Universidad Continental

FACULTAD DE INGENIERÍA

Escuela Académico Profesional de Ingeniería Mecatrónica

Tesis

Absence-Free Vision: An Intelligent Classroom Attendance System with Facial Recognition

Samuel David Velasquez Caceres
Eduardo Ildefonso Vilcahuaman Morales
Frank William Zarate Peña

Para optar el Título Profesional de
Ingeniero Mecatrónico

Huancayo, 2024

INFORME DE CONFORMIDAD DE ORIGINALIDAD DE TRABAJO DE INVESTIGACIÓN

A	**:**	Decano de la Facultad de Ingeniería
DE	**:**	Frank William Zarate Peña Asesor de trabajo de investigación
ASUNTO	**:**	Remito resultado de evaluación de originalidad de trabajo de investigación
FECHA	**:**	04 abril de 2024

Con sumo agrado me dirijo a vuestro despacho para informar que, en mi condición de asesor del trabajo de investigación:

Título:
Absence-Free Vision: An Intelligent Classroom Attendance System with Facial Recognition

URL / DOI:
10.1109/ACIRS58671.2023.10240420

Autores:
1. Samuel David Velasquez Caceres – EAP. Ingeniería Mecatrónica
2. Eduardo Ildefonso Vilcahuaman Morales – EAP. Ingeniería Mecatrónica

Se procedió con la carga del documento a la plataforma "Turnitin" y se realizó la verificación completa de las coincidencias resaltadas por el software dando por resultado 13 % de similitud sin encontrarse hallazgos relacionados a plagio. Se utilizaron los siguientes filtros:

	SI	NO
• Filtro de exclusión de bibliografía		X
• Filtro de exclusión de grupos de palabras menores Nº de palabras excluidas **(en caso de elegir "SI")**:		X
• Exclusión de fuente por trabajo anterior del mismo estudiante	X	

En consecuencia, se determina que el trabajo de investigación constituye un documento original al presentar similitud de otros autores (citas) por debajo del porcentaje establecido por la Universidad Continental.

Recae toda responsabilidad del contenido del trabajo de investigación sobre el autor y asesor, en concordancia a los principios expresados en el Reglamento del Registro Nacional de Trabajos conducentes a Grados y Títulos – RENATI y en la normativa de la Universidad Continental.

Atentamente,

La firma del asesor obra en el archivo original
(No se muestra en este documento por estar expuesto a publicación)

Absence-free Vision: An Intelligent Classroom Attendance System with Facial Recognition

Samuel Velasquez Caceres
Department of Mechatronics Engineering
Universidad Continental
Huancayo - Peru
71645190@continental.edu.pe

Eduardo Vilcahuaman Morales
Department of Mechatronics Engineering
Universidad Continental
Huancayo - Peru
72851794@continental.edu.pe

Frank Zarate Peña
Department of Mechatronics Engineering
Universidad Continental
Huancayo - Peru
fzaratep@continental.edu.pe

***Abstract*—Attendance taking is a fundamental process in educational environments, but in Peru, there has been a lack of technological advancements in this area, resulting in disadvantages such as delays and human errors. Therefore, the objective of this research project is to propose a facial recognition system for attendance taking in university classrooms using cameras and artificial intelligence based on machine learning. To achieve this objective, the VDI 2206 design methodology is employed, which allows for establishing project requirements and conducting an initial design. Electronic models will be created and integrated into the proposed system. As a result, a detailed electrical diagram, a flowchart of the facial recognition process, a programming model for accurate student identification, and an implementation model in a real-world environment are expected to be obtained. The proposed system aims to optimize and streamline the attendance taking process in university classrooms, eliminating the need for manual intervention and minimizing errors. It is anticipated that this efficient and accurate solution will enhance academic management and the overall educational experience. In conclusion, this research project focuses on developing a facial recognition system for attendance taking in university classrooms within the Peruvian context. By utilizing advanced technologies and the VDI 2206 design methodology, the aim is to achieve an efficient and reliable system that optimizes the attendance taking process and contributes to an enhanced educational experience.**

Keywords*—*Facial recognition, artificial intelligence, machine learning

I. Introduction

Globally, taking manual attendance in classrooms is a tedious process prone to human error. The traditional methods used, such as signing on sheets of paper, are time-consuming and do not provide an efficient way to manage attendance. The lack of adequate technologies for school attendance has been a long-term problem for many countries. This is compounded by the lack of a centralized attendance information system, making it difficult to track student progress and attendance. The scientific article entitled "Real-time attention monitoring system for the classroom: a deep learning approach for the recognition of student behavior" is highlighted. In this study, Trabelsi, Z. et al. Developed an intelligent classroom system that employs facial recognition and emotion detection techniques to assess student attention and engagement during classroom sessions. This approach proved especially useful for monitoring students even when they were wearing face masks, thanks to the use of a data acquisition system based on high-definition cameras [1].

