 ISSN 2714-7533

Implementation of Convolutional Neural Network and Vincenty Formula on Face Attendance System Web-Based for Managing the Attendance

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ARTICLE INFO

Article history
Received August 10, 2023
Revised September 15, 2023
Accepted October 10, 2023

Keywords
Attendance
Vicenty Formula
CNN
Student
Face recognition

ABSTRACT

The level of student attendance at tertiary institutions has a crucial role in determining the quality of education. The Information Technology Department at Padang State Polytechnic realizes the urgent need to increase the efficiency of managing student attendance, which currently still relies on a manual attendance system. As an innovative solution, this research proposes designing a face-based attendance system that utilizes facial recognition technology to verify student attendance automatically. One of the challenges in developing a face-based attendance system is the accuracy of calculating the distance between the student's location and the institutional location. To overcome this problem, the research used the Vincenty Formula method which was proven to have a high level of accuracy in calculating the distance between two points on the earth. The integration of this method is expected to increase the accuracy of calculating the distance between the student's location and the institution. Apart from that, this attendance system adopts the Convolutional Neural Network (CNN) algorithm, an algorithm specifically designed to process two-dimensional data. CNN is used to learn and detect features in images, so that facial recognition can be done with a high level of accuracy. This approach is expected to improve system performance in recognizing and verifying student attendance.

1. Introduction

In the world of higher education, the level of student attendance is a critical factor that has a significant influence on the quality and success of learning. Special focus is given to the Information Technology Department at Padang State Polytechnic, where currently student attendance management still relies on a manual attendance system which is time consuming and tends to produce less accurate data. Therefore, there is a need for innovation in the form of a more effective attendance system.

One solution that has developed rapidly is face-based attendance systems, which use facial recognition technology to automatically verify student attendance. However, certain challenges, especially in the accuracy of calculating the distance between student locations and institutions, need to be overcome. This research proposes the use of the Vincenty Formula, a distance calculation method that is renowned for its high level of accuracy.

This system will also be developed by utilizing web technology to enable access via mobile devices, which have now become a popular means of accessing various services. By combining facial recognition technology, accurate distance calculations, and accessibility via mobile devices, this research aims to increase the effectiveness of student attendance management in the Information Technology Department. It is hoped that this system will not only provide a more accurate and efficient solution but also improve the student experience in reporting their attendance. Overall, this research seeks to make a positive contribution to the development of technology in the context of higher education.

2. Method

2.1 Convolutional Neural Network

Convolutional Neural Networks (CNN) is a variation of Multilayer Perceptron inspired by human neural networks. The initial research underlying this discovery was carried out by Hubel and Wiesel, who studied the visual cortex in cats' sense of sight. The visual cortex in animals has very strong visual processing capabilities [3].

Convolutional Neural Networks have connection weights similar to biological neurons that are shared across the neural network. CNN can reduce connection weights and simplify the complexity of the network model, which results in shortening CNN model training. When an image becomes input to a CNN, it can also be fed into the neural network directly to avoid feature extraction and data reconstruction.

CNN (Convolutional Neural Network) is an algorithm designed to process two-dimensional data. CNN is usually used to learn and detect features in an image. If neural networks generally use 1-dimensional array data as input, in the CNN algorithm the data used as input is two-dimensional data. Just like neural networks in general, CNNs also consist of many neurons that have weights, biases and activation functions [4].

2.1.1 Activation Function

The performance of a neural network is related to the structure and also the activation function chosen as a non-linear function to handle some complex problems.

Three activation functions that are often used in CNN

Sigmoid $(x) = 1\ 1 + e{-}x$ (1)

Tanh $f(x) = ex - e - x\ ex + e - x\ 1$ (2)

ReLU $f(x) = (0, x)$ (3)

2.1.2 Back Propagation Algorithm

The algorithm most often used to train neural networks and mapping input and output data is an optimization problem. The back propagation algorithm can be updated iteratively by minimizing the mean squared error between the real value and the expected value. It can be formulated as follows:

$$(W,B) = 1\ NL\ \sum(aiL - tiL)\ 2\ NL\ i{=}1 \quad (4)$$

2.1.3 Convolution Layer

Convolution layers are mathematical operations that have been widely used in image processing. The convolution results can be sorted into three modes, namely Full, Same and Valid. The convolution layer consists of neurons that form a filter with a certain length and height (pixels) [5].

