TED UNIVERSITY
FINAL REPORT

CMPE 492
SENIOR DESIGN PROJECT 2

Begüm AKDENİZ 16669037806
Umut YILDIRIM 10822781650
Ceren BÜYÜKGÜLLÜ 27142510204
İrem TAMAY 59701366816

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1.Introduction

“School Entrance with Facial Recognition System” is a solution product that is intended to be used in educational institutions and aims for high security for security needs. Our project is a technological initiative based on keeping the safety of students and staff at the highest level and improving the quality of education. With a modern approach, we will ensure rapid transition with our project by increasing security when logging in and keeping login times to a minimum. We also aim to optimize operational efficiency. In our project, we designed a system that will allow students to pass through the turnstiles by detecting students' faces with cameras at the entrances of schools. Passage will be allowed by matching the faces with the video recordings and pictures we have taken from the database, and the successfully recognized faces will be directed to the turnstiles by indicating their numbers on the monitor. In order for the camera to read the face, it must be at a certain distance from the camera. For this reason, a line will be drawn at the school entrance for students who want to pass, and the faces of the students on that line will be recognized. Our system also offers the opportunity to record student entry/exit times. Our main goal is to improve our school's entrance process with modern technology, to accelerate the physical identity verification process by recognizing the faces of our students and staff, and to maximize student and staff security by quickly detecting potential security threats with facial recognition.

2.Background Information

A technical innovation called the "School Entrance with Facial Recognition System" aims to improve security and operational effectiveness in educational establishments. Facial recognition technology replaces conventional entrance techniques, speeding up the identifying process, cutting down on access times, and increasing overall security. Quick and safe admission is made possible by cameras at entry points that record and compare students' faces to a centralized database. To track attendance, the system also logs entry and exit timings. The initiative, which focuses on updating school security, enhances safety by promptly identifying any risks. The ethical and data privacy requirements must be strictly followed to guarantee the appropriate application of face recognition technology in learning environments.

3.Proposed System

There is a major security vulnerability in the system currently used in our school. Security must be physically present at the doors. Students pass with their ID cards, but outsiders can easily pass as school students by using their own student cards. For this reason, theft and security vulnerabilities occur. Thanks to our system, people whose faces cannot be identified will not be allowed to pass. People will not be able to gain entry by impersonating each other. This will increase security and reduce security personnel, that is, manpower. Our system aims to strengthen security in general. Passages will be made by entering the angle of the camera and facial recognition of the people on the line.

4. Tools And Technologies

The face recognition system is designed to be integrated into the university's turnstile system. Therefore, it is very critical that the developed software system is reliable, fast and scalable. Because the system was designed assuming that there are five thousand students and that there will always be people entering and exiting the security gates. The software was developed to meet these criteria.

4.1 Tech Stack

Our system uses the following tools and technologies:

- Python
- OpenCV
- Cuda Deep Neural Network (cuDNN)
- YuNet face recognition models
- Linux (Ubuntu)
- OracleVM Virtual Box
- Arduino Uno
- FTP Server

Thanks to these tools/technologies, the system was able to achieve the desired objectives in a fast, reliable and scalable manner.

4.2 Frameworks and Libraries

Various libraries and frameworks were used during the software development process. Some examples include json, PIL, opencv, tkinter, ftplib etc.

- YuNet Face Recognition Models: At first, we worked with models based on Cascade Classifier. However, the system started to respond slowly when it had a large number of face photos. (scalable level is low) Then, we used YuNet models recommended by OpenCV, thus both the success rate and speed of our system increased. Thanks to the YuNet, our system works efficiently even with data found on Kaggle containing approximately eight thousand human face photos.

- Cuda Deep Neural Network: At first, we did not try to solve the slowness of the system by changing the model. Instead, we tried running the face recognition algorithm on the GPU instead of the CPU. For this purpose, cuDNN offered by Nvidia was integrated into the system via CMake. Although the system worked fast when there were 50-100 photos, it still could not respond in the required time (2 seconds at most) when there were a large number of photos. However, while cuDNN was already integrated into the system, we did not remove its use, so the face recognition algorithm became running on the GPU.

