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Quantification of Facial Geometrical Dimension for Student Attendance Tracking

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***Abstract*—The traditional method of manual attendance-taking has been used in educational institutions for decades which have consumed one-sixth amount of class time for attendance marking. Great research on attendance systems has come up with techniques like biometrics, NFC's and QR codes. Moreover, with advancements in technology, this research project can provide a more efficient and effective solution. This research project utilizes image processing, computer vision and facial recognition technology to mark the attendance of the students in class. The objectives of the system are registration of facial image, perform landmarking of the facial image and develop automated attendance system. As a result, this project works by installing a camera on top of the board which detects the student faces and performs attendance marking. Now is the time to implement this system in schools, institutions, colleges, and universities to streamline the attendance-taking process. This automated system will not only save time and effort but will also provide accurate attendance records, which will benefit both management and students.**

***Keywords*—Attendance System, image processing, automated attendance, facial biometric, facial recognition, computer vision, facial landmarking, encoding facial geometry**

I. INTRODUCTION

Attendance monitoring in educational institutions plays a crucial role in monitoring student performance and ensuring academic compliance. Traditional systems, such as manual sign-in sheets, responding to called names, are notorious for their inefficiency, distractive and error-proneness. This article proposes a novel way to attendance monitoring based on a facial recognition system, with the goal of improving accuracy and efficiency. Considering the drawbacks of traditional attendance systems, innovative methods are recommended such as utilising facial recognition technology.

In contrast to manual attendance methods, this research provides a faster, more efficient, and error-free alternative. The context emphasises facial recognition's transformational potential in automating attendance and delivering real-time information into student participation. The primary problem addressed by this research is the inefficiencies and errors associated with manual attendance tracking methods. The project's goal is simple: create an automated attendance monitoring system by combining image processing techniques with facial recognition technology utilising OpenCV software and OpenCV-related Python libraries.

Face registration, pre-processing facial pictures, encoding the landmarking and generating the facial graph, marking the land markings on the facial image for precise biometric measurements, and deriving outcome measures through morphometric quantification are some of the specific goals. On the other hand, tracking the attendance recorded is the crucial task. This research project uses the Google Firebase services and store the data of the student attendance in the real-time database of the Google Server based in Singapore, South-east Asia.

This research project focuses on the development of an automated facial attendance tracking, emphasizing facial recognition technology and image processing techniques, facial landmarking techniques for encoding the facial geometrical dimensions, and morphometric quantification for deriving the facial graph. The article provides a brief overview of the organizational structure, including chapters addressing the problem, literature review, methodology, results, and conclusion. Through this focused approach, the article aims to contribute to the advancement of efficient and accurate attendance tracking in educational institutions.

II. LITERATURE REVIEW

This part provides a brief overview of the existing research on attendance tracking systems, focusing on the transformative role of facial recognition technology in educational institutions. After great research, scientists have come up with innovative techniques like attendance systems based on biometrics (fingerprints, face and iris), qr codes and NFC's. Emphasizing the significance of accurate attendance records for academic assessment and classroom management, the review critiques traditional methods, such as manual sign-in sheets, highlighting their time-consuming nature and susceptibility to errors and proxy attendance.

The importance of modern technologies in facilitating presence behind the scenes is emphasized, and facial recognition plays a promising role. This technology uses imaging and machine learning techniques to deliver flying solutions very effective for. The study examines several literatures that critically examine the advantages and disadvantages of the traditional attendance management system. It goes into potential usefulness and applications in face recognition, including face registration, detection, and well-known techniques such as Eigenface and Local Binary Pattern Histograms

Previous research on attendance tracking systems has been reviewed, with special emphasis on NFC technology and biometric-based methods. The advantages and disadvantages of an NFC-based system, as well as the security and ethical concerns of a biometric-based system, are examined. Privacy and maintenance issues related to biometric technology are under investigation.

Integration of digital facial recognition and image processing techniques is emphasized as essential for improving facial recognition systems. Research further explores the effectiveness of these techniques in the area of detection accuracy, revealing the role of digital image processing in recognizing facial landmarks and improving image quality. For example, support vector machines and convolutional neural networks support adaptive and efficient learning, providing robust and accurate positioning.

The paper reviews three popular face recognition methods: Eigenface, Local Binary Pattern Histograms (LBPH), and deep learning methods. The application of principal component analysis (PCA) of Eigenface has been discussed at length, as well as its success in a controlled environment. The ability of LBPH to withstand light and occlusion changes is highlighted. Haar Cascade Classifiers, CNNs for Face Detection, and real-time facial recognition improvements are studied to improve presence detection. The advantages and disadvantages of Haar Cascade classifiers are examined, and their real-time processing capabilities are emphasized.

CNN is said to have played a game-changing role in understanding ranked facial attributes. The research continues by monitoring advances in real-time facial recognition, including machine learning algorithms and hardware optimization for faster and more accurate.