2.1.4 Rectified Linear Unit (ReLU) activation

The ReLU layer functions to apply an activation function to the output value of the convolution results in the convolution layer. The output of the activation function is stated as 0 (zero) if the input is negative. However, if the input is positive, then the output will be the same as the input value of the activation function itself. Below in the figure is a graph of the activation function on the ReLU layer.

2.1.5 Pooling Layer

The pooling layer is usually located at the back of the convolution layer. The purpose of using a pooling layer is to speed up the computing process. This can happen because after passing through the pooling layer, there are fewer parameters that need to be updated, so the risk of overfitting is minimal. Just like the convolution layer, the pooling layer also has a filter of a certain size which will carry out a sliding window process on the input matrix.

2.1.6 Classification

The classification process functions to classify each neuron that has been extracted in the feature learning process. This section consists of several layers that are related to each other. The following is an explanation of each function in the classification section.

2.1.7 Flatten

The feature map produced in the feature learning process is in the form of a multidimensional array. Meanwhile, the input for the fully connected layer must be data in vector form. Therefore, we need a function that can convert multidimensional array data into vector form. Flatten functions to reshape feature maps from multidimensional arrays into vectors. This is necessary so that these values can be used as input to the fully connected layer.

2.1.8 Dropout Regularization

Dropout is a neural network regularization technique where some neurons are selected randomly and not used in the training process [6]. By removing a neuron, it means temporarily removing it from the existing network. The image shows a comparison between a neural network that does not use the dropout technique, and a neural network that uses the dropout technique.

2.1.9 Fully connected layer

Fully connected layer is a feed forward neural network which consists of a hidden layer, activation function, output layer, and loss function.

2.1.10 Softmax

The main role of softmax in the classification process is to calculate the probability of each target class against all existing target classes in figure 1. The output probability range in softmax is a value from 0 to 1, and if all the probability values for the target class are added up, the value will be equal to one.

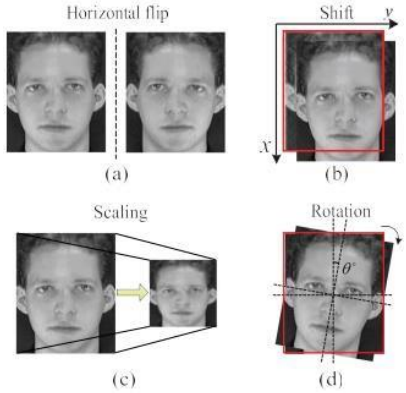

Figure 1. Four Methods for Data Augmentation

The application of CNN in face recognition involves two convolution layers and two pooling layers, using a facial dataset that is enlarged using data augmentation methods in figure 2. CNN is trained by taking into account facial recognition accuracy, MSE, and comparison with other facial recognition methods such as ANN, PCA+ANN, PCA+SVM, Wavelet+SVM, and Wavelet+PC+SVM.

Figure 2. Data Addition for First Face

2.2 Vincenty Formula

Vincenty Formula is a method for calculating the distance between two points on the earth's surface. This method was developed by Thaddeus Vincenty in 1975. This method uses an ellipsoid model for the earth, which is more accurate than the spherical model in general. This theory takes into account the height differences and changes in direction required to reach the destination point. This method considers geodetic parameters such as the balance radius and eccentricity of the ellipsoid to calculate the distance between two points [7]. This method consists of several complicated mathematical formulas, and is usually implemented in a computer program or GIS (Geographic Information System) software. This method is often used in navigation, surveying and mapping, as well as other applications that require accurate distance calculations between two points on the earth's surface [7].

2.3 Dataset

The data used is facial data for semester 5 students, undergraduate study program in software engineering technology, Department of Information Technology, Politeknik Negeri Padang, in the 2023/2024 Academic Year. Data is divided into Training Data and Test data on the Convolutional Neural Network model.

2.4CNN Model Training

The facial data that has been selected is used as training data, then training data is carried out for the CNN model. Model training is carried out with the aim of making the model able to recognize the faces of each student.

2.5 System Implementation

Implementing the CNN model into a website-shaped system. This system allows managing student attendance automatically using student facial data.

2.6 CNN Implementation

The implementation is carried out using the Python programming language and does not use a lot of training data, so the results of the introduction are faster and there is not much difference.

2.7 Vicenty Formula Implementation

Implementation of the Vincenty Formula in a web-based facial attendance system to calculate the distance between two geographic coordinate points. This will be used to verify the student's location of attendance [12] [13] [14].

