Development of Student's Uniform Compliance Detection System Using Real Time Image Recognition at Politeknik Statistika STIS

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Abstract. Regulations in the Politeknik Statistika STIS (hereinafter called Polstat STIS) aims to produce graduates who are qualified, with integrity and trusted. In enforcing regulations in Polstat STIS, there are a student squad of regulations enforcement, which is called Satuan Penegak Disiplin or SPD in Indonesian, which aims to maintain the order, discipline and student ethics during their activities on and off campus. In upholding the regulations, SPD carries out surprise inspection and during the weekly morning assembly to check completeness and tidiness of student's uniform as well as his/her look. However, previous research related to the student's commitment to the campus regulations shows that half of the students have low commitment. This is partly due to the lack of supervision of students. Therefore, it is necessary to monitor the discipline and neatness of students on an ongoing basis. In order to conduct the monitoring and inspection on a more regular basis, the method of image recognition can be used to assist in overseeing student discipline and neatness. In this study, we developed a system which can detect in a real-time manner the completeness of attributes the student wears. The system we developed uses object detection to detect the completeness of student attributes. The system shows and records student(s) whose attributes are incomplete. The system expected to improve the discipline and neatness of the students.

1. Introduction

Regulations are a form of education, especially in schools whose existence serves as a guide for students in discipline and an attitude of responsibility [1]. The regulations in the Politeknik Statistika STIS (hereinafter called Polstat STIS) are made to produce graduates who are qualified, with integrity and trusted when they work as a civil servant in government agencies especially as a statistician in Badan Pusat Statistik, the national statistical office in Indonesia. This regulation includes official dress regulations for students which are regulated based on the Director Regulation Number 001 of 2020 concerning the use of uniform in academic and non-academic activities inside and outside the campus [2], as well as the regulations regarding the recording of student achievements and violations which are regulated in Director Regulation Number 003 of 2020 which regulates the code of ethics and rules of conduct for Polstat STIS students [3]. Research on student commitment to STIS regulations for the 2016/2017 academic year says that the implementation of these regulations is still not good, this is reflected in violations committed by STIS students from first to fourth grade such as lateness and absence during the weekly morning assembly, as well as disciplinary violations such as long hair inappropriate, incomplete uniform attributes, and others [4].

In enforcing regulations at the Polstat STIS, there is a student squad called Satuan Penegak Disiplin (SPD) which aims to maintain security, order, discipline, and student ethics in participating in all activities on and off campus to enforce regulations [5]. To support the SPD's goals, several tries have been carried out to uphold student discipline include surprise inspections and inspections when a morning assembly is held to check the completeness and tidiness of the Polstat STIS students. Enforcement of discipline that is not carried out at any time can lead to indiscipline in the rules by students. Therefore, continuous supervision is needed so that student discipline can be maintained.

One way to carry out continuous surveillance can be done by recording through a camera. Supervision can be carried out by detecting the neatness of Polstat STIS students such as the completeness of the uniform attributes or usually called Pakaian Dinas Akademik (PDA) attributes. Based on the Director Regulation Number 001 of 2020 article 2 section 1 the completeness of PDA includes shoes, socks, bivouac, belts, bags, badges, nametag, chevrons, student corps emblems, Polstat STIS emblems, BPS emblems, and position marks in the form tali kur and lencana. Completeness of attributes as an object is then can be detected using object detection in the image recognition method. Object detection is a process for detecting objects captured in a visual data, whether in the form of images or videos [6]. In a detection, a model is needed to detect an object and integration with the camera is required. Object Detection requires image data as the material for making models and integrating models with cameras to detect attribute violations in students wearing academic uniforms. This paper reports our study in developing a system that can detect the completeness of PDA uniform attributes to increase student discipline in terms of neatness and completeness of PDA uniform attributes and can carry out continuous monitoring.

The purpose of this research is divided into general objectives and specific objectives. The general objective of this research is to build a system capable of detecting the completeness of student attributes and storing them for validation. While the specific objectives to be achieved are to build a completeness attribute detection model and build an application that is able to detect and store the results of the completeness of attribute detection.

2. Literature Study

In this study, several related studies included research conducted by Harani et al in 2019, namely object detection and vehicle license plate character recognition [7]. The research aims to detect and recognize characters on vehicle license plates using the Convolutional Neural Network (CNN) method. They developed an application system which is capable of recognizing Indonesian license plate characters.

Budiyanta et al. conducted research on computer vision-based rice purity detection with the YOLO algorithm reinforcement in 2021 [8]. This study aims to detect the purity of rice against a mixture of impurities. The detected object is a stone or gravel (gravel) using the YOLOv3 object detection process. The results of the entire object detection system in this study went well and had an accuracy of 86.11%.

