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Implementation of Computer Vision for Efficient Attendance and School Uniform Checking System

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Abstract—Managing school administrative tasks can consume substantial time and effort. Every semester, teachers find themselves occupied in repetitive manual tasks such as attendance tracking, disciplinary documentation, and assignment grading. These sometimes could take longer time than preparation for teaching. In this research, we proposed an Artificial Intelligence (AI) approach to handle this problem. In the era of Industry 4.0, AI has been managed to be personal assistance and do human repetitive tasks efficiently. However, the implementation of AI in Indonesia especially for educational institutions is still rare. Therefore, we have developed an innovative AI-driven attendance and uniform detection system by implementing computer vision models. Computer vision is a field of AI that equips machines with the ability to interpret and understand visual information from images and videos, enabling them to classify images and detect objects. The results show that computer vision has successfully facilitated swift and accurate detections for this task. We have also incorporated a timestamp to provide information about the time when students arrive at school. Subsequently, all the recorded data will be saved and organized within the school's database. As a result, teachers are liberated from the tedium of manual data entry and can redirect their efforts toward pedagogical materials and instructional strategies.

Keywords: Computer vision, attendance report, uniform checking system, artificial intelligence

1. INTRODUCTION

The attendance and uniform checking processes play a crucial role in formal schools across Indonesia. These policies aim to instill discipline, neatness, and equality among students, and assess student participation in the learning process. In Indonesia, it is customary for teachers to conduct these checks every morning before commencing classes. Additionally, at the end of each academic term, teachers must recap this information for the school database and student reports. Unfortunately, these administrative tasks are time and energy-consuming (Sennen, 2018). While essential for managing the education process, they often leave teachers with limited opportunities to focus on crucial activities such as preparing teaching methodologies, instructional materials, and grading assignments. Moreover, these tasks are susceptible to risks, including misplaced notes, miscalculations, and human errors. Therefore, we need innovation to make this system more efficient and effective (Warsah & Nuzuar, 2018).

In the era of Industry 4.0, Artificial Intelligence (AI) technology has experienced exponential growth (Sigov et al., 2022). The vast amount of data available on the internet has enabled machines to learn and perform tasks akin to human abilities (Cioffi et al., 2020). This allows humans to delegate repetitive tasks to AI, allowing them to concentrate on more critical responsibilities. AI has been successfully implemented in various business processes to enhance efficiency (Benotsmane et al., 2019). However, its application in educational institutions remains relatively rare (Chen et al., 2020), especially in Indonesia.

In recent years, computer vision, a subfield of artificial intelligence, has garnered significant attention as an innovative technology seeking to replicate human visual capabilities within machines (Xu et al., 2021). By enabling computers to interpret, analyze, and comprehend visual data extracted from images or videos, computer vision empowers machines to make informed decisions and take appropriate actions (Stockman & Shapiro, 2001). The interdisciplinary nature of computer vision combines computer science, machine learning, mathematics, and image processing to develop powerful algorithms and models capable of interpreting complex visual information (Zhang, 2021). As this technology continues to evolve, it potentially affects many sectors, including education (Sophokleous et al.,2021). Therefore, we assumed that it could be used to solve school-image-related tasks.

In this research, we aim to help the teacher to optimize their time by implementing AI for attendance and a uniform checking system. To address this, we pose the following research question:

1) What kind of AI model will work effectively for the attendance and uniform checking system in school, and how efficiently does it perform compared to the manual system?
2) What are the key steps and challenges involved in implementing an AI model and integrating it with a school database system to enhance attendance and uniform checking processes?

2. LITERATURE REVIEW

2.1 Implementation of AI for Optimizing Education System in Europe

Nowadays, AI has been well-developed to optimize business processes. If we talk about AI in education, the most common research is about how to prepare the education system to be adapted with the development of AI. Both teachers and student need to have AI literacy as the next level of computer literacy. On the other hand, it is still rare to find research about how to leverage AI to optimize the education system, especially in Indonesia. However, currently, AI has been developed to support education process in Europe. According to Holmes and Tuomi, there are 3 kinds of implementation of AI in education system in Europe; Student-focused AI, Teacher-focused AI, and institution focused AI (Holmes & Tuomi, 2022).