3. Results

a Login

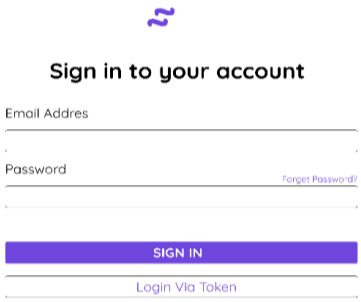

Figure 3. Login

Figure 3 is a display of the login page of the system. This page will be useful for all users by filling in their registered email and password so they can enter the system.

b Token Login Page

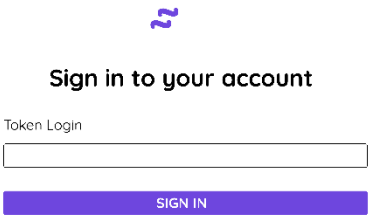

Figure 4. Token Login

Figure 4 is a login display using a token. This token will later be given by the admin so that he can enter the system.

c Dashboard Page

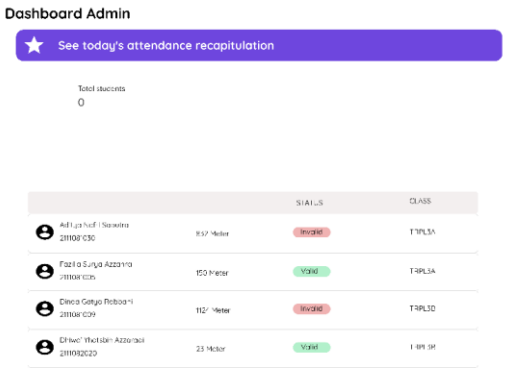

Figure 5. Dashboard

Figure 5 shows the total students, total lecturers, total departments, total study programs, total classes and total courses.

d Data Input Page

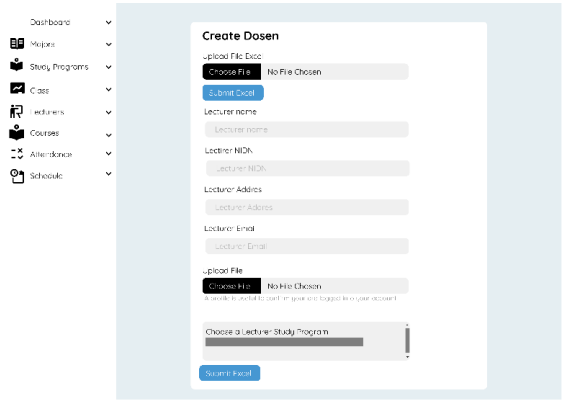

Figure 6. Data Input

Figure 6 shows the page for entering data used by the admin.

e Department Page

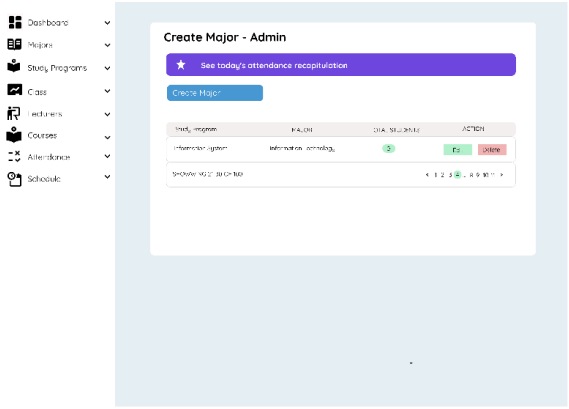

Figure 7. Department Page

Figure 7 displays the name and department head with actions that can be edited or deleted. This page can only be used by admin.

f Study Program Page

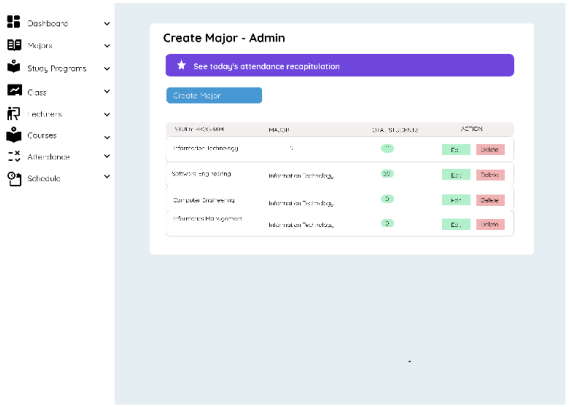

Figure 8. Study Program Page

Figure 8 displays the name, department, head of the study program with actions that can be edited or deleted by the admin only.

