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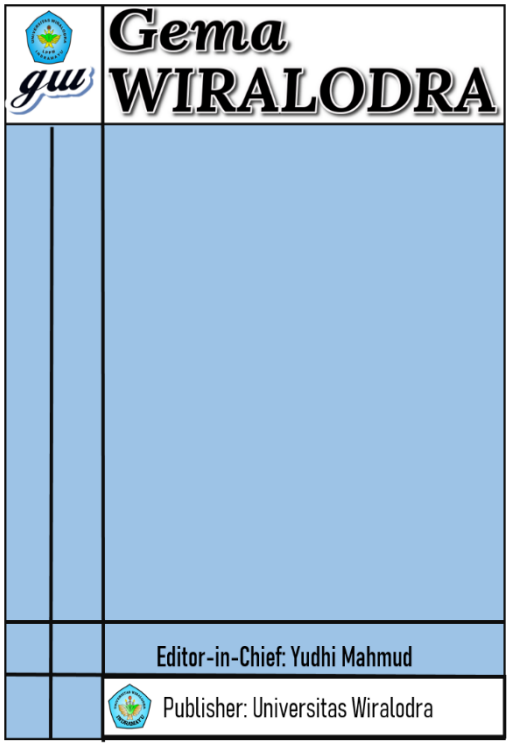

Smart and Portable Attendance System Based on Face Recognition that Implements the Local Binary Pattern (LBP) Algorithm

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Abstract
Research about facial recognition-based attendance system implementing artificial intelligence is usually us-ing laptops or personal computers, as a result, the device is not practical because they have large dimensions and heavy, it is not like Fingerprint attendance's which is widely used nowadays. Aim of the research is to solve the problems. Therefore, a portable facial recognition-based attendance that applies artificial intelligence are built by means of Raspberry pi 3 B+. Experimental method is employed to calculate the accuracy of local binary pattern algorithm in attendance's device. The device's dimensions are 97. 28, and 66 cm for length, width and height respectively. It is work through three stages, the first one is the face detection. At this stage the device captures the user's face, then image preprocessing is carried out by means of Haar cascade. The second stage is the data training by employing local bi-nary pattern algorithm, the last stage is the face recognition. The success rate in recognizing face is 60%, 80% and 100% for 1, 3 and 5 training data respectively. The results show that accuracy of the device is getting higher along with the increasing amount of training data. The device is ready to be applied in school, office, and so on.
Keywords: facial recognition-based attendance system, artificial intelligence, raspberry pi, haar cascade, local binary pattern.

1. Introduction

Attendance procedures have developed along with technological development. Starting from manual attendance using the paper provided, now with a touch of technology attendance can be done using QR (quick response) codes, RFId (radio frequency identification) (Fuji et al., 2015) and fingerprint methods. It is certain that the QR code, RFId and fingerprint methods are more modern than the paper one. However, these three methods have several advantages and disadvantages. For example, attendance with a QR code is the cheapest in terms of cost but the drawback is that the storage capacity is small (Pulungan & Saleh, 2020), cannot be reprogrammed, whereas RFId which has a larger storage capacity, can be reprogrammed even though it is more expensive in terms of cost (Setiawan & Kurniawan, 2015). But both the QR code and RFId methods have the same drawback, namely if someone who is going to taking attendance forgets to bring a smartphone (in the case of attendance using an application or via the website) or forgets to bring an RFId card then the attendance activity cannot be carried out. Meanwhile, the fingerprint method is the attendance method that has been used frequently, but since the outbreak of Covid-19 cases, this method is considered to have the potential to transmit the corona virus from one person to another. Therefore, an attendance system using a camera based on facial recognition has become a solution and has become a research trend in attendance systems in recent years, because apart from being able to prevent users from having direct contact with the equipment so as to avoid the corona virus, this system also applies artificial intelligence technology.

Tej Chinimilli et al (2020), creating attendance based on facial recognition, this research involved 18 people, each person took 60 pictures. Then 10 people were added to check recognition for unknown people. The way it works is that people stand in front of the camera, the camera will record and convert it into an image. The image is converted from RGB to grayscale, then the Haar cascade is used for classification to obtain an ROI (Region of Interest).