The problem addressed in this study lies in the tedious and error-prone process involved in taking manual assistance in classrooms. The implementation of a facial recognition system will automate this process, reducing the workload for teachers and improving accuracy in the collection of attendance data.

In the educational field, the design of intelligent systems has proven to be an effective tool to improve the learning experience and follow-up of students. In line with this trend, the present study aims to design a facial recognition system for attendance in classrooms, in order to streamline this process and minimize associated human errors. In this context, the present work focuses on the design and development of an artificial vision system based on facial recognition, with the aim of streamlining and improving attendance in the classrooms of educational institutions. Through the application of cutting-edge technologies, it is expected to provide an innovative and precise solution to optimize academic management in the educational environment.

II. Metodology

A. Objective

The main objective of this research work is to propose the process to develop a vision system for attendance taking in universities using the Haarcascade and Face Recognition libraries of OpenCV.

B. Problematic Situation

In the global context, manual attendance taking in classrooms is a tedious process prone to human errors. Traditional methods such as signing on paper sheets consume a lot of time and do not provide an efficient way to manage attendance. The lack of suitable technologies for attendance taking in schools has been a long-standing issue in many countries[2]. This is further exacerbated by the absence of a centralized attendance information system, making it difficult to track student progress and attendance.

In South America and Peru, the problem is similar. Manual attendance taking is carried out in most schools, which can be inefficient and costly. Additionally, security issues are also a concern as student information is manually recorded on paper sheets, which can be prone to data loss or manipulation[3]. The lack of suitable technology for attendance taking also hinders the collection of accurate information and generation of reports, which in turn can have a negative impact on student tracking and academic progress. Implementing an artificial vision system for attendance taking in classrooms can help effectively address these issues.

Taking into account the inefficiency and tediousness generated by traditional attendance taking methods, as well as the security concerns regarding unauthorized access to the institution, there is a need for a more efficient and accurate system. This system aims to provide a seamless and sequential tracking of student attendance. To address these challenges, the plan is to develop an artificial vision system that can recognize and identify students in a classroom up on entry.

C. Factors to Consider

Factors to consider for the project include lighting, facial angles, and facial changes. The first and most important factor is lighting. It is necessary to have good lighting in the environment where the project would be implemented.. This will enable the camera to more accurately recognize facial vectors and yield better results. When working with real-time recording, it is important to have a mostly frontal facial angle as it makes it easier to obtain recognition vectors. Lastly, it should be considered that factors such as hairstyles, makeup, or accessories like glasses or caps can affect the system's accuracy as they may hinder the acquisition of facial vectors.

D. Table of Requirements

The requirements table is a tool that lists and organizes the requirements and needs of a project, both functional and non-functional, to guide its development and ensure that customer expectations are met. Within this table, we can observe the requirements and desires that are taken into consideration when developing a project [4]. In our list of requirements and desires, we have presented all the features, parameters, and indicators that we aim to consider and take into account for the project development. We have based these on what should be considered, as well as some parameters for potential improvements or additions in future work.

	Demands and desires.	System accuracy	Data	Response time	Image processing	Image processing	System accuracy	Stability	Implementation	Image processing	Data
E	The system must have a facial recognition accuracy of 95% or higher.	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐
E	The system must integrate with an updated student database to verify their attendance.	☐	☑	☐	☐	☐	☐	☐	☐	☐	☐
E	The recognition and registration time for each student must be less than 5 seconds.	☐	☐	☑	☐	☐	☐	☐	☐	☐	☐
E	Ability to process in real-time the information obtained through the cameras.	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐
E	The system must be able to recognize and work with 20 students.	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐
E	Face detection must be constant even during movement or changes in position.	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐
E	The system must be able to recognize students at any time of the day.	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐
D	Ability to update and improve the software and hardware of the system.	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐
D	The system must be able to recognize all students and professors of the university.	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐
D	Generation of attendance reports per day, week, and month.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑

Fig. 1. Table of requirements.