g Class Page

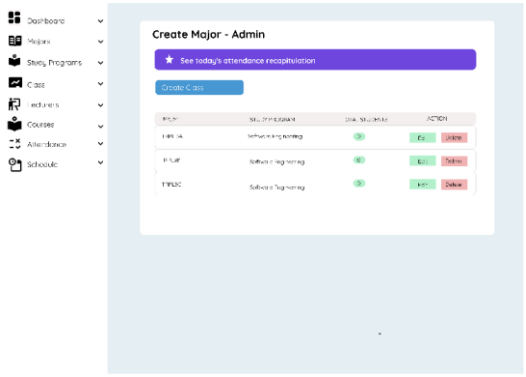

Figure 9. Class Page

Figure 9 displays a list of classes accessed by admin and lecturers. This page displays the study program, class level, study group with edit and delete actions by the admin.

h Student Page

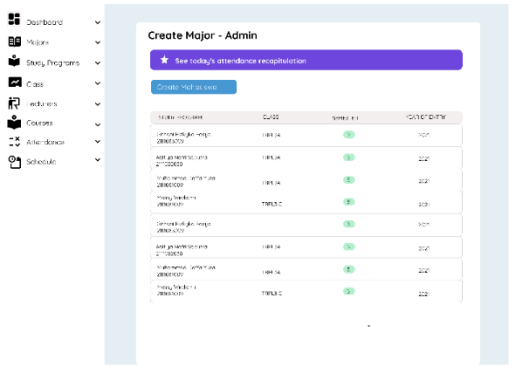

Figure 3. Student Page

Figure 10 displays student data in the form of name, registration number, photo, semester, entry year and class, as well as edit and delete actions. Admin can add students manually.

i Lecturer Page

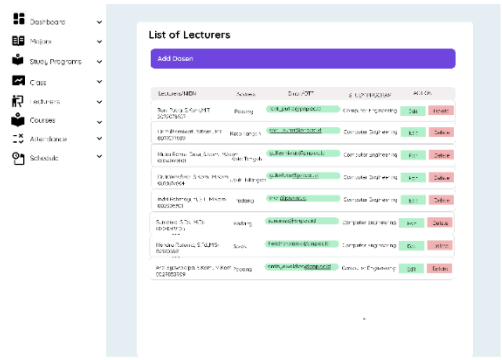

Figure 4. Lecturer Page

Figure 11 displays lecturer data in the form of lecturer name/NIDN, address, photo, email, position and study program which can be edited or deleted by the admin.

j Lecture Schedule Page

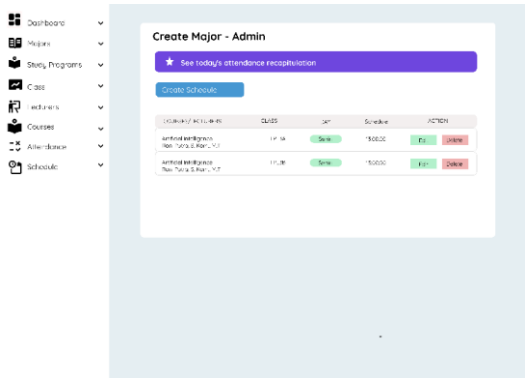

Figure 5. Lecture Schedule Page

Figure 12 shows the course schedule in the form of classes, subjects and times which can be edited or deleted by the admin.

k Course Page

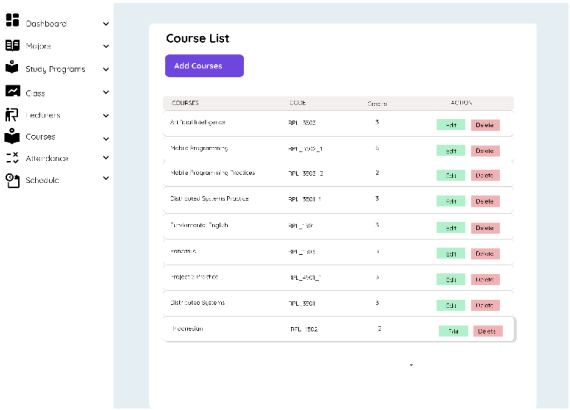

Figure 6. Course Page

Figure 13 displays course data in the form of course name, course code, and course credits which can be edited or deleted by the admin.