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The LBP (local binary pattern) algorithm is applied to the ROI to recognize its face. The result is an accuracy of 77% with a false-positive rate of 28%. Gupta et al. (2020) conducted a review of facial recognition based attendance systems, in general the method described is almost the same as (Tej Chinimilli et al., 2020), namely using the Haar cascade and the LBP algorithm, (Gupta et al., 2020) also explains the KNN (K-Nearest Neighbor) classifier which can be used in machine learning. If the algorithm used is CNN (Convolutional Neural Network) then Tensorflow is used for face recognition. James & Nettikadan (2019) created an attendance system based on facial recognition, which differs from the research of Tej Chinimilli et al. (2020), Gupta et al. (2020) is that James & Nettikadan (2019) uses a raspberry pi 2 as a replacement PC (personal computer), this is more practical because the size of this minicomputer is like an ATM card and its light weight. In this research, the Viola and Jones algorithm was used for facial recognition. However, the image sample used is only one person so the accuracy is 100%. Bai et al. (2020) Created an attendance system based on facial recognition, but the Haar classifier was not used but instead used the Adaboost classifier. For face recognition, the LBP algorithm is used. This algorithm was tested for its accuracy by comparing it using the Fisherface and Eigenfaces algorithms. 30 user samples were used as research objects, 5 pictures were taken of each person then the accuracy of LBP, Fisherface and Eigenfaces was the same, namely 95%, but if 8 pictures per person added to these algorithms then the LBP algorithm outperformed the others.

Research on attendance systems was also carried out by Winarno et al. (2019), but the method was different, namely two-dimensional image samples from users were processed and converted into three dimensions using a Convolutional Neural Network (CNN). Then the shape and texture vectors from the three-dimensional images are processed and extracted using Principal Component Analysis (PCA). PCA functions to reduce the dimensions of facial resolution. The result is an accuracy of 90-96% if only using PCA but the accuracy increases to 90-98% by combining CNN and PCA. Research by (Huang & Luo, 2020), created an attendance system using the MTCNN (Multitask convolutional neural network) algorithm for face detection, and then used the FaceNet neural network to convert facial images into vectors with dimensions of 128. This research used a PC equipped with a camera. (Bhattacharya et al., 2018) created an attendance system based on facial recognition for use in the classroom. The algorithm used to recognize faces is CNN. In the research, UDOO X86 Ultra was used. Although attendance system research uses different algorithms such as the LBP algorithm, CNN and others such as the Viola and Jones algorithm (Sriratana et al., 2018; Wagh et al., 2016). But most of these studies use the OpenCV library (Chen & Li, 2021; Gupta et al., 2020; Harikrishnan et al., 2019; James & Nettikadan, 2019; Mehariya et al., 2020; Sriratana et al., 2018) to implement facial recognition.

Based on previous research, only James & Nettikadan (2019) made an attendance system using the Raspberry Pi 2, even though if we want to make a small, light, portable attendance device then the Raspberry Pi meets these criteria. Therefore we propose to make an attendance system using a Raspberry Pi 3 b+, with Broadcom BCM2837B0 specifications, Cortex-A53 (ARMv8) 64-bit SoC @ 1.4GHz with 1GB RAM. So this type of Raspberry is suitable for use in artificial intelligence projects, including facial recognition based attendance systems. Apart from that, the Haar cascade is used to classify image data from users. From the Haar cascade, ROI (Region of Interest) is obtained. The LBP algorithm is used on the ROI that has been obtained so that the system is able to detect or recognize the user's face. We chose the LBP algorithm because there are differences in results between studies Bai et al. (2020) which prove that this algorithm has higher accuracy than the others. But in another study conducted by (Tej Chinimilli et al., 2020) the accuracy was only 77%. This difference could be due to the samples

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used being treated differently and the camera used being of different quality. In this research, a pi camera with a resolution of 5 megapixels was used.

2. Method

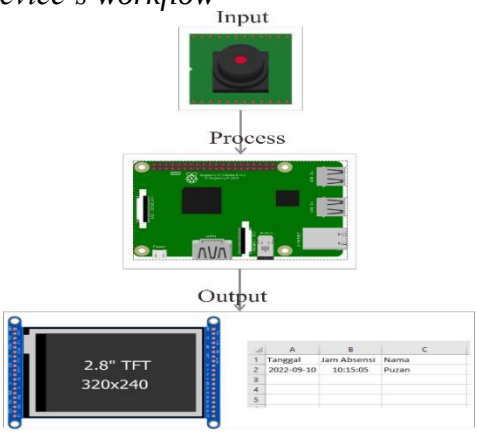
The first step is to determine the concept of the tool that will be created, then create a circuit between each component, after the hardware circuit has been successfully assembled then implement the LBP algorithm in Python and OpenCV which are already installed on the Raspberry Pi 3 B+.