E. Black Box

A black box refers to the analysis of a system without knowing its internal workings, focusing solely on its inputs and outputs [5]. In this project encapsulates the facial recognition process, where cameras and artificial intelligence techniques are used to identify and verify the presence of students in the classroom. The internal details of how facial recognition is performed, how algorithms are trained, and how images are processed are kept hidden in this representation.

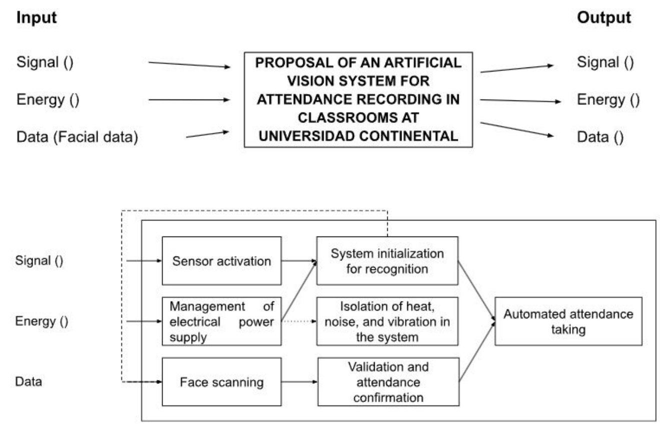

Fig. 2. Black box.

F. Function Diagram

The function diagram is a graphical representation that shows the main functions of a system or process in a project. It is used to visualize and communicate the interactions and relationships between the different functions of the system in a clear manner [6, 7]. In the context of the project represents the main functions or activities performed by the facial recognition system for attendance taking in classrooms. It provides an overview of the actions and processes that occur within the system, showing the interrelation between different functions.

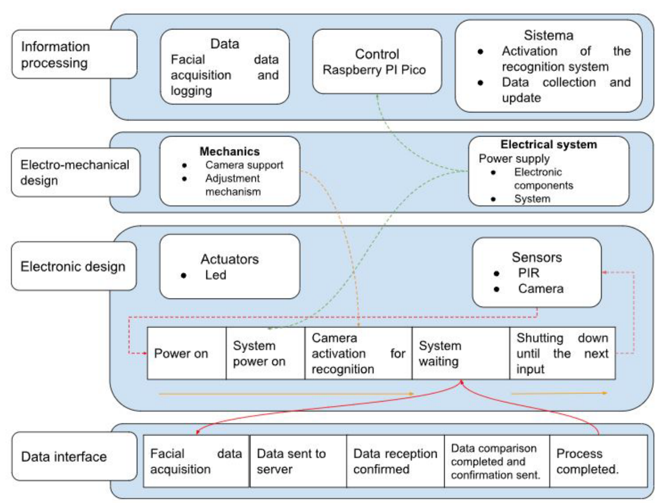

Fig. 3. Function diagram.

G. Final Function Alternative

The final alternative collects images using a fixed camera, which sends the images captured through the Wi-Fi network. This prototype is activated with the help of a PIR presence sensor; being thus of automatic actuation. The processes of the electronic part are controlled using the Raspberry Pi Pico, which is fed directly from the electrical network. The collected and analyzed data is saved on a microSD. The area of data collection that this prototype has is the door sector. The material of the structure in which the chamber will rest is made of ABS, and is located at the top of the classroom entrance. Finally, facial recognition is performed using Open CV software.

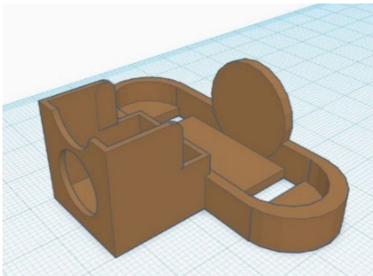

Fig. 4. Support model.

III. Development

For the development of this project, three phases were considered: data collection, recognition training, and facial recognition. The operation of the system is as follows: it begins with face detection, which is conditioned by lighting and accessories on the head. In this phase, we introduce photos of the individuals who will be recognized, forming a small database. The second phase is recognition training, which is based on the characteristic vector extracted from the images provided in the previous phase. With these images, the system is trained to detect vectors that will be compared in the last phase. Finally, in the last phase, recognition is performed by comparing the vector obtained in phase two with real-time recording. The system recognizes the vectors from the recording and compares them with the characteristic vector previously obtained from the database, providing a result indicating the presence of a student in the class.