Since the education systems and challenges in each country vary, the priorities for AI development differ as well. In Europe, student-focused AI helps disabilities to learn in class. For example, they provide text-to-speech for blind students, sign language translation, etc. They also combine it with Virtual reality to make game-based learning. Furthermore, teacher-focused AI mostly used are the implementation of natural language processing for plagiarism and cheating detection and computer vision for class monitoring. In addition, institution-focused AI assists in managing the class schedule, admission process, etc. All innovation of AI is really useful to make the learning process more efficient.

2.2 The Development of Automated Attendance System

Automated attendance system is commonly used in many companies. In general, there are 4 kinds of automated attendance system; Radio-Frequency Identification (RFID), biometric (fingerprint, face recognition, etc.), Barcode, and magnetic stripe-based (Ali et al, 2022). RFID uses wireless sensor technology that could potentially detect a person from at least 30 meters from the detector. So, the process will be simple since we do not need to queue in a line in front of the detector. However, it requires schools to prepare some expensive tools to use it. The biometric approach is the most popular system in many companies. Here we need to input one of (or all) biometric data, such as face image, fingerprint, voice, etc. It looks simple but we need to train the AI model since it uses machine learning to identify the person. The barcode system is the simplest way so it is commonly used in many institutions. Nevertheless, it is too risky to be implemented for student since their id card could be probably lost. The last one is not recommended for school since it requires complicated instruments. Therefore, the most possible approach for this problem is biometrics that needs machine learning with high accuracy.

2.3 Machine Learning for Detecting Object

The utilization of machine learning to identify some objects and mark it with the name of the object is called object detection. This process combines both image classification and localization techniques, allowing multiple objects to be detected simultaneously. There are many kinds of object detection models depending on the problem and dataset. Traditional-based approaches such as haar cascade and histogram of oriented gradients (HOG), often require the integration of traditional machine learning models. Adaboost and Support Vector Machines algorithms are commonly chosen in this context. This traditional approach is computationally efficient compared to deep learning methods. Deep learning algorithms, on the other hand, demand large datasets to perform effectively. However, they typically achieve higher precision compared to traditional approaches. To address the data requirements, many computer scientists have developed pre-trained models. These models have already undergone training on extensive datasets, giving them pre-established weights that can be further fine-tuned, even with smaller datasets.

Based on the survey of current deep learning models for object detection, there are some kinds of approaches; single-stage detectors, 2-stage detectors, and lightweight networks (Zaidi et al., 2022). Single-stage detectors aim to identify and locate objects in a single pass through the neural network. They are made for real-time applications where speed is a priority. On the other hand, 2-stage detectors are usually chosen to do a task that needs very high accuracy but may be computationally more demanding. Furthermore, computer scientist has tried to make another option with more efficient computation and low number of parameters so that it works faster than 2-stage detectors. The precision of this model outperformed 1-stage and is almost similar to 2-stage detectors. Therefore, this type of model fits the need of our problem since it requires less memory but performs well. Popular examples of lightweight networks include MobileNet, SqueezeNet, and Tiny YOLO.

3. METHODS

3.1 Requirement Engineering Process

In this step, we identify what kind of AI model characteristics fit with teacher and school database systems. Since most school in Indonesia does not have an IT staff, the system should be easy to operate, using a simple but high-accuracy model, and can be integrated with the school database system. Therefore, from the 4 types of face recognition systems we choose.