The Device's work-system

In general, portable attendance tools are divided into three main parts: input, process and output. For more details, see Figure 1.

Figure 1

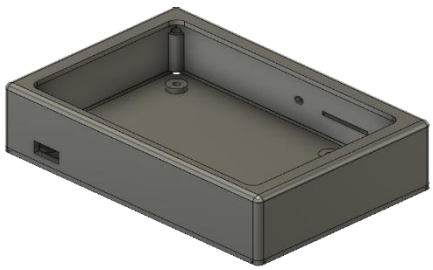
Smart portable attendance device's workflow



Based on Figure 1, the Raspberry Pi functions as the brain of the system created, we could apply the Haar cascade and LBP algorithm. To carry out these commands, the Python programming language installed on the Raspberry Pi is used. Apart from that, to support the implementation of image processing, a library called OpenCV (Open Computer Vision) was installed. Another component used is the Pi camera, this camera is a camera that is compatible with the Raspberry Pi and there is even a camera slot available so the camera can be easily installed. This camera has a resolution of 5 megapixels, from this camera images are taken from the user and then forwarded to the Raspberry Pi for image processing. Then a casing for portable attendance was designed, the 3-Dimensional casing design was made using Fusion 360 software, the design and results can be seen in Figure 2.

Figure 2

3D casing design



Facial Recognition and Training the Data

After the hardware connection process is complete, the next step is to install Python version 3.7 on the Raspberry Pi, after the installation is complete. The next step is to install OpenCV and its accompanying modules, one of which is the LBP algorithm. So, LBP is included in the

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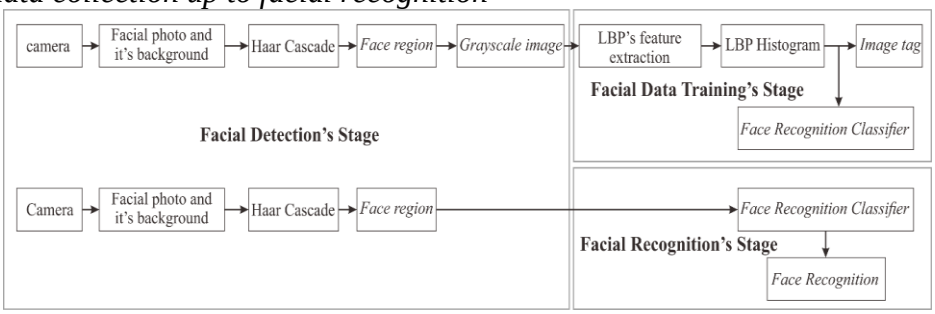
modules in OpenCV. The facial recognition process is divided into three stages: facial data retrieval, image preprocessing and facial data training. At the data collection stage, the user's face is taken using a camera installed in the device, before the data is stored, image preprocessing is carried out using the Haar cascade, then training is carried out using the LBP algorithm, so that the flow of data collection up to the face recognition stage is clearer, which can be seen in Figure 3.

Figure 3

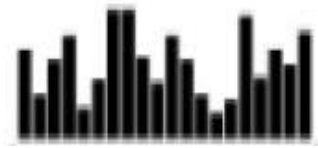
Steps for data collection up to facial recognition



Based on Figure 3, the first stage is the face detection stage. At this stage the image obtained from the camera is then processed using the Haar cascade for classification to obtain an ROI (Region of Interest). The result of this process is a photo of the face that has been cropped from the background. The facial data is then converted from RGB to grayscale, the aim is so that the LBP algorithm can work optimally. After that, proceed to the facial data training block, at this stage the LBP algorithm is applied to perform feature extraction on the ROI obtained, the result is a textured facial image. From the face extraction data, the 3x3 pixel LBP algorithm is then applied, meaning there are 8 neighboring pixels in the thresholding pixel. Therefore, an LBP histogram was created in the value range 0-28 or from 0-256. From the histogram data obtained, a tag is then given, the aim is to tell the system that the person with the histogram shape like that is user A, and so on depending on the amount of data we want to enter. The more data, the better the LBP histogram's result, the shape of the histogram can be seen in Figure 4. In the end, a database is obtained which contains the classification of each user's faces. At this stage we have trained on facial data. Training results data is saved in .yml format.

