Video based classroom monitoring

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ABSTRACT In traditional classroom environments, the demand for tools to automate attendance tracking and analyze student emotions has become increasingly important. This project develops a video-based classroom monitoring system that performs automated attendance and emotion analysis to evaluate student engagement. The system uses facial recognition to identify students and records attendance data into a well-organized Excel file for each session. Additionally, emotion recognition algorithms are implemented to analyze students' emotional states. While the system operates in real time, it suffers from slow processing speed and moderate accuracy. Built using Python and OpenCV, the system was tested in a simulated classroom environment, achieving basic project objectives. However, improvements in performance and accuracy are necessary for broader applications. This innovation supports educators in managing classrooms more effectively while providing valuable insights into student engagement.

1. Introduction

1.1. Motivation

- **Increased Efficiency**: Automates attendance tracking and emotion detection, saving time and reducing administrative burden.
- **Enhanced Accuracy**: Minimizes errors associated with manual entry, ensuring reliable attendance and engagement data.
- **Improved Security**: Reduces the risk of fraud and unauthorized access through biometric verification.
- **Emotion Detection**: Assesses student engagement in real-time, providing actionable insights to improve teaching strategies and learning outcomes.
- **Real-Time Data Capture**: Offers immediate insights into attendance and engagement, facilitating better decision-making.

1.2. Objectives

1.2.1. Main objectives

Design and implement a video-based classroom monitoring system capable of automating the attendance-taking process using facial recognition technology.

Aims to reduce the manual effort required for roll calls, improve accuracy, and ensure seamless attendance management experience in educational settings.

Specific objectives

Here are some specific objectives that are the detailed objective to achieve the main objective:

- **Detecting and recognizing student:** Design a low-cost and simple system that automatically dectects students and recognizes their attendance in real-time during classroom sessions, eliminating the need for traditional manual methods.
- **Taking attendance and taking roll call in Excel file:** Securely store the recorded attendance data and enable seamless export of this data into Excel files for efficient review, analysis, and long-term record-keeping.
- **Tracking student's emotions in the real time:** This functionality will help educators assess classroom engagement, identify patterns in students' emotions, and adapt teaching methods to improve learning outcomes.

2. Methodology

2.1. State of the art

Methods for video-based classroom monitoring
a. Sensors

- The RGB camera is used for real-time video recording, providing image data for facial recognition and emotion detection modules.
- Video data is recorded using the *record_video* function and stored as *.avi* files in the *uncutvideo* folder.

- Frames are extracted from the video using the *extract_frames* function to facilitate subsequent facial recognition and emotion analysis.

b. Algorithms

This section surveys three key methods for implementing video-based classroom monitoring, focusing on face recognition and emotion recognition. The methods are based on studies from scientific papers.

b.1. Detecting and recognizing student:

To detect faces in the video, the system utilizes the *Multi-task Cascaded Convolutional Networks* (MTCNN) method from the *facenet_pytorch* library. MTCNN is a deep learning-based model known for its effectiveness in real-time face detection, especially under varying lighting conditions and viewing angles [1]. This method has been widely applied in real-time object and face detection tasks [1].

Once a face is detected, the system uses the *face_recognition* library, a robust Python library for facial recognition, to identify and match the face against a pre-stored database. Each recognized face is linked to the student's personal information, including their name, as discussed in prior studies on facial recognition for attendance systems [2].

Related Work:

Redmon et al. (2016) introduced the *You Only Look Once (YOLO)* method for real-time object detection, which can also be applied for face detection in classroom videos [1].

Jain et al. (2011) surveyed face recognition methods such as *Eigenfaces* and *Fisherfaces*, which laid the foundation for the development of modern face recognition approaches [2].

b.2. Taking attendance and taking roll call in Excel file

Once a student's face is successfully recognized, attendance data (such as student name and timestamp) is logged into an Excel file using the *pandas* and *openpyxl* libraries. Specifically, *pandas* is employed for data manipulation, while *openpyxl* handles writing the data into spreadsheet cells. Each time a student is identified, the system automatically records their attendance along with the timestamp, ensuring an accurate and up-to-date attendance list. This method of logging and

managing attendance is a key feature in similar systems like the one proposed by Chien et al. (2019) [3].

Related Work:

Chien et al. (2019) introduced an automated attendance system using facial recognition and the *Internet of Things* (IoT), which employs similar technology to capture and store attendance data [3].

b.3. Tracking student's emotion in the real time

To recognize emotions, the system uses the *HSEmotionRecognizer* from the *hsemotion* library, a deep learning-based tool designed to analyze facial expressions and classify emotions such as happiness, sadness, anger, surprise, and focus. Each detected facial expression is mapped to a specific emotional state, enabling the system to continuously track students' emotional states throughout the class. This real-time emotion detection is based on approaches similar to those used in the work of Mollah et al. (2020), which applied deep learning for real-time emotion recognition from facial expressions [4].

The video frames are processed in real-time, and the emotions of students are classified instantly, providing immediate feedback to the teacher.

Related Work:

Mollah et al. (2020) developed a real-time emotion recognition system using deep learning models, allowing the classification of emotions from facial expressions in environments such as classrooms [4].

