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UAD Lecturer's Introductory System Through Surveillance Cameras with Eigenface Method

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ABSTRACT

Technologies related to processing using computers are developing so rapidly, such as applications to identify a person automatically through camera monitors (CCTV). The human recognition application in real time can be found in the surveillance system, identification and facial recognition. The direct observation of human beings has a weakness such as fatigue and saturation that may occur, resulting in decreased accuracy. For that, computer can be an alternative solution to overcome it. For example, the human Face Recognition (Eigenface) detection system. This system can be very helpful when you want to find and know the existence of someone in a place, for example to help in finding the existence of lecturers on campus. Students often seek lecturers to conduct guidance or for other academic matters, but students often do not know whether the lecturers sought on campus or not. Therefore, in this research an application will be made to help students in knowing the existence of lecturers on campus. This final project examines the system to recognize lecturers who are on campus using CCTV. The method used is eigenface. Eigenface is one of the facial pattern recognition algorithms based on the Principle Component Analysis (PCA). The basic principle of facial recognition is to cite the unique information of the face and then be encoded and compared with the previously done decode result. The process itself consists of data collection and facial recognition processes. In the process of collecting data, the data taken in the form of the name and the image of the lecturer will be used as a database to recognize the face of the lecturer. While the facial recognition process is the process by which the face of the lecturer who has been caught by the camera will be compared with the database that has been taken to recognize the lecturer. From the research done can be concluded that there are several factors that affect the accuracy of the system including the distance of the camera sensor with the most effective object is 1 to 2 meters, the intensity of bright or dim light, the face positioning and Number of datasets owned. The test results obtained an accuracy of 89%.

1. Introduction

Keeping an eye on and recognizing someone from photos, videos or face-to-face is an easy task for people. But this task is difficult when done continuously in a relatively long period of time without feeling tired or losing concentration. The automatic face recognition system is the right answer to this problem. The system can supervise an area for 24 hours per day and recognize anyone entering the area [1].

The human recognition system in the media of the image or video becomes a subject of interesting research. The easiest feature to recognize humans is to know the existence of human faces, both on images and video. After the existence of the face is known, the recognition process can be done [2].

Facial recognition is certainly very easy when done by humans. But not for computer technology that has not been equipped by an intelligent system. Therefore, it takes a smart system that can perform facial recognition process. The facial recognition system is divided into three parts namely segmentation/detection, feature extraction and facial recognition. The most important thing in facial recognition is the extraction of all relevant information on the face image. The extractions of facial features are divided into two, holistic (to know the face as a whole) and partials (recognize the face of the part per section, for example eyes, nose, mouth and so on). A proven approach capable of delivering the best results in the extraction of facial features is the overall processing of the face image [3].

Nowadays, the development of information technology plays an important role in various sectors of human life. One example is the human face recognition system that can be very helpful when looking to find and know the existence of someone in a place, for example to help in finding the existence of lecturers on campus. Students often seek lecturers to conduct guidance or for other academic matters, but students often do not know if the lecturers are sought on campus or not, because the uncertainty of the arrival schedule of the lecturers, and the students often find the lecturers not being in their room. Therefore, an application will be made in this research to help students in knowing the presence of the lecturers on campus.

The method used is eigenface to recognize lecturers who are on campus using surveillance cameras that are installed in the Lecturer Room Informatics Engineering Ahmad Dahlan University Yogyakarta.

2. Previous Research

First, the research was conducted [4] under the title "Sistem Pengenalan Wajah Secara Real-Time dengan Adaboost, Eigenface PCA & MySQL". The problem faced is the direct face observation by humans has a weakness because the fatigue and saturation that may occur can cause a decrease in accuracy, for which the use of computers can be an alternative solution. The method used to detect faces is Adaboost, facial recognition using the Eigenface PCA method and MySQL database to store profile information. Use of such methods for facial recognition with real-time conditions with the difference between the distance between the sensor and the face, the face position, the light intensity that is about the face, facial notions and facial attributes in the study provide a level of success of 80% identifying faces.