Figure 4

LBP's histogram



After the facial data training stage is done, the face recognition stage is then carried out, at this stage the faces that were previously recorded are now tested on the device. The process is almost the same as the data training process, but at this stage the ROI obtained from the user is analyzed using the database stored in the face recognition classifier block in Figure 3. The system would conclude what percentage the user's face is similar to the existing data.

Device Testing

At this stage, the main goal is to test the accuracy of the device against the amount of data being trained. Therefore, one user is used with different amounts of training data. The first stage of testing is to use 1 data for training, then test it on the device for facial recognition. The second stage uses 3 training data and the third stage uses 5 training data.

3. Results and Discussion

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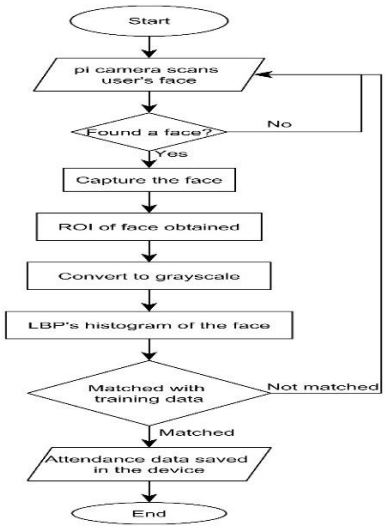
The Device workflow

The smart and portable attendance system in general has a workflow as shown in Figure 5. The camera in the tool will be active continuously, the camera detects the user's face, if the face has not been trained in the previous stage, then the device will not recognize it. But if the face being captured is a face that has been trained, the device would recognize it.

Figure 5

Flowchart of the Device



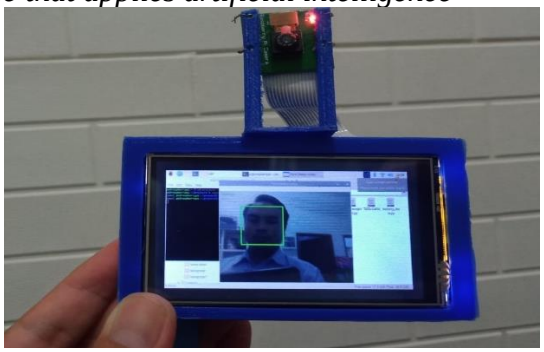
The LBP (Local Binary Pattern) algorithm begins to be applied after the gray image is obtained, the gray image is processed and then facial feature extraction is obtained. From the feature extraction, a facial histogram plot was then carried out using the matplotlib library. The histogram data is matched with a database of facial training results. If the data trend is the same then the face is recognized by the device, but if it is not the same then the user would not be counted.

Device Specification

The results of Raspberry Pi with camera pi enclosure by the casing, can be seen in Figure 6. Based on Figure 6, the dimensions of the attendance made are 97 cm long, 28 cm wide and 66 cm high, with these dimensions the attendance tool can be easily installed. brought and installed at the workplace. As for electrical power, the Raspberry Pi-based attendance device can operate at 5V DC, so a 5V adapter is needed if we want to connect directly to PLN source.

Figure 6

Portable attendance device that applies artificial intelligence



In summary, the specifications for the attendance device can be seen in table 1.

Table 1

Device's specification

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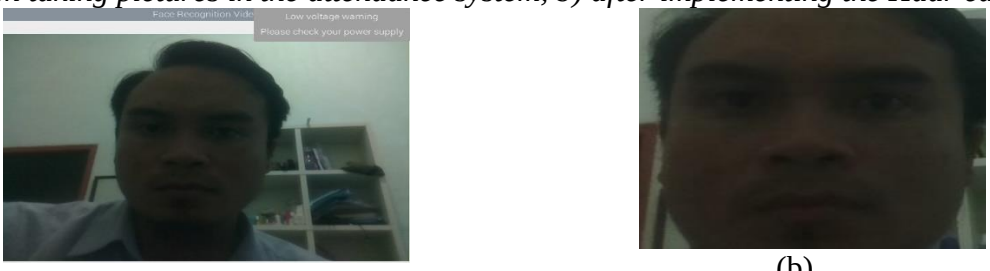
Specification	Information
Dimension	28 mm x 66 mm x 97 mm
Pi camera's current	200 – 250 mA
Raspberry pi's current	520 mA
Power of Attendance Device	3,6 – 3,85 watts
Operational temperature	0^o – 85^o C
Distance from user's face to the device	30 cm

Device Performance

When a user scans her/his face in front of the device, the device would capture the face and its background as can be seen in Figure 7a. Then, image preprocessing is carried out, the Haar cascade is used to obtain ROI, the results can be seen in Figure 7b. The data stored is only the user's face without any background as in Figure 7a.