In 2017, Aini et al. conducted research on object detection and recognition using the YOLO machine learning model [9]. This study discusses the advantages and disadvantages of each version of the YOLO model. This research found that each version of the YOLO model had deficiencies, but over time these deficiencies were corrected and the YOLO model continued to develop and be improved to a better level.

In 2020, Hasma and Silfianti conducted research with the title implementation of deep learning using the Tensorflow framework using the Faster R-CNN method [10]. This study aims to detect and classify acne. This research succeeded in detecting and recognizing three skin conditions on the human face, namely acne, scars, and pus.

3. Methods

3.1. Data collection
Data collection methods are carried out to help understand existing business processes, problems and opportunities that occur and collect information that helps in system development. In this study, data was collected using literature study and interview methods.

1. Literature research
   Literature studies are used to find information on theoretical basis and related research and find solutions to system problems and requirements. This method is carried out by reading documents related to discipline and neatness regulations at the STIS Polstat as well as related research literatures.
2. Interview
   The interview method was carried out to find information about problems, running systems, and system requirements. Interviews were conducted through one of the BAAK and UPK employees. BAAK (Bagian Administrasi Akademik dan Kemahasiswaan) is the administrative implementing element at Polstat STIS, it has the task of managing academic administration and student affairs. UPK (Unit Pembinaan Kemahasiswaan) is a unit that has the task of carrying out student affairs development. Based on the results of the interviews, an overview of the system to be created is generated.

As for the data collection for the object detection model formation dataset using image data of students in PDA uniforms with complete uniform attributes collected by the researchers themselves.

3.2. Model development
In the model formation method, the stages are carried out in forming an object detection model with the YOLO algorithm. The following are the stages in the formation.

1. Data annotation
   Image data in the form of student images that have been collected are labeled or annotated by the object to be detected. Objects detected in this study are limited to people and attributes, namely bivouac, chevrons, nametag, and badge. The annotation process uses the LabelImg library available in Python.
2. Model construction
   After annotating the image data, the data is divided into training datasets and testing datasets. In the training dataset, training is carried out using the YOLO algorithm by paying attention to the model parameters used to form the model and in the testing dataset used to evaluate the model resulting from the training process.
3. Model evaluation
   After the training process produces the model, the model is evaluated using dataset testing. Evaluation of the model uses evaluation matrix to assess the performance of the model with precision, recall, F1-score, and mAP.

3.3. System development
In this study, we developed the object detection system using the System Development Life Cycle (SDLC) with a waterfall model approach. The following are the SDLC waterfall model stages.

1. Requirement analysis
   At the requirement analysis stage, the problems are identified, running systems, and system requirements by interviewing and studying literature. The interview process was conducted with the staff from the student affairs and the student coaching unit.
2. System design
   At the system design stage, the results of the requirements analysis that have been collected to formulate solutions to existing problems are evaluated. Accordingly the system design is established that will be built based on the results of the requirements analysis.

3. Implementation
   At the implementation stage, a system is built according to the design that has been established. The system built consists of a website application and a desktop application. The program code of the application being built is written and tested in this stage.
4. Integration & testing
   In the integration and testing phase, the system that has been developed in the form of a desktop application and a website application will be integrated and tested. Tests are carried out to identify and correct errors in the system being built.
5. Operation & maintenance
   During the operation and maintenance phase, a system that has successfully passed the testing phase will be deployed in a production environment, which is at Polstat STIS. After implementation, the system will enter the maintenance phase, where problems that arise after the release will be fixed and system updates will be made if necessary.

Figure 1 shows the flow of the waterfall SDLC method.

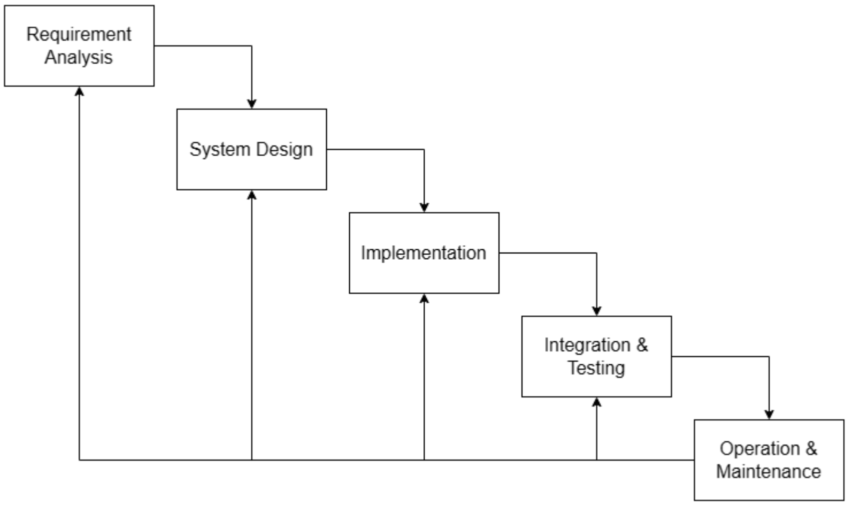

Figure 1. Sommerville's Waterfall Model SDLC Stages [11]

3.4. Evaluation
In this study the developed system was evaluated using black box testing. Black box testing is a test to find out whether the built system meets the user needs or not. Testing is done by listing the scenarios of the features contained in the system, then these features are tested.