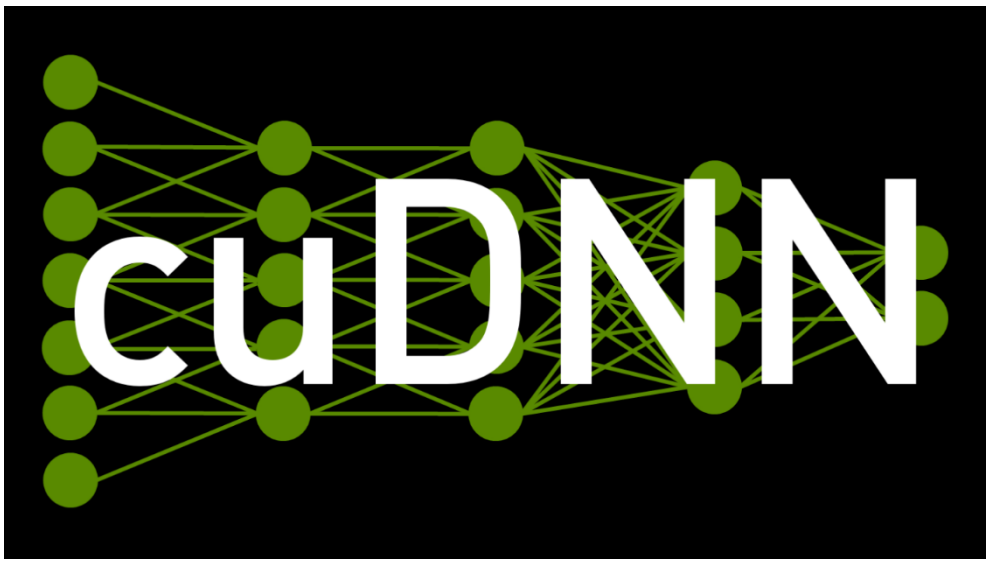

Figure 1: cuDNN, Deep Neural Network

- Client Server Architecture: The face recognition algorithm runs on a host computer with a strong graphics card (thanks to the cuDNN, we are using GPU) and a processor. Every entrance to the school has a security, and his/her computer. These computers upload the photos taken at the turnstile entrances with a camera to a server via FTP. The host computer takes these photos from the server, and if the face is recognized, a JSON file containing the recognized person's information is sent to the security personnel's computer via FTP. Client server architecture was used for these operations, that is, for a host computer to communicate with more than one virtual machine through a server.

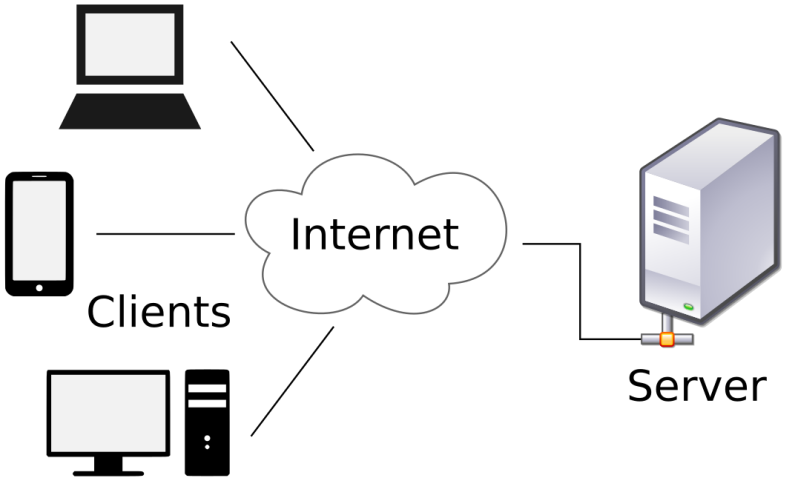

Figure 2: Client Server Architecture

- Arduino Uno: With the help of Arduino, if the system recognizes the face of an individual, Arduino shows this to us with the help of electronic operations.

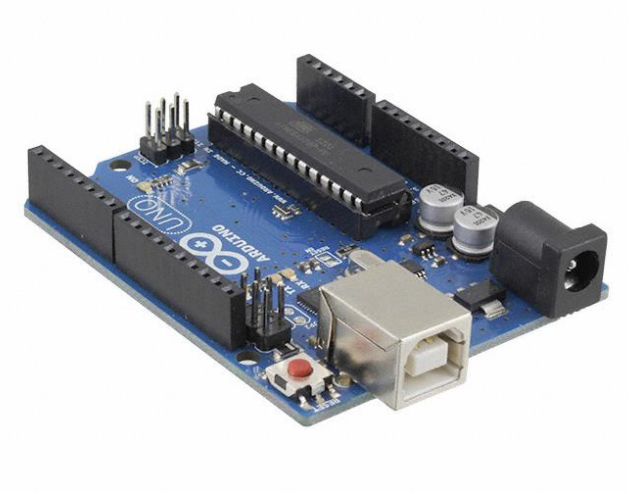

Figure 3: Arduino Uno

4.3 Responsive Design

The interfaces of our project were designed in accordance with the responsive design rules. This is important for logging in users and security personnel. It can be accessed from any device connected to the system. Software technologies such as Python, OpenCV, Cuda Deep Neural Network, YuNet Face Recognition model, Linux (Ubuntu), OracleVM, ArduinoUNO, frameworks and libraries have been integrated into the system for the successful operation of the project. Thanks to Python and OpenCV, the facial recognition algorithm is processed and visual data is used. These technologies serve to integrate this system into different screens. cuDNN and YuNet improve user experience by optimizing performance. Ubuntu Linux and OracleVM provide responsive design on different devices by using them on a virtual machine. Thanks to the integrated approach of all these technologies in the project, the adaptability of the project to various devices of different sizes has been expanded and it has been enabled to work faster.