In a 2017 study by [2] There were a number of methods for the identification process of facial existence including using a template base, neural network, color base. Several improvements to the method have been made by adding knowledge-geometry face verification. However, from a number of such methods are only effective for images or video with a single face and background applied to skin color and hair color distribution. This method is relatively fast in identifying the presence of a number of human faces in complex backgrounds. However, if the hair is not black and the face is not elliptical then there will be a failure. To overcome this, the quantification of skin color is combined with the transformation of the wavelet package. Merging both of these methods works quite well when compared to previous methods, but requires considerable computation. To overcome the computing magnitude, a repair is done where wavelet transformation is not done in all parts of the image, but only on certain parts that have been indicated as human facial skin using the method evolutionary and combined with the transformation of the wavelet package. Based on both methods, research on detection of human face on imagery using Fourier decomposition.

In a 2016 study by [3], the facial recognition was a personal identification system that used the characteristics of a person's face. Facial recognition itself is a branch of biometric science, a scientific field that uses the physical characteristics of a person to determine or reveal their identity. In general, the facial image recognition system is divided into two types, namely feature based system and imaged based system. In the first system the features are extracted from the face image components (eyes, nose, mouth, etc.) which then the relationship between the features is modeled geometrically. While the second system uses the raw information of the image pixels which are then represented in certain methods, e.g. Principal Component Analysis (PCA). The face detection process is an important part, the system should detect the existence of the face on the imagery with a variety of poses, lighting, facial expressions, obstructions (glasses, mustache and beard) and size. Image processing serves to highlight certain features as well as reduce noise so that imagery is ready for analysis purposes. The processing of the imagery carried out includes skin detection, light normalization, and dimensional normalization [5].

3. Method

3.1. Face Detection

The method used for face detection is the Haar Cascade Classifier. Haar like feature or known as Haar Cascade Classifier is a rectangular (rectangular) feature, which gives specific indications on an image. Haar Cascade classifier comes from the notion of Paul Viola and Michael Jhon, since it was named Viola's & Jhon method. The idea of Haar like feature is to recognize an object based on the simple value of the feature but not the pixel value of that object image. This method has an advantage that is very fast computing, as it only depends on the number of pixels in the square instead of each pixel value of an image. This method is a method that uses the model statistical (classifier). The approach to detect objects in the image combining four main keys are Haar like feature, Integral Image, Adaboost Learning and Cascade Classifier [6].

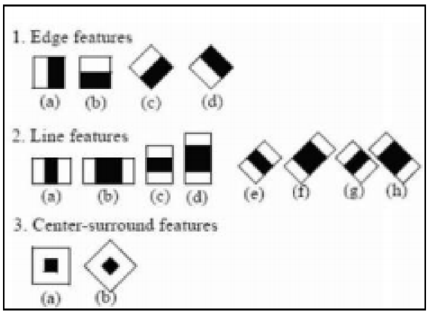

Fig. 1. Haar like features

Haar Feature is a feature that is based on the Haar Wavelet. The Haar wavelet is a single wave of squares (one high interval and one low interval). For two dimensions, one light and one dark. The next box combinations are used for better visual object detection. Each Haar-like feature consists of a mix of black and white squares. The presence of Haar is determined by reducing the pixel average in dark areas of the pixel average in bright areas. If the value of the difference is above the threshold value, it can be said that the feature exists. The value of Haar-like feature is the difference between the total number of pixel grades of gray levels in the black box area and the white box area. Where to box on the Haar like feature can be counted quickly using an "integral image".

Integral Image is used to determine the presence or absence of the hundreds of Haar features on an image and on different scales efficiently.

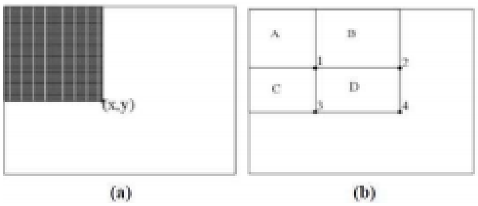

Fig. 2. Integral image

As shown by Fig. 3 After integration, the value of the pixel location (x, y) contains the sum of all pixels in the rectangle from the top left to the location (x, y) or the shaded area. To get the average pixel value in the rectangular area (shaded area) This can be done by simply dividing the value on (x, y) by the rectangle area [7].