3.2 Dataset

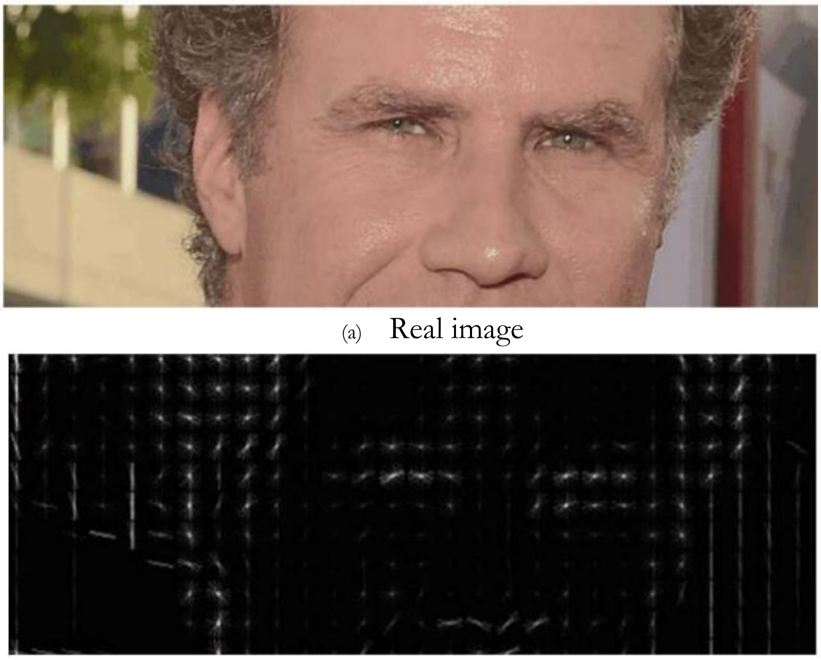
There are 2 datasets used to train the model. First, we used "Labelled Faces in the Wild (LFW)". This dataset contains more than 13,000 labeled face images provided by University of Massachusetts. Then, we also collected 50 images of secondary high school students with their uniform to train model.

3.3 Model of Face Recognition for Attendance System

Face recognition is a computer vision task that is used to identify and verify a person based on their facial features. It is a biometric technology that has gained significant attention and widespread applications in various domains, including security, authentication, surveillance, and human-computer interaction. In this research, we used a library on Python named "face_recognition" that was already trained with "Labelled Faces in the Wild (LFW)" dataset and reach 99.38% of accuracy. However, we still trained it again by student image dataset to make sure that it really works for our system. This system consists of 4 steps; feature extraction, posing and projecting, data encoding, and image classification.

3.3.1. Feature Extraction

In this process, we implemented HOG that is normalizing the color and finding the pattern of intensity gradients or edge directions. The aim of this process is to identify the location of face on image.



(a) Real image

(b) After implementing HOG

Figure 1. The illustration of implementing HOG (b) to real image (a) (Geitgey, 2019)

3.3.2. Posing and Projecting

In this process, we want to detect the position of the nose, eyes, mouth, etc. By accurately determining the positions of these landmarks, the computer vision system gains valuable information about facial expressions. The method used is Face Landmark Estimation which involves identifying and localizing specific key points or landmarks on a human face.

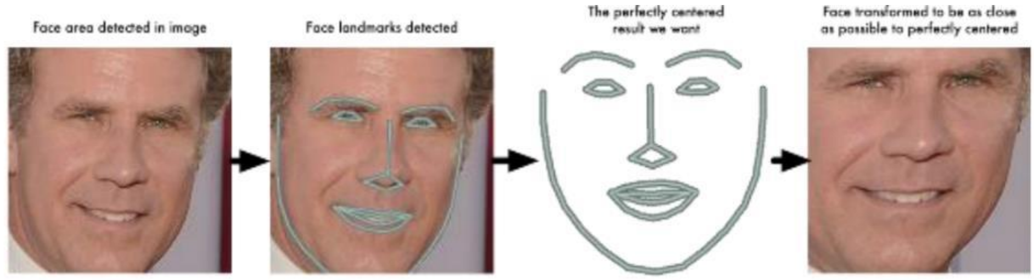


Figure 2. The illustration of Implementing Face Landmark Estimation (Geitgey, 2019)

3.3.3. Data Encoding

Before the classification process, we need to transform the data into numbers. Here we will make a matrix with a size of 128 that represents the image. This matrix will be used to classify images to identify the names of students based on the school database.