4.4 Architecture of the System

Architecture of the System is based on the school's initiative to establish a facial recognition system. The realization of this project is based on the integration of various software and hardware components into one. It is possible to assume that the project is generally divided into 5 layers. User interface layer, application logic layer, data management layer, hardware integration layer and network layer.

For the UI layer, it is the layer with which users interact. Interface designs, login screen, information displays and other factors that the user sees can be mentioned.

The application logic layer refers to the layer where the algorithm is processed. The basis of the system is Python programming language. The facial recognition system was developed in Python language. OpenCV, YuNet models and Python are located in this layer.

Data management layer is the database where the necessary information of the users is stored, information such as database management, data records, entry/exit times are kept.

The hardware integration layer includes hardware components such as Arduino Uno. Thanks to this layer, the results of the data obtained from the face recognition algorithm are reflected on electronic indicators (turnstile, circuit, etc.).

Thanks to the network layer, operations such as database sharing, FTP server and data transfer are managed through the common network used between different devices in the system. These layers help manage the different functions of the project in an organized and modular manner.

A one-to-many relationship is used in this scenario, where a student can make more than one entry, but only one entry can belong to one student.

The personnel has a username and password to log in to the system and this belongs to the personnel. For this reason, an employee can have more than one login record, and since it belongs to a single person, there is a one-to-many relationship here as well.

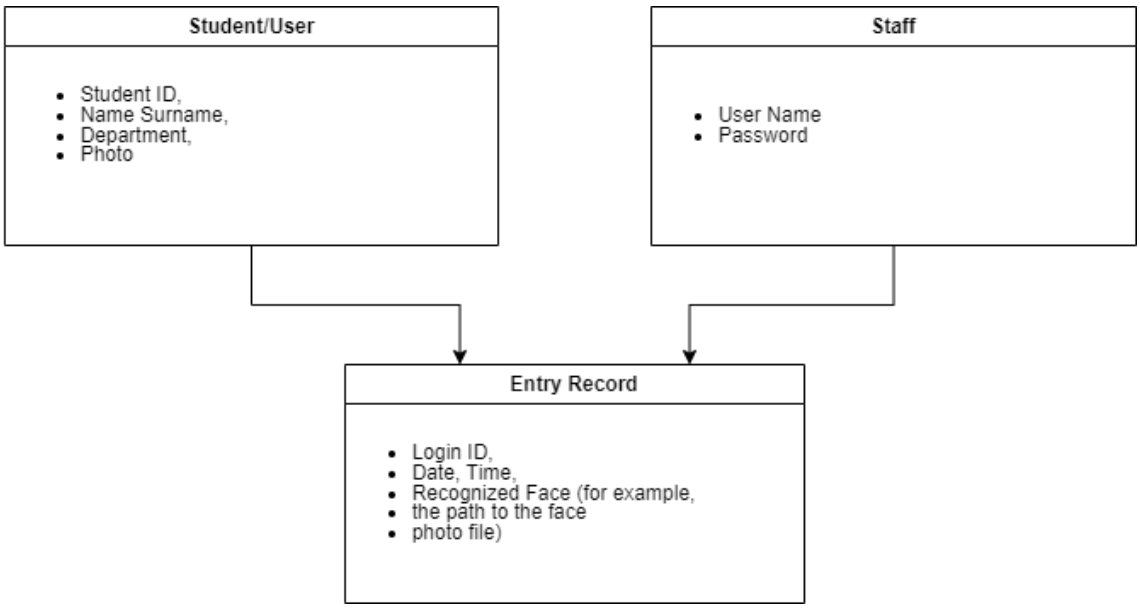

Figure 4: ER diagram of Architecture of the System

5. Test Results

5.1 Test Cases

Test Case 1: Simple Face Recognition

Scenario: When the face of a defined person is shown to the system, the recognition algorithm should recognize it successfully and this should be considered successful entry and the turnstile should be opened.

Expected Result: Opening of the turnstile due to successful facial recognition.