4. Results

4.1. YOLO model construction
The development of the YOLO model goes through the stages of image data collection, image data annotation, model training, and model evaluation. The following are the results of the YOLO model development stages.

1. Image data collection
   Image data collection was carried out by collecting images of students wearing PDA uniforms with complete attributes. Image data collected are as many as 150 image data, hereinafter referred to as the dataset. The collected dataset consists of 65 images of male students, 71 images of female students wearing the hijab, and 14 images of female students not wearing the hijab.
2. Image data annotation
   After the dataset is collected, the annotation process is carried out on the dataset, the annotation process is carried out by labeling objects on the image data in the dataset. Objects that are labeled

are students and attributes including bivouac, chevrons, nametags, and badges. the annotation process is done by giving a bound box to the annotated object. The annotation process generates a text file for each image data that contains the object bound box coordinates in it. Figure 2 shows the annotation process.

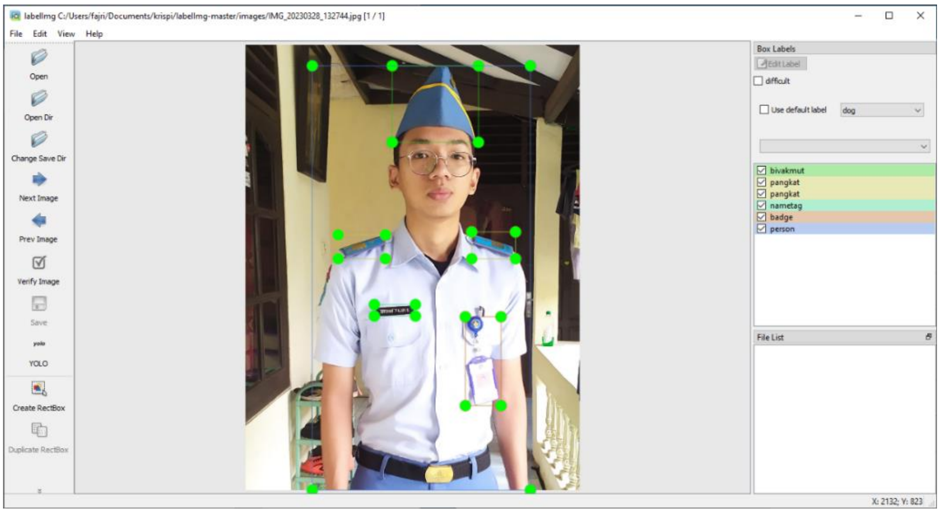

Figure 2. Annotation Process

3. Model training
   After the annotation process is complete, the dataset is divided into training data and test data with a total ratio of 7:3, those are 105 for training data and 45 for test data. The distribution of training data consisted of 48 pictures of male students, 46 pictures of female students wearing hijabs, and 11 pictures of non-hijab female students. While the test data consisted of 17 images of male students, 25 images of female students wearing hijabs, and 3 images of non-hijab female students. Then the training data is used to build the YOLO model version 5. The hyperparameters used to build the model include image size, batch size, momentum, training iterations, and learning rate. The following parameter sizes are shown in Table 1.

Table 1. Training model hyperparameter

Parameter	Value
Image size	640 x 640
Batch size	20
Momentum	0.937
Training iteration	1000
Learning rate	0.01

   In the training process, the training iteration that was carried out stopped at the 441st iteration because there was no increase in mAP in the last hundred iterations. The training process produces a model with a weights format.
4. Model evaluation
   After the training process ends, the model is evaluated using precision, recall, F1-score, and mAP. The following is the model evaluation value in Table 2.

Table 2. Evaluation model

Evaluation method	Value
Precision	0.939
Recall	0.943
F1-score	0.941
mAP 0.5	0.964
mAP 0.5:0.95	0.704

The precision value of 0.939 means that about 93.9% of the objects classified as positive by the model are true positive. The recall value of 0.943 means that around 94.3% of all positive objects the model actually managed to find. The F1-score value of 0.941 indicates that the model can correctly identify most of the objects that are correct (precision) and find most of the objects that are actually positive (recall). At a threshold value of 0.5, the model achieves an average precision of 0.964, which indicates a good ability to classify objects correctly at different recall levels. With a mAP of 0.704, the prediction results from the model may contain a higher number of errors, which could mean that objects were missed or objects that were identified incorrectly in the detection results. Based on the evaluation of the model, the model can be said to be quite good at detecting objects.