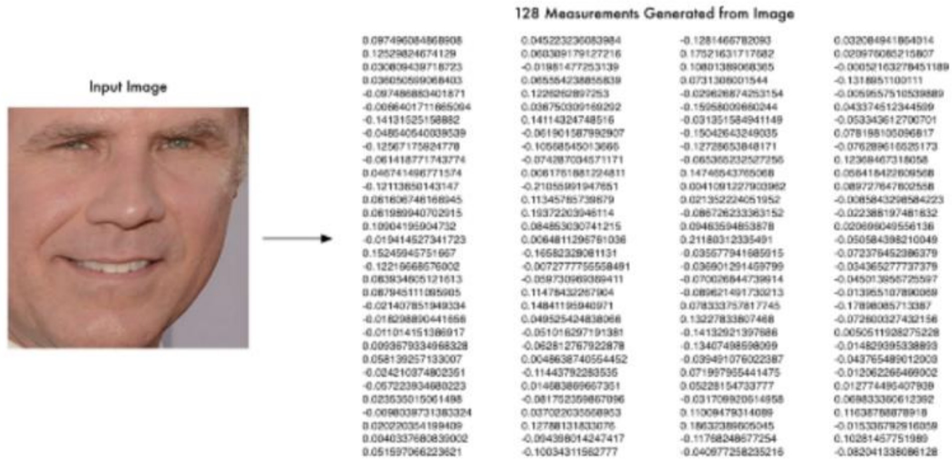


Figure 3. The illustration of Data Encoding (Geitgey, 2019)

3.3.4. Image Classification

The next process is matching the image and name of the student. Here we implemented the Support Vector Machine (SVM) algorithm by using the matrix as the input. SVM is a supervised algorithm that makes hyperplane to find the difference between the classes (Sheykhmousa et al., 2020). Key concepts of SVM are;

a. Hyperplane: if we consider the dataset to become a point in 2-dimensional space, a hyperplane is a straight line that separates points of different classes or labels. For binary classification, the SVM algorithm looks for the hyperplane that maximizes the distance (margin) between the two labels.

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b. Margin: The margin signifies the separation between the hyperplane and the closest data points belonging to each class. A wider margin indicates higher confidence in the model's predictions.
c. Support Vectors: These represent the data points that are positioned in close proximity to the hyperplane and hold a significant role in shaping the decision boundary. They are termed as "support vectors" because of their instrumental role in aiding the optimal class separation.

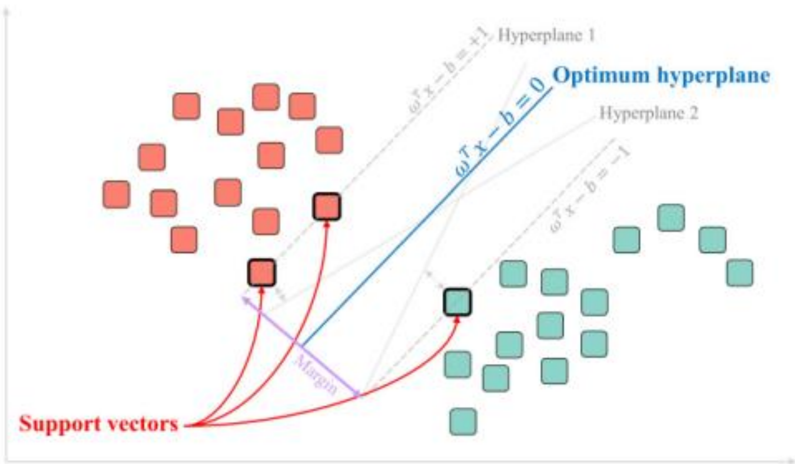

Figure 4. How the SVM Algorithm Works

After getting the name of an image, our system will save the time of detection so we can identify which person come early or late. Then, the teacher can download it as a report file.

3.4 Model of Object Detection for Uniform Checking System

This system is an object detection task that used to check white uniform, "OSIS" Logo, and tie of each student. The model used in this a research is a pre-trained model named "MobileNetV2". MobileNetV2 is a convolutional neural network with 53 layers that less computation so it is good for a system implemented in school. While MobileNetV2 is primarily designed for image classification, it can also be adapted for object detection tasks using a technique called "Single Shot Multibox Detector" (SSD) (Cheng, 2022). SSD is an object detection algorithm that combines the benefits of deep learning-based feature extraction and a priori-defined anchor boxes to predict object bounding boxes and category in a single forward pass. This process has 6 steps provided below;

3.4.1 Feature Extraction

The MobileNetV2 architecture is used to get the maps of feature from the input image. These feature maps represents hierarchy of the image, encoding both low-level and high-level features.