Figure 7

a) When taking pictures in the attendance system, b) after implementing the Haar cascade

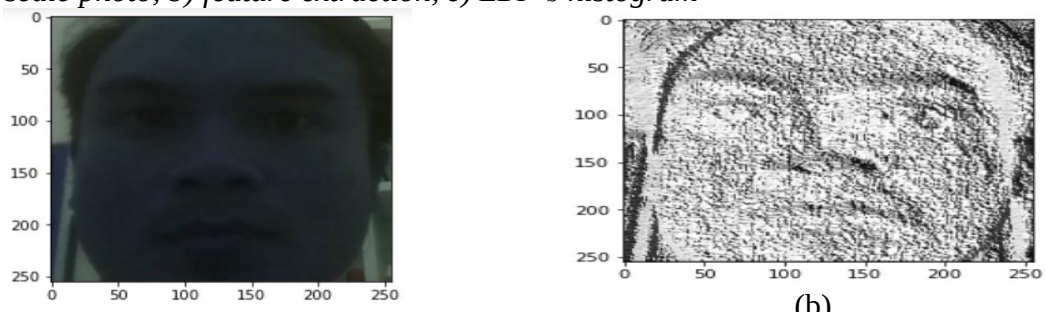


(a) (b)

The next preprocessing stage is to convert the RGB photo to grayscale, the aim of the conversion is so that the LBP algorithm could work, because this algorithm is invariant to color. With grayscale images the pixel value in the thresholding cell varies from 0-256. The conversion to grayscale form can be seen in Figure 8a. The grayscale image then has its features extracted using the LBP algorithm. The results can be seen in Figure 8b, from this image it can be concluded that the pixel value of the image is saturated from white to black. For every 3x3 pixel in Figure 8b, one thresholding cell (central pixel) is determined. This thresholding cell is visualized in the form of a histogram. The histogram form of Figure 8b can be seen in Figure 8c. All images are scanned using the LBP 3x3 concept, then the results are interpreted in histogram form. The x-axis is the thresholding result that has been calculated while the y-axis is the number of thresholding pixels.

Figure 8

a) Grayscale photo, b) feature extraction, c) LBP's histogram



(a) (b)

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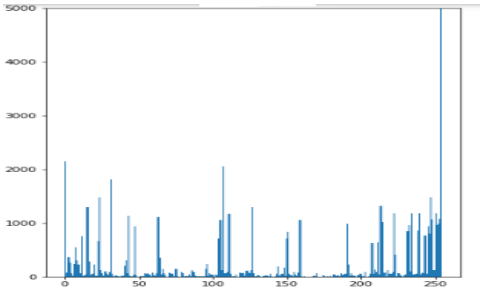

(c)

Based on Figure 8c, the number of thresholding cells on 250 (x-axis) exceeds 5000, while the number of thresholding cells on 110 and 0 is above 2000. The number of thresholding cells is what marks or uniqueness of the user. Each person has a different LBP histogram shape, therefore attendance face recognition can differentiate and recognize different people based on the shape of the LBP histogram.

The test results on one user with different amounts of training data can be seen in table 2. Based on table 2, the more training data, the greater the success rate in reading the tool. This shows that portable attendant device that applies artificial intelligence has increasingly accurate performance the more training data it has.

Table 2
Device detection results for different training data

Facial detection	1 data training	3 data training	5 data training
1th	detected	detected	detected
2nd	detected	not detected	detected
3rd	detected	detected	detected
4th	not detected	detected	detected
5th	not detected	detected	detected
6th	detected	detected	detected
7th	not detected	detected	detected
8th	not detected	not detected	detected
9th	detected	detected	detected
10th	detected	detected	detected
Success's percentage	60%	80%	100%

4. Conclusion

Smart and portable attendance device was successfully created with dimensions of 97 cm length, 28 cm width and 66 cm height. The success's percentage in recognizing faces is 60% for 1 training data, 80% for 3 training data and 100% for 5 training data. The reading accuracy gets higher as the amount of training data increases.

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