4.2. Attribute completeness detection logic construction

The model that has been built has the ability to detect objects according to the annotations given, those are students and attributes in the form of chevrons, nametag, bivouac, and badge. However, this model cannot detect the ownership and completeness of the attributes used by students. Therefore, a model to detect the ownership and completeness of the attributes used by students needs to be developed also. Figure 3 shows the flow of detection of ownership and completeness of student attributes.

```
START
├─> DETECT OBJECTS
│     ├─> FOR each detected PERSON
│     │     ├─> SET person_coordinates = (x_min, x_max, y_min, y_max) of detected PERSON
│     │     ├─> FOR each detected OBJECT (except PERSON)
│     │     │     ├─> SET object_center = center coordinates of detected OBJECT
│     │     │     ├─> IF object_center is within person_coordinates
│     │     │     │         └─> OBJECT belongs to the PERSON
│     │     │     └─> ELSE
│     │     │           └─> CONTINUE
│     └─> END LOOP
└─> END
```

Figure 3. Attribute completeness detection flow

Figure 3 illustrates the object detection flow and loop to check if the attribute object is inside the person object. Each object has x_min, x_max, y_min, and y_max coordinates which are used to define the boundaries of the object area. Next, it is repeated for each detected person object. Inside this loop, there is another loop for objects other than person which is attribute. At each iteration of the iteration, we check whether the attribute object is inside the person object, by checking whether the attribute object's center point is between the x_min, x_max, y_min, and y_max person objects. If the attribute object is in a person object, then the attribute object is considered to belong to that person. If not, then the loop will continue for the next attribute object. Then if the person is incomplete in using the attribute then a violation will be detected, and if the person uses the complete attribute then there is no violation.

Figure 4. No violation detected

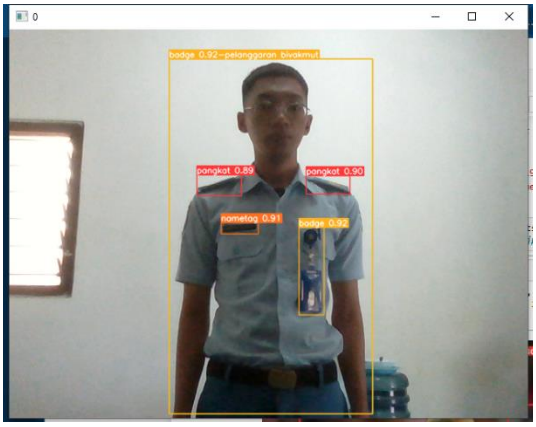

Figure 5. Violation detected

4.3. Current system analysis

Regular checking of student compliance against regulations as well as the tidiness is carried out by a student squad called the disciplinary enforcement squad or Satuan Penegak Disiplin in Indonesian (SPD). But not only SPD, lecturers and faculty staff also responsible to conduct the same thing. When a violation detected during surprise inspections or during the weekly morning assembly, the SPD records the violation. If the student is proven to be violating the regulation, a letter of violation will be given and the student badge will be confiscated.

4.4. Problem analysis

From the current system process, the problem can be seen through the following problem analysis fishbone diagram.