Test Case 2: Error Status - Face Not Found
Scenario: A person who is not defined in the system introduces his/her face
Expected Result: The turnstiles do not open, the camera continues scanning

Test Case 3: Selection of Suitable Turnstile
Scenario: After the system finds the registered face and finds successful entry, it should assign the person to the nearest available turnstile and open the door.
Expected Result: The available and closest turnstile opens to the recognized person.

Test Case 4: All Turnstiles Occupied - No Available Turnstiles Found
Scenario: The face registered in the system logs in successfully, but there is no suitable turnstile.
Expected Result: The person's facial recognition is successful, the person is kept waiting, and the first available turnstile is opened for successful entry.

Integration Testing
Test Case 5: Face Recognition and Turnstile Control Integration
Scenario: The face of the person registered in the system must be scanned and a face recognized by the algorithm must be successfully transmitted to the control module to find an available turnstile.
Expected Result: Opening of the available and closest turnstile
Test Case 6: Error Status - Integration Error
Test Case 6: Error Status - Integration Error
Scenario: There is an error in the face recognition system algorithm and the incoming face is not recognized
Expected Result: The recognition system does not open the turnstile because the correct data is not received from the algorithm.

Performance Testing:
Test Case 1: Face Recognition Speed
Scenario: Student approaches the line to pass through the turnstile.

Expected Result: Our system should produce a result in a maximum of 1.5 seconds to recognize a face.

Test Case 2: Accuracy Rate
Scenario: The face is recognized and then this recognition request is processed.
Expected Result: During the recognition process, users should be recognized 97% correctly. In a positive result, the patient should be directed to the tourniquet, and in a negative result, there should be no change.

System Testing:
Test Case 1: User Registration and Database Integration
Scenario: The new student is enrolled in the school and added to the system.
Expected Result: The database is successfully added. After adding a student, it should be easily integrated into the facial recognition system and an easy transition to school should be provided.

Test Case 2: Facial Recognition and Turnstile Integration
Scenario: Student approaches the line to pass through the door.
Expected Result: The facial recognition system should be implemented successfully. If the face is recognized, the door must be opened with the signal sent from the main server

5.2 Overall Assessment

The testing scenarios collectively validate the functionality, integration, and performance of the proposed system. The system exhibits efficiency in recognizing authorized individuals, appropriately handles errors, integrates well with turnstile controls, and meets performance benchmarks. The focus on user registration and system-wide integration further ensures a holistic assessment of the "School Entrance with Facial Recognition System." The results suggest that the system is well-equipped to enhance security, streamline operations, and provide a reliable solution for school entrances. Continuous monitoring and updates may be necessary to address any potential issues that may arise in real-world scenarios.

6. Impact Assessment

The "FaceGuard" project creates many effects by allowing students and staff to enter and exit the school quickly and safely thanks to the facial recognition system.

Economical: The face recognition system reduces the costs of the school administration by reducing checks made through entrance cards and security guards. At the same time, faster check-in and check-out can increase efficiency.

Environmental: The production and constant renewal of plastic ID cards can harm the environment. The "FaceGuard" project provides a sustainable authentication solution by reducing this environmental impact.

Security: Security standards are kept high as people cannot enter without permission, and importance is given to student and staff security.

It is important to pay attention to privacy issues and ethical responsibilities when evaluating the project's impacts on society. The improvements made may be an important step in increasing the security of educational institutions, but respecting the rights of individuals is a critical element.

7. Contemporary Issues

Data Privacy: Facial recognition technologies process individuals' personal data. In this regard, giving importance to the data security and confidentiality issues of the project should be a priority. Particular attention should be paid to securely storing facial data of students and staff.

Equity: In some cases, facial recognition technologies may misidentify based on personal factors such as gender and ethnicity. This situation should be taken into account for the sake of equality.

Accessibility: Facial recognition systems may pose some challenges in providing equal access to people with disabilities. Alternative solutions should be considered, especially for visually impaired individuals, and the system should facilitate access for disabled individuals.

Cyber Security: Facial recognition systems can be vulnerable to cyber attacks, resulting in student and staff data being compromised. To minimize such risks, a strong cybersecurity methodology should be an important part of the project.

In the "FaceGuard" project, steps were taken to find solutions to these current problems. In addition, with the awareness that facial recognition systems can increase productivity levels in the short term, but there are uncertainties in providing motivation in the long term, further studies are being carried out to investigate how the software can contribute to creating a more positive working environment.

8. Conclusion

In conclusion, the "School Entrance with Facial Recognition System" is proof of the revolutionary potential of technology in learning environments. Based on state-of-the-art face recognition technology, this creative solution not only reimagines customary school admission processes but also takes important security, efficiency, and adaptation issues into account. The system has demonstrated its functionality, integration capabilities, and performance standards through a rigorous testing procedure, guaranteeing a safe and efficient access experience for both staff and students.

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