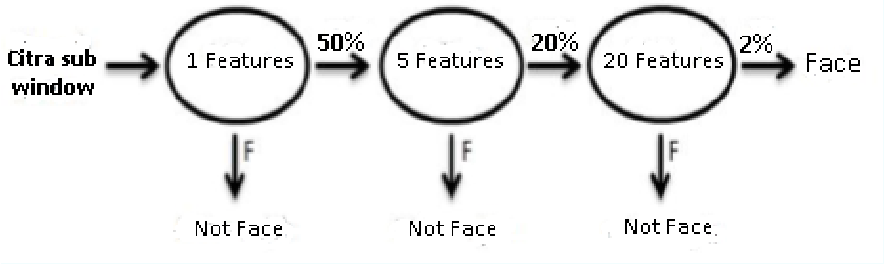

Fig. 3. Multilevel classification workflow

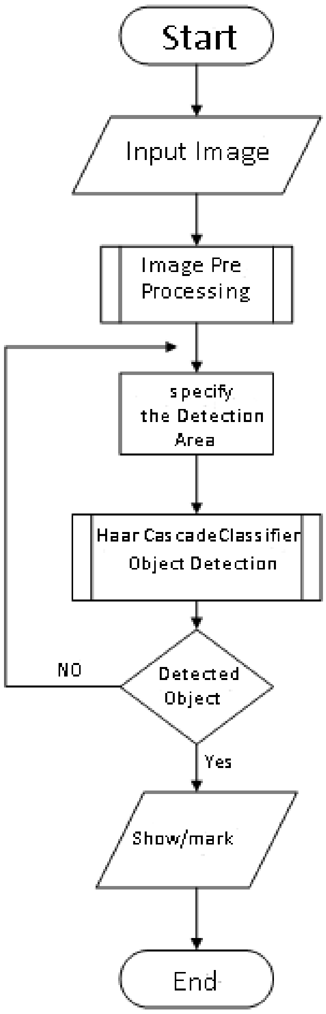

Fig. 4. Object detection cascade classifier

To select the Haar feature used and to change the threshold value, use a machine-learning method called AdaBoost. AdaBoost combines many classifiers to create one classifier. Each classifier establishes a weight, and the combination of these weights will form a strong classifier. In general boosting is adding weak learner into one strong learner. Each iteration, one weak learner learns from a training data. Then the weak learner was added to the strong learner. After the weak learner is added, Datadata is then changed each of its weights. Datadata, which encountered classification errors, will experience weight gain and correctly classified data will undergo weight reduction, therefore weak learner at the next loop will be more focused on the data that encountered an error classification by the previous weak leaner. By combining classifications in a Cascade of Classifier, the detection speed can increase, which is to focus on areas in the imagery that are likely to be. This is done to determine where the object is being searched on an image [8].

Fig. 4 shows first-level classification, each sub-image will be classified using one feature. This classification will roughly leave 50% of sub-imagery to be classified in the second-level. The number of sub-imagery that passes the classification will be reduced to a total of about 2%. The cascade structure is useful for rejecting negative sub-window as much as possible and as quickly as possible at possible levels. While positive examples will trigger an evaluation of each classifier on cascade. Classifications are subsequently trained using examples that pass through all previous levels. The face detection process can be seen in Image 2.5. Object detection with Cascade Clasifier.

3.2. Face Alignment

Face alignment is a computer vision technology to identify the geometric structures of human faces in digital images. Given the location and size of the face, it automatically determines the shape of the face components such as eyes and nose. The face alignment Program usually operates by iteratively adjusting the model that can be deformed, which encode the previous knowledge of form or facial appearance, to account for low-level image evidence and find Face in the image based on the facial landmarks. Landmark is the main point on the face. Landmark faces are used to localize and represent areas of prominent faces, such as eyes, eyebrows, nose, mouth, and jaw [9].

The landmark detector used is shape_predictor_68_face_landmarks. A pre-trained facial landmark detector inside the Dlib library is used to estimate the location of 68 (x, y)-the coordinate mapping the face structure in the face. The index of the 68 coordinates can be visualized on Fig. 5 Visualization 68 coordinates of landmark face.