3.4.2 Anchor Boxes

SSD requires pre-defined anchor boxes of different sizes and aspect ratios to cover various object sizes and shapes in the image. These anchor boxes act as reference templates during the detection process.

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3.4.3 Prediction Layers

Multiple prediction layers are added to different feature maps to make predictions at multiple scales. Each prediction layer is responsible for predicting bounding boxes and class scores for objects at a specific scale.

3.4.4 Bounding Box Prediction

For each anchor box, MobileNetV2 predicts the offset from the anchor's center to the actual bounding box location. This process refines the initial anchor boxes to tightly fit the detected objects.

3.4.5 Class Prediction

MobileNetV2 also predicts the probability of each anchor box belonging to a particular class. The model assigns a class label to each anchor box based on the highest confidence score.

3.4.6 Non-Maximum Suppression (NMS)

After obtaining bounding boxes and class predictions from multiple scales and prediction layers, NMS is applied to remove duplicate and low-confidence detections, keeping only the most accurate and highest-scoring bounding boxes for each object.

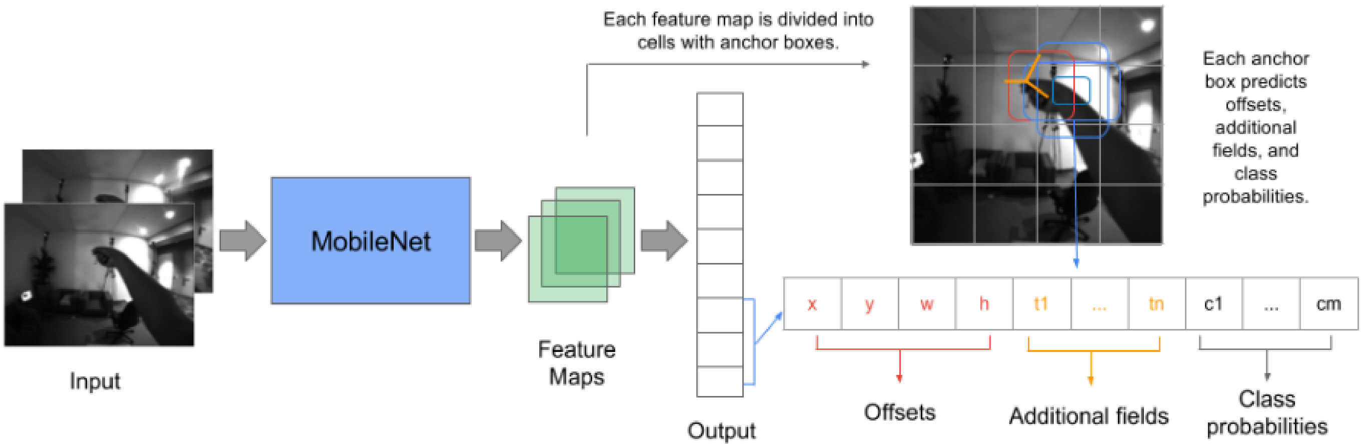

Figure 5. The illustration of How MobileNetV2 and SSD Work (Pandey et al., 2018)

3.5 Deployment

In this research, we build an AI model with Python. Then, the trained models are saved and deployed using Flask. Finally, we deploy the Flask app on a cloud platform as a part of the school website

4. RESULTS AND DISCUSSION

Upon completing the model training, an outstanding outcome was achieved as our face recognition system achieved an impeccable accuracy of 99.38%. It impeccably and swiftly identifies the names of students in real time. Following successful recognition, the system compiles a concise summary containing the names of each student and their corresponding arrival times at the school. This valuable data is then conveniently saved as a CSV file, ensuring easy accessibility and efficient data management. For a detailed visualization of our testing results, please refer to Figure 6.