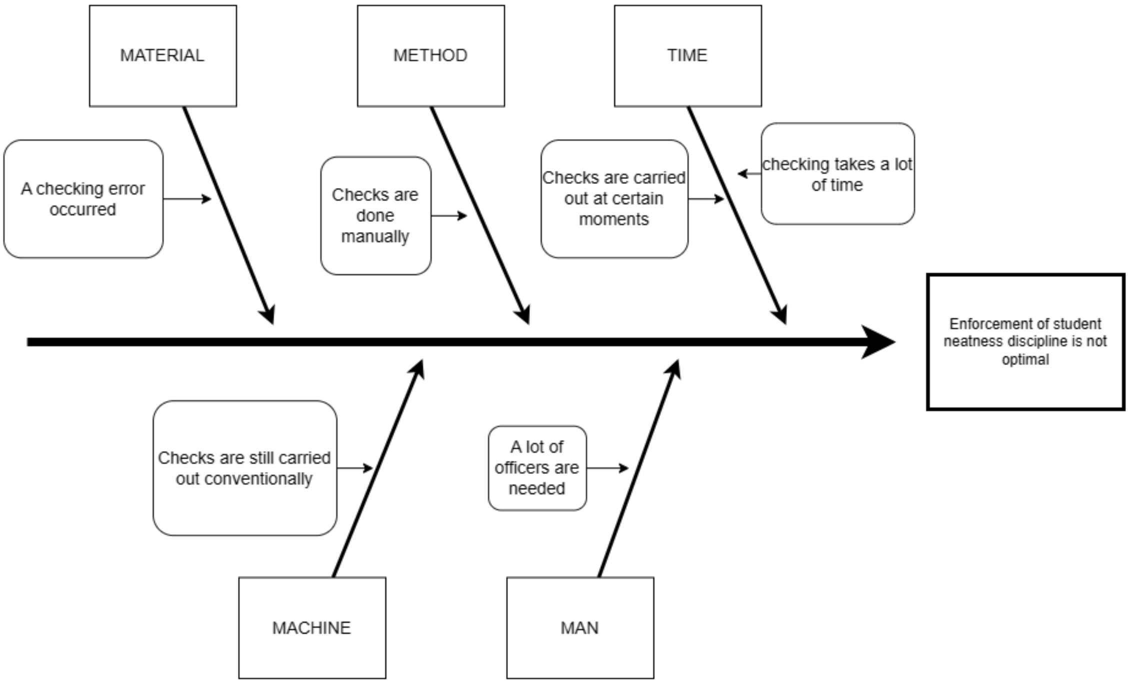

Figure 6. Fishbone diagram

The main problem faced is that the enforcement of neatness discipline has not been optimal. This is caused mainly by the method being used which is checking the neatness is still done manually with the observation of the SPD, in the material factor which is the occurrence of checking errors, in the machine factor which is checking is still done conventionally, in the man factor which is checking requires many personnel, and in the time factor which is checking requires a lot of time and only at certain moments.

4.5. Requirement analysis

Requirements analysis in this system consists of functional requirements and non-functional requirements.

1. Functional needs
   - An information system that can detect the completeness of student attributes.
   - An information system that can store the results of the detection of the completeness of student attributes.
2. Non-functional needs
   - The system can be accessed easily at any time.
   - The system can be used easily.
   - The sistem is easy to learn
   - The system display is easy to understand.

4.6. Proposed system design

1. Business process of the proposed system

   There are two users, namely operator and admin. The operator performs a running detection of the completeness of student attributes. Then the system will begin to detect the completeness of student attributes. If a student wears a complete uniform, it will not be recorded as a violation. If a student does not wear the complete uniform attribute, the student will be recorded as a violation. After the violation is recorded, the admin validates the violation, checks the truth of the violation whether it is match or not.

   The proposed system business process is shown in Figure 7.

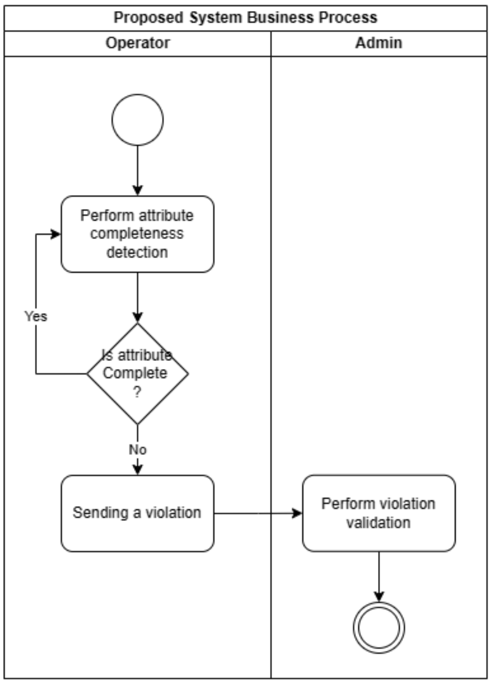

Figure 7. Proposed System Business Process

2. System architecture design
   On each computer an application will be installed to detect the completeness of the attributes that are connected to the camera to carry out the detection. When the application catches a student who commits a violation without wearing the complete uniform attribute, the violation will be sent to the web server via the API. System architecture is shown in Figure 8.

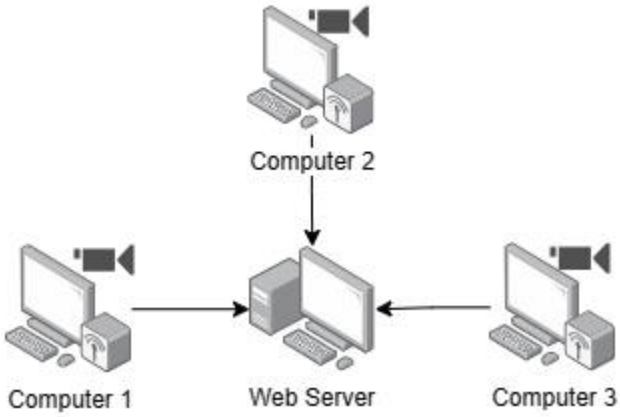

Figure 8. System architecture design

   The web server will catch violations via the API then the violations will be displayed on the web page.
3. Proposed system use case diagram
   Use case diagrams are used to map users to proposed system functionality. The proposed system use case diagram can be seen in Figure 9.