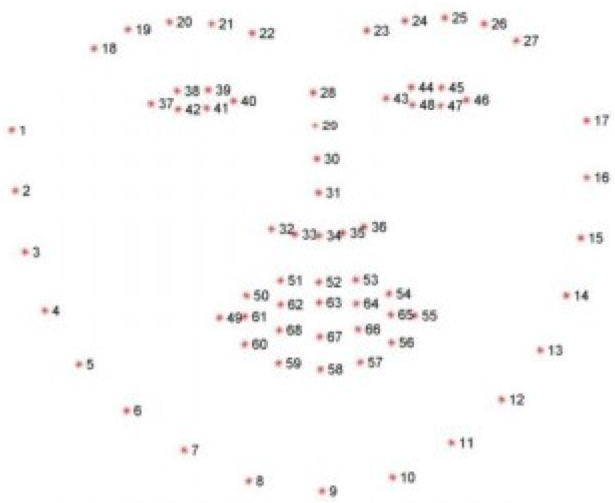

Fig. 5. Visualization 68 coordinate of face landmark

The landmark function takes a picture in the form of a numpy array, and returns a matrix of 68x2 elements, each row corresponding to the x, y coordinates of a particular feature point in the input image

3.3. Adaptive Thersholding

Adaptive Thresholding is one of the image segmentation methods that separates between objects with the background in an image based on the difference in brightness or dark of its light. The darker-inclined Region of the imagery will be made darker (the black is perfect with an intensity value of 0), while the lighter image region will be made brighter (white is perfect with an intensity value of 1). Therefore, the output of the segmentation process with the Thresholding method is a binary image with a pixel intensity value of 0 or 1. Once the image is segmented or has successfully separated its objects with background, then the obtained binary image can be used as a masking to do the cropping process so that the original image is obtained without background or with the background can be personalized [10].

The steps to perform the thresholding adaptive process are as follows:

1. Take the first subimage of M × m
2. Calculate the variance of the subimagery after doing the mean calculations.

Formula mean Subimagery calculated using (1):

$$\text{mean} = \bar{x} = \frac{\sum_{i=1}^{n} xi}{n} \tag{1}$$

Subimagery Variance Formula (2):

$$\text{Var} = \frac{\sum_{i=1}^{n} (xi - \bar{x})^2}{n-1} \tag{2}$$

3. If Var > 100, then T = (max (subimg)-min (subimg))/2, then use T value to do global thresholding.
4. If var < 100, then T = (Max (img)-min (img))/2 then directly use T value to specify the output of binary image.
5. Repeat step (1) with the next subimage until all the subimagery finishes processing.

The illustration of the pixel value changes in the thresholding process is shown by Image 2.5. Pixel value changes in the thresholding process.

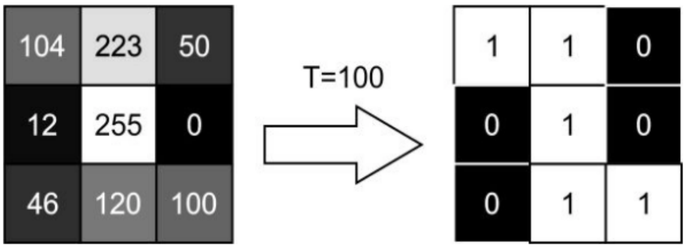

Fig. 6. Pixel value chages in the thresholding process

3.4. Eigenface

The word eigenface actually comes from the German language "Eigenwert" where "eigen" means characteristic and "wert" meaning value. According to Hanif (Al-Fatta. H, 2006). Eigenface is one of the facial pattern recognition algorithms based on the Principle Component Analysis (PCA). The basic principle of facial recognition is to cite the unique information of the face and then be encoded and compared with the previous decode result. In Eigenface method, decoding is done by counting eigenvector then represented in a large matrix. Eigenvector is also expressed as a characteristic of the face, therefore this method is called Eigenface. Each face is represented in a linear eigenface combination. The Eigenface method was first developed by Matthew Turk and Alex Pentland from The Vision and Modeling Group, The Media Laboratory, Massachusetts Institute of Technology in 1987. This method was further enhanced by the Turk and Pentland in 1991. The facial recognition algorithm starts by making the column matrix of the face inserted into the database. The average image vector (mean) of the column matrix is calculated by dividing it by the number of images stored in the database. The overall eigenface algorithm is quite simple. The full calculation phase can be seen as follows [11-13].