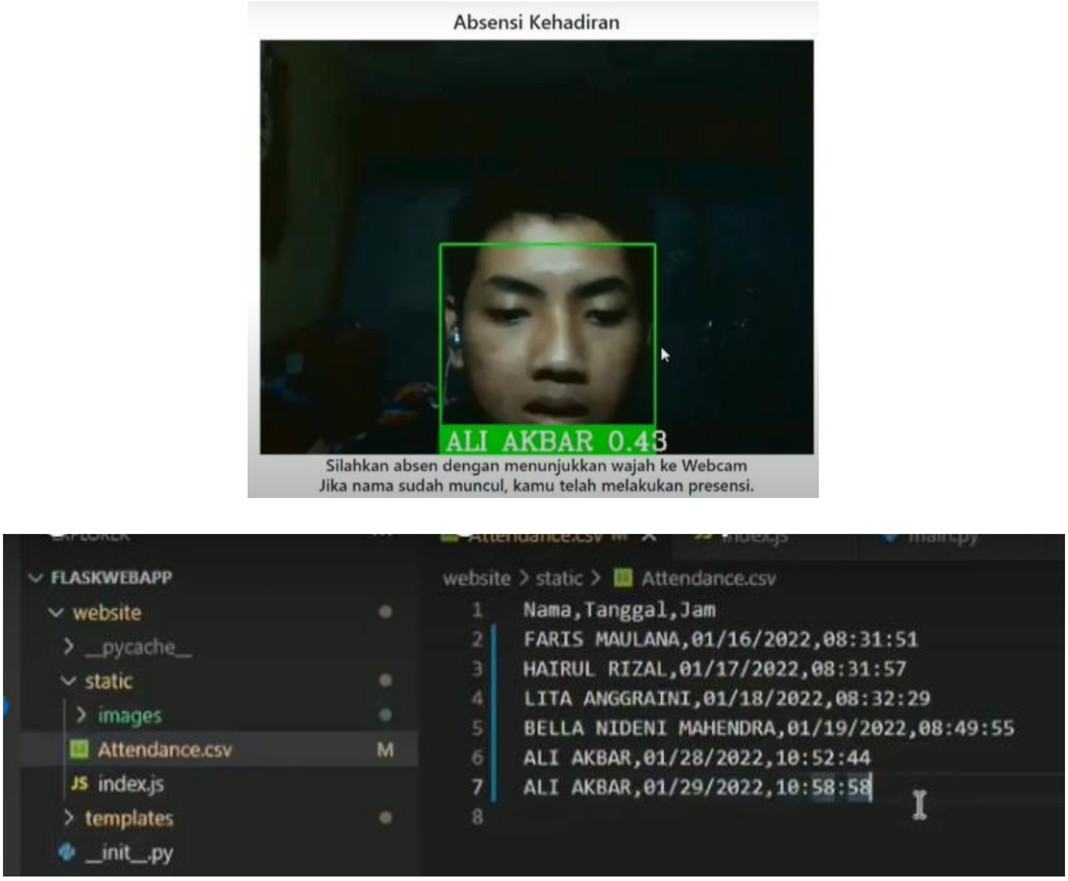

Figure 6. Face Recognition Testing
(Note: The person names and image are our team member)

For school uniform checking, first we label 80% of our dataset to train the model. Then, we test our model on 20% of our dataset. We trained MobileNetV2 with 3000 steps. The loss function during training is provided in Figure 7. In the end, it reaches 84% detection precision. The testing result of our system can be seen in Figure 8.

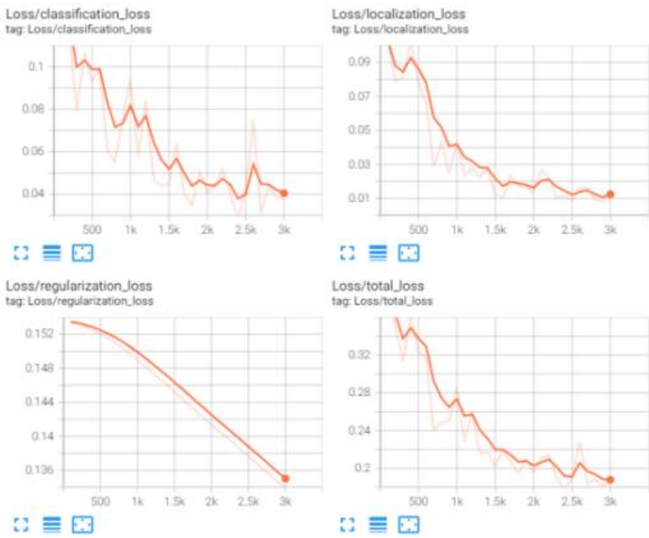

Figure 7. Loss Function of Training

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Figure 8. Testing Result of School Uniform Checking