And the block diagram is as follows:

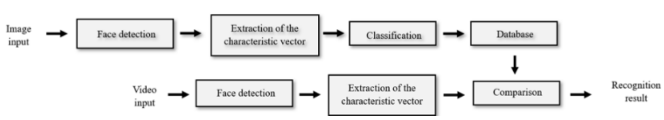

Fig. 5. Block diagram.

The figure above shows the phases of facial recognition represented by a block diagram, having as inputs the images for the database and the video in real time, and as outputs the result of facial recognition.

A. Data Collection

The classifier database was found using Haarcascade is face detector [8], which works using machine learning, this function is trained from the large number of images contained in the OpenCV library. The classifier used for this project is the $haarcascade_frontalface_default.xml$, obtaining the location of each face provided by the input images. Next, the images obtained will be resized to 150 pixels x 150 pixels to have the same size in each of the images of faces obtained. Finally, all the faces obtained were saved by classifying them by their names.

B. Train Recognition

To train facial recognition, faceRecognition was used, so it was necessary to change the images from BGR to RGB since openCV works in BGR and faceRecognition in RGB. Using faceEncodings, the images of faces were encoded transforming it into a coded vector of 128 elements of the detected face, classifying them by the names previously placed.

C. Facial Recognition

For facial recognition, a real-time video was used as input, which using faceRecognition in each frame performs the face derection. Next, it was also necessary to switch from BGR to RGB. On the other hand, using faceEncodings, the face obtained by the video was transformed in real time into the encoded vestor of 128 elements. Finally, using compareFaces, the comparison was made between the vector of the database with the vector of the face obtained from the video in real time.

Finally, the collected data is saved in an Excel file thus showing an attendance list of students detected by the face recognition.

IV. Results

The results obtained by this project will focus on the two main ones, which are face detection and coding and face recognition.

A. Face Detection and Coding

For image detection, faceRecognition was used, with which the images of faces were extracted from the images arranged as a database, saving them in a folder called faces1:

Fig. 6. Creation of new folder.

Extraction of faces from images: Below are the images of faces transformed into 128-element vectors:

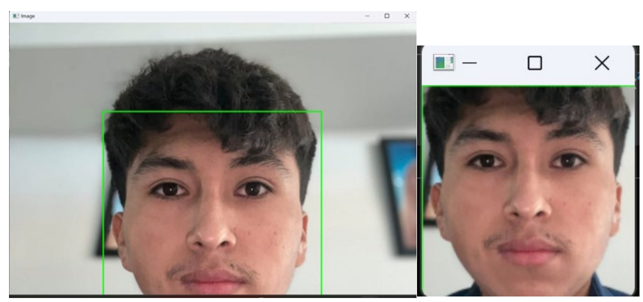

Fig. 7. Input image to the system and saved face Eduardo

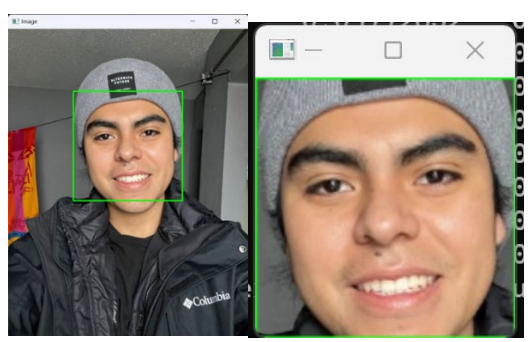

Fig. 8. Input image to the system and saved face Samuel.

Fig. 9. Vector 1.

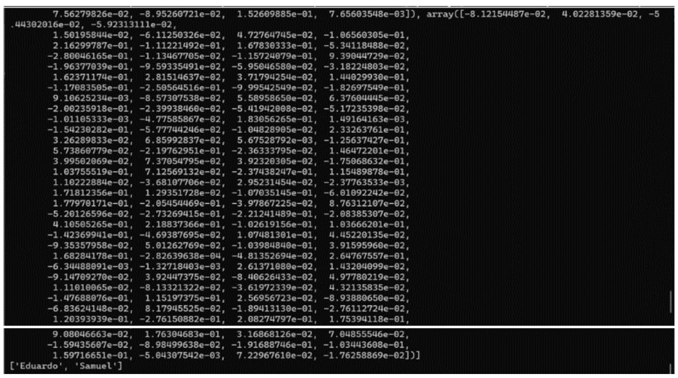

Fig. 10. Vector 2.