1. The first steps is to set up the data by creating a set of S consisting of all the training images, (Γ1, Γ2, …, ΓM) S = (Γ1, Γ2, …, ΓM).
2. The second step is to take the middle value or mean (Ψ) (3).

$$\Psi = \frac{1}{m} \sum_{n=1}^{m} \Gamma n \tag{3}$$

3. The third step then look for the difference (Φ) between the value of training image (Γi) with the middle value (Ψ) (4).

$$\phi i = \Gamma i - \Psi \tag{4}$$

4. The fourth step is calculating the value of matrix covariant (C) (5).

$$C = \frac{1}{M}\sum_{n=1}^{M} \phi_n \phi_n^T = AA^T \tag{5}$$

$$L = A^T A \qquad L = \phi_n \phi_n^T$$

5. The fifth step calculates the eigenvalue (λ) and eigenvector (v) of the covariant matrix (C) (6).

$$C\ x\ vi\ =\ \lambda i\ x\ \ vi \tag{6}$$

Find Eigenvalue (λ) and eigenvector (v) values (6) and (7).

$$L \times v = \lambda \times v \tag{7}$$

$$L \times v = \lambda l \times v \tag{8}$$

$$(L - \lambda l) = 0 \text{ or } (\lambda l - L) = 0$$

Eigenvector (v) is produced by substituted for the eigenvalue (λ) value in the λi − l v = 0 equation. Eigenvector of each eigenvalue is obtained based on each eigenvalue column and then re-compiled into one matrix.

6. Step six, after Eigenvector (v) is obtained, eigenface (μ) can be searched with the formula (9):

$$\mu_i = \sum_{k=1}^{M} v_{ik} \phi_k \tag{9}$$

Stages of facial recognition:

1. A new face image or Test face (Γnew) will be tried to be recognized, first apply the way in the first stage of eigenface calculations to get the Eigen value from the image (10).

$$\mu_{new} = v \times (\Gamma_{new} - \Psi) \tag{10}$$

$$\Omega = [\mu_1, \mu_2, \dots\ , \mu_M]$$

2. Use the Euclidean distance method to find the shortest distance between the eigen values of the training image in the database with the Eigen value of the test face image (11).

$$\epsilon k = \Omega - \Omega_k \tag{11}$$

4. Results and Discussion

Data used in the research "Introduction system lecturer at UAD campus through surveillance camera with Eigenface method" is the image data from the Lecturer Informatics Engineering University Ahmad Dahlan Yogyakarta obtained by shooting the lecturers.

4.1. Data Collection

Data taken is a picture of the face of the Informatics Engineering lecturer Ahmad Dahlan University Yogyakarta that will be used as a Database, then every picture in the give ID as in Fig. 7 Database lecturer.

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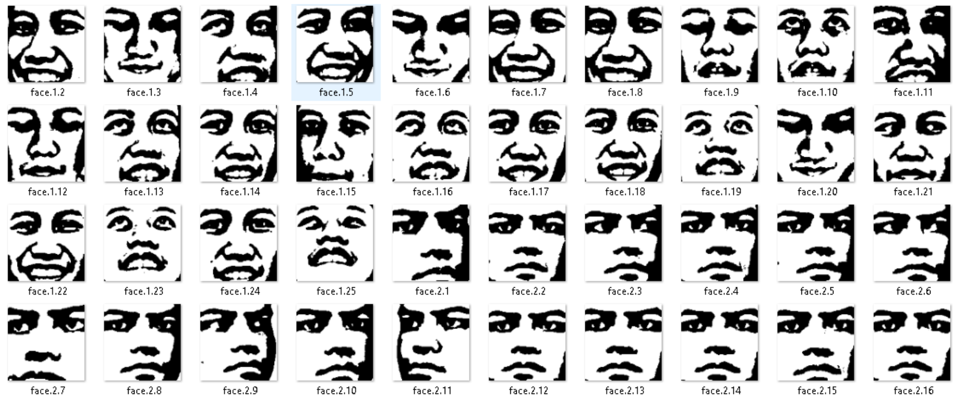

Fig. 7. Lecturer database

4.2. Face Recognition

At the face recognition stage, 2 cameras were used to take pictures of the object, where the first camera was used to take a picture of the lecturer who was entering the room and the second camera to take a picture of the lecturer coming out of the room. The system will automatically detect the face of the object and match the face with the image of the face contained in the database, then the system will display the result of the face recognition in real time.