Based on our experiment, the position of the student in front of the camera and the intensity of light can significantly influence the quality of our detection system's results. For optimal performance, the student should be positioned precisely in the center of the frame, and there should be sufficient brightness to ensure clear visibility of their face and uniform. By adhering to these guidelines, the AI system will be more likely to successfully and precisely detect the student's face and uniform. Therefore, we also prepare a guidance in order for teachers can use it well. The design of our web application is provided in Figure 9.

Figure 9. Example of Our Web-App Design

After evaluating the whole system, start from detection to recapitulation we have a comparison result provided below (see Table 1).

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Table 1. Comparison of Traditional and AI-based System

	Traditional	**AI-based system**
Time of detection	In seconds per student	In seconds per student
Accuracy and precision	Almost 100%	84% – 100%
Teacher involving	Yes, for almost all teachers	Need only 1-2 teachers on duty
Recapitulation of attendance	By teacher and only provide a day of attending	By system, provide the time of arrival so the teacher may know a student who comes late
Recapitulation of students who always wear school uniform	There is a potential that the teacher forgets to take a note and recap it	By system, the teacher may get it from the school database

As we can see that AI-based system will reduce the administration task of teachers and provide a high accuracy of detection. Therefore, teachers will have more time to prepare a better model of teaching. In addition, this system is still available for more supported AI services. As a result, it will optimize the education process in Indonesia.

5. CONCLUSION

AI for the education process is still rarely developed compared to its implementation in industry. It may be caused by the education system in every country being different so computer scientist needs to develop various types of model based on the problem they found. Indonesian teacher has a lot of administrative tasks that sometimes takes longer time than teaching itself. Moreover, since not many school has IT staff, we need to find an efficient AI model with low computation but performs well to assist the teacher.

This research study the possibility of computer vision to solve this problem. Here we found the impressive accuracy of the "face_recognition" Python library, achieving a remarkable 99.38% precision in recognizing students' faces. However, the positioning of students in the center of the frame significantly influences the model's performance.

For school uniform detection, we combined the MobileNetV2 and SSD models, yielding a respectable 84% precision in detecting key uniform components such as ties, "OSIS" logos, and white attire. Nonetheless, the system's efficacy relies on appropriate lighting conditions surrounding the students. The system efficiently compiles essential information, including students' names, uniform completeness, and arrival times, into a single CSV file. As a result, teachers are relieved of manual tasks, gaining more time to focus on crucial activities like preparing materials and grading assignments.

While our current system caters to one student at a time, we recommend future development to extend its capabilities for simultaneous detection of multiple students, thus enhancing overall efficiency. Furthermore, there is ample room for improvement in the school uniform checking system, as we acknowledge its current precision level stands at 84%. Continued refinement and advancements in computer vision technology hold the promise of further elevating the educational landscape.

Additionally, we encourage more AI engineers and scientists to develop student-focused AI and institution-focused AI. For student-focused AI we can implement Natural Language Processing to make a chatbot that allows them to ask any question related to the topic they learn in the class. We can also develop virtual reality (VR) to explore complex concepts in a visual and engaging manner, for example in biology class.

It also facilitates personalized learning by tracking students' progress and adapting content based on individual needs and abilities. Moreover, computer vision-powered tools can assist in identifying learning disabilities and provide early intervention, ensuring that every student receives the necessary support to succeed. Overall, AI has the potential to make our education system more efficient, accessible, and effective for learners of all ages.

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Supplementary Material

The code of this project is written here: https://github.com/akbar081200/WebFaceRecognition

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