l Attendance Page

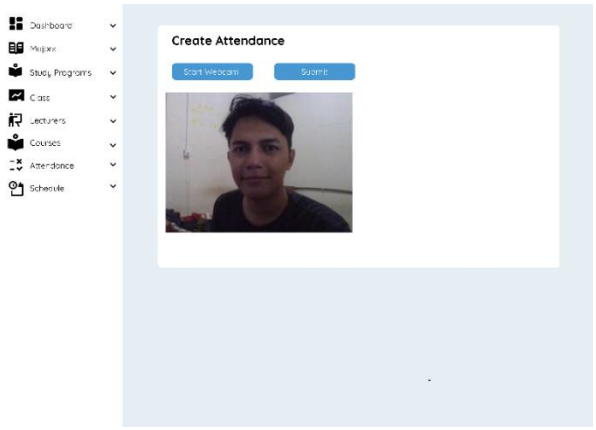

Figure 7. Attendance Page

Figure 14 shows the student attendance page which will later be used by students to take absences by scanning their faces.

m Absence Recapitulation Page

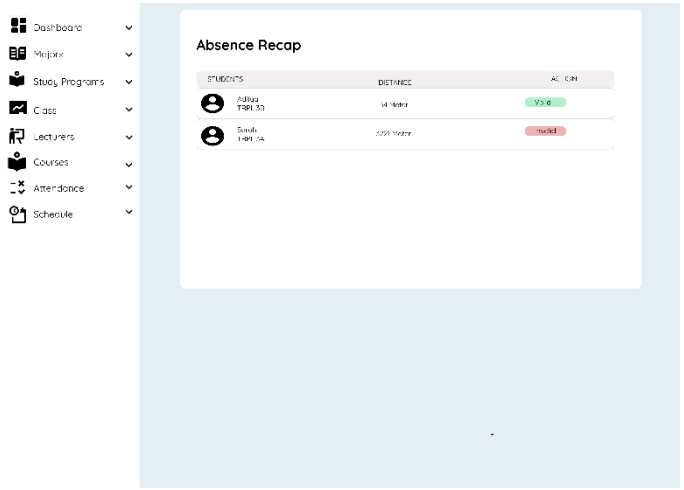

Figure 8. Absence Recapitulation Page

Figure 15 shows a recap of attendance that can be accessed. On this page, lecturers can record student attendance in class.

Researchers collect facial data from several students. The data is collected as training data to carry out training and testing data on the Convolutional Neural Network model. After the data is collected, pre-processing of the data will be carried out such as normalization, data augmentation and dividing the data into training data, validation and test data.

The proposed approach combines CNN with an augmented facial dataset, so that it can achieve higher facial recognition accuracy than others. Augmented face datasets can improve face recognition performance due to the abundant features that can be obtained.

After the web-based facial attendance system is implemented, researchers will evaluate the system's performance in managing student attendance. Evaluation can be carried out using accuracy, precision, recall and F1-score metrics to assess how well the CNN model can recognize student faces, as well as the efficiency of the system in managing attendance.

4. Conclusion

After going through a series of tests and developments on an attendance system using facial recognition technology in the Information Technology department of the Software Engineering Technology study program, the research results revealed several significant conclusions. This face-based attendance system proves convenience for lecturers and students in implementing the teaching and learning system. Its ability to accurately identify faces speeds up the attendance process and optimizes learning time. The reliability of this system is proven by the use of facial recognition technology and the Vincenty formula. This combination is designed not only to facilitate attendance, but also to avoid the potential for fraud in taking student attendance. Security and accuracy are the main priorities in implementing this system. Furthermore, this system is able to support the implementation of attendance for both face-to-face learning and online learning. This flexibility provides the best solution in dealing with various learning conditions, thereby providing an optimal learning experience. It is important to note that the use of this attendance system is not limited to computer devices only. With support for access via mobile devices that have cameras, students can easily access this system anytime and anywhere according to their needs. This not only increases the affordability of the system, but also strengthens efficiency in student attendance administration. Overall, the results of this study indicate that attendance systems with facial recognition technology have great potential to increase effectiveness and efficiency in student attendance management in academic environments, making a positive contribution to the learning experience.

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Acknowledgment

Thank you to Politeknik Negeri Padang and all parties who have assisted in this research.

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