2.1.2. Existing products for video-based classroom manage
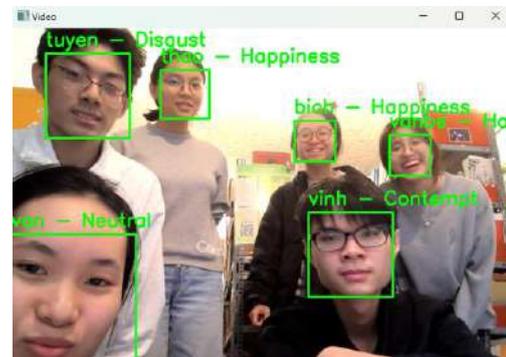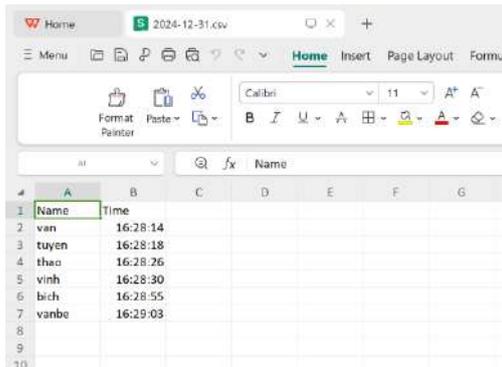
Illustration:

Figure 2-1. Simulation of our product

Figure 2-2. Result data from the product

2.2. Step 8: Testing

2.2.1. The main factors affecting the product:

1. The distance between the camera and human faces.
2. The quality of lighting in the environment, bright to low-light conditions.
3. The number of individuals appearing simultaneously in the frame.
4. Partial occlusion of faces, where parts of the face are obstructed.
5. The angle of the face is relative to the camera, which affects accuracy.

*2.2.2. Describte the scenario for testing:*

1. Testing face recognition performance at varying distances to determine the maximum effective range.
2. Assessing recognition accuracy in different lighting conditions, including bright, dim, and uneven lighting.
3. Evaluating the system's ability to handle multiple individuals appearing simultaneously in the video frame.
4. Analyzing the impact of different facial angles (e.g., side profiles or tilted heads) on recognition accuracy.

2.2.3. Conduct the test

1. For the distance problem

2. For light and noise problem:

3. A group of people
4. Angle challenges:
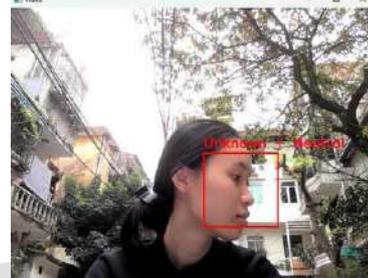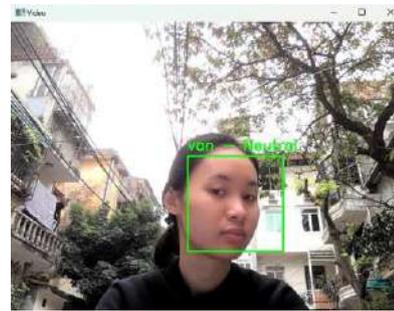
2.2.4. Analys the test result:
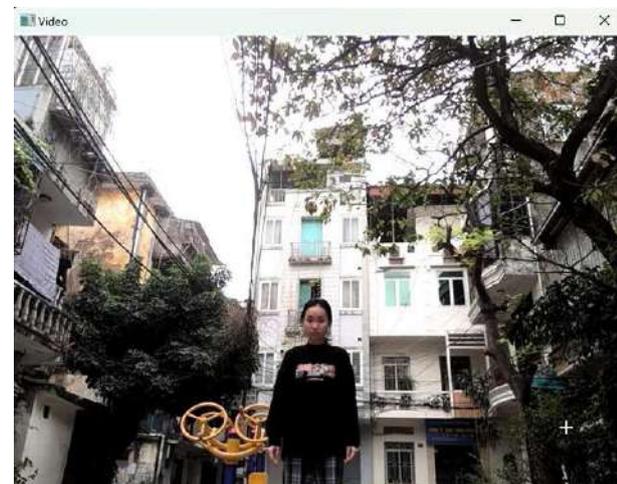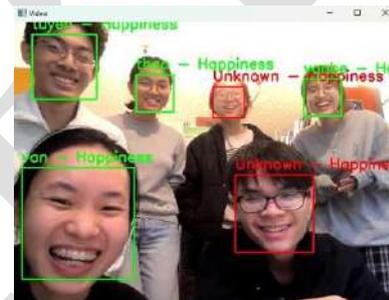
performed well up to 3 meters but faced challenges beyond that range. At distances beyond 3 meters, the system was unable to detect faces due to the resolution limitations or the reduced size of the faces in the frame.

2. The system performed well in both bright and low-light environments, of course it struggled when there was no light at all. In backlit conditions or when lighting was uneven making part of the face overexposed or obscured by glare, the system failed to detect faces due to the lighting causing parts of the face to be washed out or obscured.

3. Due to limited human resources, the system was tested with 6 people. However, the number of people could potentially rise to 15. The webcam's narrow field of view made it difficult to capture multiple faces at once. As the number of people increased, the system's processing speed decreased dramatically, but no significant reduction in accuracy was observed.

4. The system was most accurate when faces were directly facing the camera. Recognition accuracy dropped when faces were tilted or turned to the side, especially beyond a 45-degree angle.

3. Conclusions and future works

3.1. Conclusion

The video-based classroom monitoring system has demonstrated its potential to enhance classroom management by automating attendance tracking, monitoring student engagement, and identifying hand-raising activities. Under typical classroom conditions, the system performs effectively and provides valuable insights for 10.1007/s11390 -020-9912-3]

educators. By reducing administrative workload, it allows instructors to focus more on teaching while ensuring accurate records of student participation. However, environmental factors, especially lighting, can impact the system's overall accuracy, highlighting the need for a controlled environment to optimize its performance.

Overall, this system represents a step forward in utilizing technology to improve educational experiences. Its ability to track and assess student behavior in real-time can provide instructors with valuable data to foster better classroom interactions and engagement.

4. Reference

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