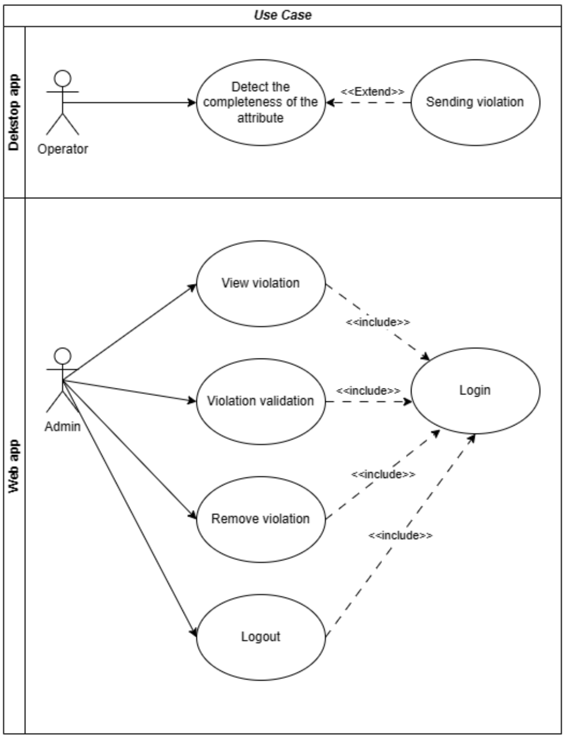

Figure 9. Use case diagram

Operators can only perform attribute completeness detection while admins can login to the web application, view violations, validate violations, delete violations, and log out.

4. Database design
   Figure 10 shows the proposed system database ERD design.

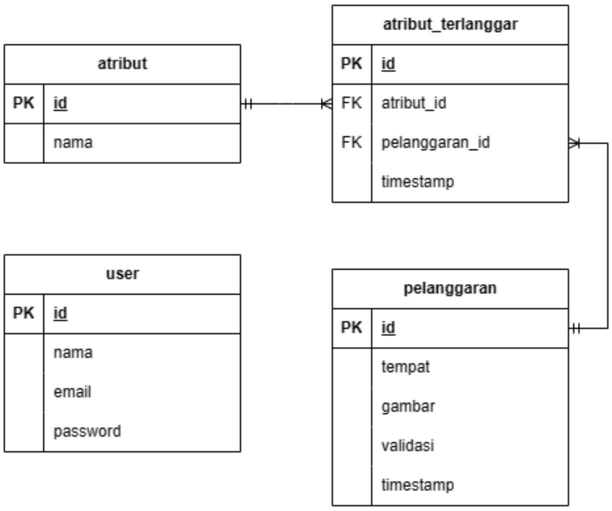

Figure 10. Database ERD design

In ERD there are four tables, namely atribut, atribut_terlanggar, pelanggaran, and user.

4.7. System implementation

1. Hardware implementation
   The hardware used in the development of this system is a laptop branded Acer A514-52G with the following specifications.
   - Processor: Intel® Core(TM) i5-10210U CPU @ 1.60GHz 2.11 GHz
   - Graphics: Intel® UHD Graphics 620
   - Memory: RAM 8GB
   - Hard Drive: 512GB SSD
   - Monitor: 14.0” with 1366 x 768 resolution

   The hardware used is also the XiaoMi Redmi Note 7 handphone with a 48MP camera.
2. Software implementation
   The software used in the construction of this system is as follows.
   - Windows 10 64-bit Operating System
   - Python version 3.8.8
   - Apache version 2.4.56
   - MariaDB version 10.4.28
   - phpMyAdmin version 5.2.1
   - PHP version 8.2.4
   - VSCode version 1.79.2 as a text editor
   - Microsoft Edge browser version 114.0.1823.58
3. Database implementation
   Database implementation using MariaDB is shown in Figure 11.

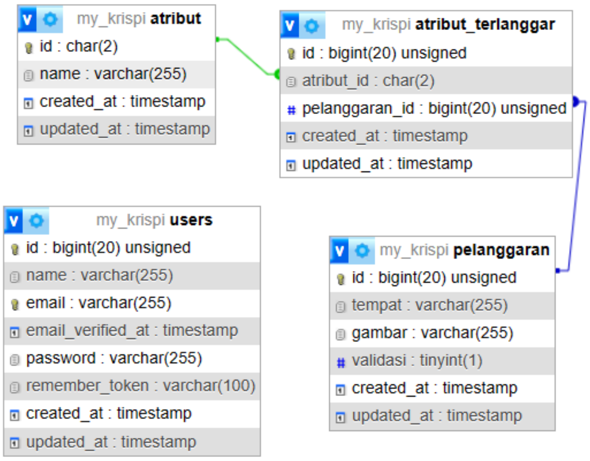

Figure 11. Database implementation

There are four tables in the database, namely atribut, atribut_terlanggar, pelanggaran, and user.

