIT*, *12*(1), 1–7.