Fig. 8. Face recognition

4.3. Data Storage

Once the system recognizes the face of the lecturer, the data from the lecturer will be saved into a CSV file which will be used to display the results of the lecturer's facial recognition. When the system gets data from the first camera, then the data from the lecturer will be stored and the status of the lecturer will be changed to "Ada" or presence and when the system camera gets data from the second camera then the status of the lecturer will be changed to "Keluar" or absence.

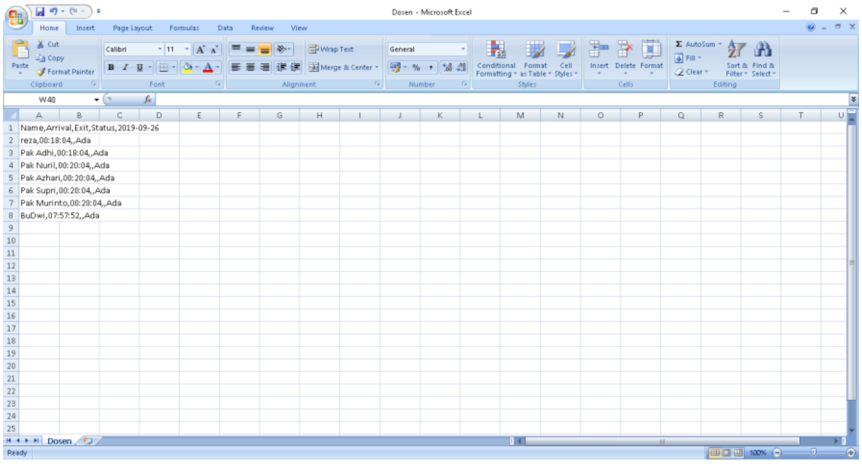

Fig. 9. Lecturers data storage

4.4. Display Data

The system will display the data that has been saved in the CSV file to the website that has been created as in Fig. 10 Lecturers Presence Data Display.

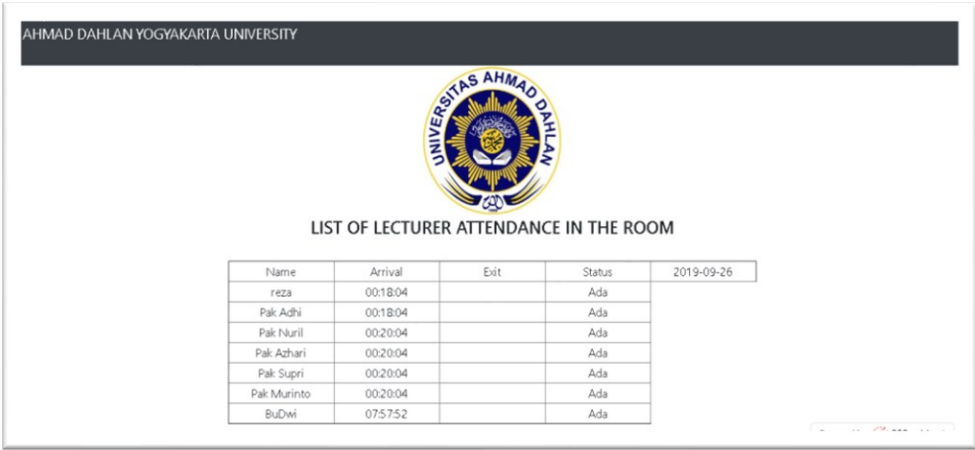

Fig. 10. Lecturers presence data display

4.5. Confusion Matrix

In this test used a total of 50 pictures of the face of 10 informatics engineering lecturers of Universitas Ahmad Dahlan, and 5 faces not contained in the database. Here are the test results on confusion matrix based.

$$Recal = \frac{47}{47+3} = \frac{47}{50} = 0.94$$

$$Precision = \frac{47}{47+3} = \frac{47}{50} = 0.94$$

$$Accuration = \frac{47+2}{47+2+3+3} = \frac{49}{55} = 0.89 \times 100 = 89\%$$

5. Conclusion

Based on research conducted, data obtained from 10 informatics engineering lecturers of Ahmad Dahlan University, the results obtained was good with 89% accuracy. The Program is expected to assist students in finding lecturers on campus.

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