4. Interface implementation
   a. GUI of attribute completeness detection application

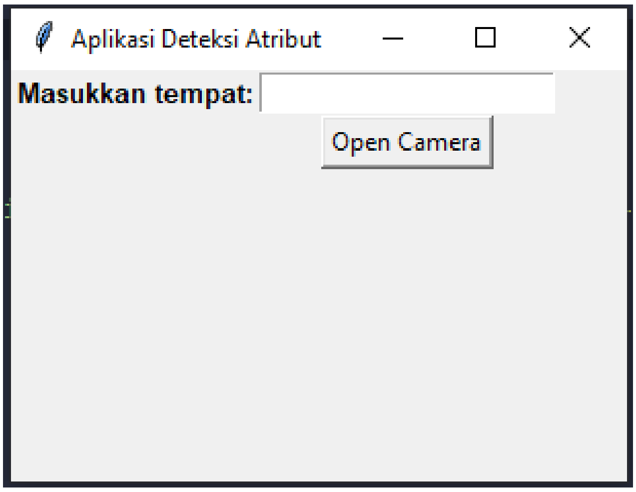

Figure 12. Detection application GUI

Figure 12 shows the contents of the interface display of the attribute completeness detection application. The user is required to fill in the location for the detection process first, then press the "Open Camera" button so that the detection process can run.

   b. Login page interface

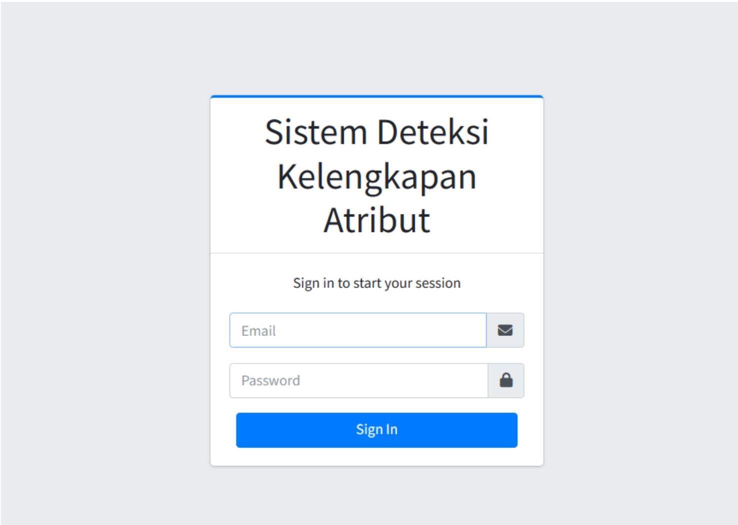

Figure 13. Login page interface

Figure 13 shows the login page of the Attribute Completeness Detection system. Users are required to fill in an email and password with their registered account. After that, the user can press the "Sign In" button and the system will redirect to the home page.

c. Home page interface

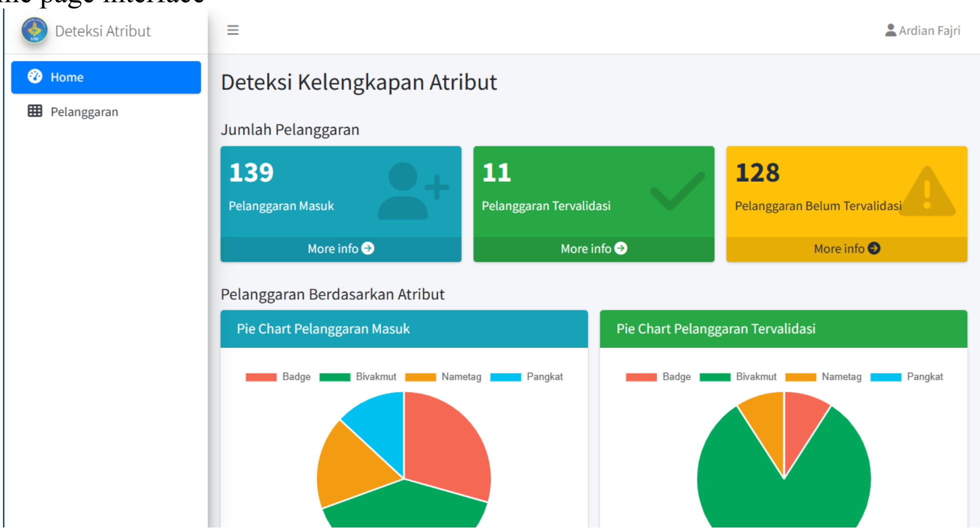

Figure 14. Home page interface

Figure 14 shows the detection system home page. The home page presents a visualization of incoming violations. Visualization of incoming violations includes the number of entered violations, the number of validated violations, the number of violations that have not been validated, and the attribute piechart that was violated. On the home page there is also a sidebar containing the page menu and a navigation bar containing a dropdown of the user's account name which, if pressed, a "Logout" button will appear to logout.