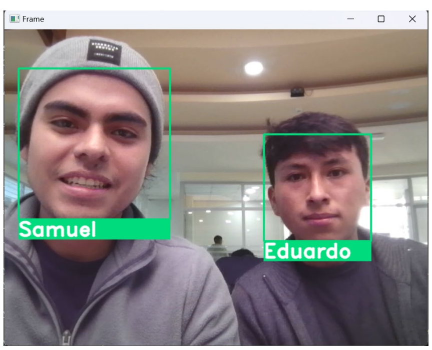

Fig. 11. Video test with Samuel and Eduardo.

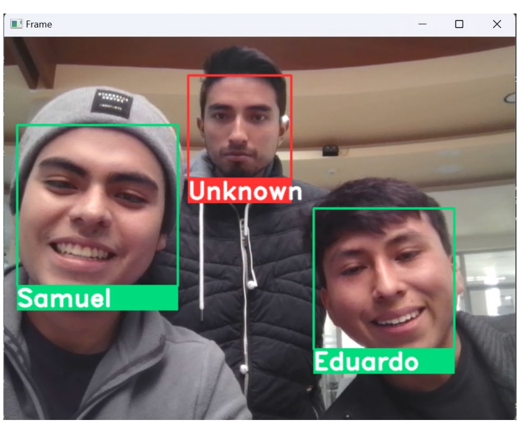

Fig. 12. Facial recognition in operation.

B. *Face detection and coding:*

In the facial recognition phase, the detected face and the name of the detected person are shown in real time in the video with a rectangle. The ambient light can affect the quality and accuracy of facial recognition, so it is recommended to use a suitable light source and avoid reflections or shadows on the face.

	A	B	C	D	E	F
1	**List of Assistants**					
2	Samuel					
3	Unknown					
4	Unknown					
5	Eduardo					
6	Unknown					
7						
8						
9						
10						

Fig. 13. Facial recognition in operation.

V. CONCLUSIONS

In conclusion, it was possible to implement the proposal of the process to develop a vision system for attendance taking in universities using the Haarcascade and Face Recognition libraries of OpenCV.

Secondly, it was possible to export in an Excel file the attendance list of the students detected by facial recognition, showing their respective names and if not recognized show the detection of someone unknown.

Finally, the work began with a search for information on the topic using search equations. Then, an analysis was applied that reduced 40 documents, theses, and articles to 15, which were organized into morphological matrices to obtain different perspectives on the main topic. Additionally, an alternative final function was proposed that relates the project to the incorporation of a Raspberry Pi, allowing the developed solution to be adapted to other types of environments or needs as required.

For future work, the proposed system can be improved and adapted to different environments with the support of neural networks. Additionally, external factors that can affect the recognition process, such as lighting or detection angle, should be taken into consideration. Furthermore, the integration of the Raspberry Pi allows for the combination and adaptation of additional technologies to enhance the system's performance.

REFERENCES

[1] M. Khan et al., “A deep learning approach for facial emotions recognition using principal component analysis and neural network techniques,” Photogrammetric Record, vol. 37, no. 180, 2022, doi: 10.1111/phor.12426.

[2] E. Manrique, “Machine Learning: análisis de lenguajes de programación y herramientas para desarrollo,” Revista Ibérica de Sistemas e Tecnologias de Informação, 2020.

[3] Z. Trabelsi, F. Alnajjar, M. M. A. Parambil, M. Gochoo, and L. Ali, “Real-Time Attention Monitoring System for Classroom: A Deep

Learning Approach for Student's Behavior Recognition," Big Data and Cognitive Computing, vol. 7, no. 1, 2023, doi: 10.3390/bdcc7010048.

[4] J. A. C. Moreano, R. H. M. Pulloquinga, G. A. F. Lagla, J. C. C. Chisag, and O. A. G. Pico, "Reconocimiento facial con base en imágenes," Revista Boletín Redipe, vol. 6, no. 5, 2017.

[5] L. Rouhiainen, "Inteligencia artificial 101," Alienta editorial, 2018.

[6] M. L. T. Cossio et al., Tecnicas y Algoritmos Basicos de Vision Artificial, vol. XXXIII, no. 2. 2012.

[7] S. K. Izquierdo and C. Ventura Royo, "Diseño de un sistema de reconocimiento automático de matrículas de vehículos mediante una red neuronal convolucional," Universitat Oberta de Catalunya, 2016.

[8] C. J. Tablada and G. A. Torres, "Redes Neuronales Artificiales | Tablada | Revista de educación matemática," Revista de Educación Matemática, vol. 24, no. 3, 200