d. Violation page interface

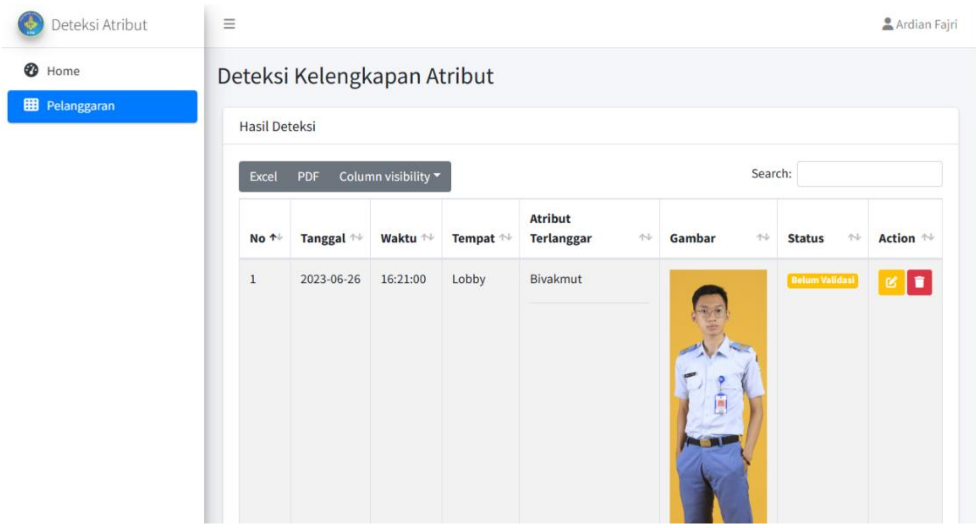

Figure 15. Violation page interface

Figure 15 shows the violation page interface. On the violation page there is a table of detection results that stores student violations. The columns in the table are number, date, time, place, violated attribute, image, validation status, and action. In the action column there is a button to validate the violation and a button to delete the violation.

4.8. System testing

The system evaluation method built is by using Black Box Testing. Black Box Testing is a testing method that aims to check the suitability between the input and output of the system without having to know the structure of a system. This system test was carried out on four members of the Polstat STIS UPK. Table 3 shows the results of Black Box Testing.

Table 3. Black box testing

No	Scenario	Expected result	result
1	Open the detection application	Successfully Opened the application window	match
2	Fill in the field where the detection is run	Successfully filled in the field of detection	match
3	Perform attribute completeness detection	successfully bring up the detection window	match
4	Closes attribute completeness detection	Successfully closed the detection window	match
5	Close the detection application	successfully closed the application window	match
6	Login using email and password	Successful Login	match
7	Enter the home page	Successfully entered the home page	match
8	Go to the violation page	Successfully entered the violation page	match
9	Performs a preview of the image on the table	Successfully previewed the image on the table	match
10	Perform image preview on validation modal	Successfully previewed the image on the validation modal	match
11	Perform violation validation	Successfully perform violation validation	match
12	remove violations	successful elimination of infringement	match
13	logout	Successfully logout	match

Based on the results of Black Box Testing, the built system functionality can work well in accordance with the desired expectations. This indicates that the system is ready to use.

4.9. Simulation

The simulation was carried out by detecting the completeness of student attributes at the entrance to the STIS Polstat campus lobby with the camera position in the lobby facing the entrance. Detection using the HP XiaoMi Redmi Note 7 48 MP camera.

Simulations using the Xiaomi Redmi Note 7 48 MP camera for 30 minutes resulted in the detection of 85 violations with a total size of 1.66 MB. Violation image sizes range from 4 KB to 58 KB with an average of 20 KB in JPG file format. Based on this simulation, estimates for calculating storage requirements for one day for 9 hours of use from 07.00 to 16.00 require approximately 40 MB of storage.

5. Conclusion

In this paper conclusions obtained from the system development that has been carried out are as follows.

1. The attribute completeness detection model has been successfully built with a precision of 0.939.
2. An attribute completeness detection application capable of detecting and storing detection results has been successfully built.
3. The results of testing the system with Black Box Testing show that the functions that have been made can run well in accordance with the expected results.

Based on these points, it can be concluded that the completeness detection system for student attributes has been successfully built.

The suggestions that can be given for further research and system development are as follows.

1. The model development dataset can be improved by equalizing the number and characteristics of the dataset.
2. Detection can be further developed related to student identification features.
3. It needs to be studied more deeply related to the detection system implementation strategy.

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