Advances in facial recognition technology are discussed, with a focus on 3D facial recognition algorithms, facial expression analysis, and robustness/security improvements Transitions from traditional 2D to 3D recognition systems are described in detail, with emphasis on accuracy best practice is to resist spoofing attacks provided. Facial expression analysis has been shown to improve cognitive performance in dynamic situations. The review concludes by emphasizing improvements in quality and security systems, ensuring the reliability of attendance control systems (Bohringer, S. 2019).

In result, the detailed review of the literature highlights the capacity of facial recognition technology to revolutionise attendance monitoring systems in educational institutions. The combination of digital image processing, machine learning, and advanced facial recognition algorithms ameliorate attendance management accuracy, efficiency, and security.

III. METHODOLOGY

The system for monitoring attendance of student's using facial reputation era is investigated. Recognising the importance of attendance in academic institutions as well as the limits of vintage structures, facial recognition technology is suggested to improve accuracy and efficiency. This novel method replaces guide sign-in sheets and time-ingesting ID card scanning with automated and seamless attendance monitoring.

The blessings of the usage of facial popularity era in attendance monitoring are discussed, with an emphasis on actual-time monitoring, fast file-preserving, reduced administrative burden, informative attendance developments for instructors, multiplied security, and fraud prevention. The technique digs into the attendance monitoring machine's running principles and design issues, illuminating the underlying era, such as facial popularity algorithms and the integration of OpenCV for face detection and analysis.

Proceeding directly to the assignment design, the mission is made of a laptop as a hardware element and Python with OpenCV and different libraries as a software program element. The facial recognition attendance marking device is designed to offer a green and correct approach of recording student attendance. Hardware components are diagnosed, along with a computer machine with sufficient processing energy and reminiscence. Facial detection and identification algorithms written in Python, a database control gadget (Google Firebase Realtime Database), and the introduction of a graphical user interface (GUI) are all critical software program components. The seamless operation of the attendance marking machine is dependent on the combination of those hardware and software program components.

A. Working Principle of Original LBP

Local Binary Pattern (LBP) is a texture-based identifier that uses binary characters for decoding local primitives. The original LBP operator used a 3 x 3 mask size. There are 9 pixels in the 3 X 3 mask size. The center pixel will be used as a threshold to convert the eight remaining pixels to binary numbers.

If the value of the nearby pixel is larger than the value of the center pixel, it is assigned a value of 1, in all other cases 0 will be assigned to it. The pixel bits from the adjacent neighbourhoods are then concatenated into a binary code to form a byte value illustrating the central pixel.

The Equation for the LBP is as follows:

$$\sum n(P_n - P_c) \cdot 2^n \tag{1}$$

In the above equation the term Pc denotes the centre pixel and the term Pn (where n = 0,1,2…...7) denotes 8 of its neighbouring pixels respectively. The original LBP operator is made up of three three-pixel filters. Instead of a circular design, it appears to be rectangular in terms of shape. The 9 pixels suggest that every detail, even non-essential features, will be sampled.

Subsequently, Because the tiny filter size emphasises small scale detail, it is more impacted by uneven lighting conditions, as is the shadow cast by non-uniform lighting conditions. a greater radius (R) is utilised in the LBP operator in our suggested technique (Md. Abdur Rahim *et al*. 2013). The impact of changing the radius size, however, was not noted in the paper. The proposed technique examines various radius sizes to optimise the system and reduce the lighting impact.

As the radius size is increased, so will the filter size. The radius from the centre pixel is denoted by R, the angle of the sample point regarding to the centre pixel is denoted by angle, and the quantity of sample points considered on the edge of the ciecle to compare with the centre pixel is denoted by P.

The X and Y coordinates of the pixel located at centre is denoted by Xc, Yc and the coordinates of the P neighbours (Xp, Yp) on the circle's edge with a certain radius (R) may be found using the sin & cos as stated in the below equation given.

$$X_p = X_c + R\cos\left(\frac{\theta}{P}\right) \tag{2}$$

$$Y_p = Y_c + R\sin\left(\frac{\theta}{P}\right) \tag{3}$$

An example of LBP conversion is shown in below,

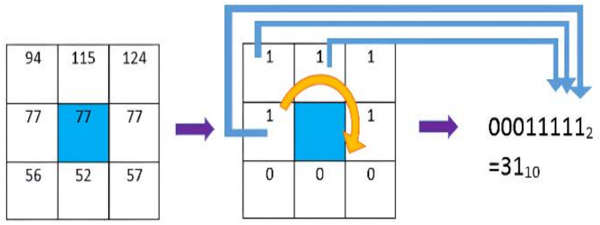

Fig. 1. Example of LBP Conversion

To extract features from facial photographs, the suggested technique employs an extended Local Binary Pattern (LBP) operator. Despite the wider radius used in this extended LBP, 8 sample points are obtained, that is consistent with the original Local Binary Pattern operator.

The application of Contrast Limited Adaptive Histogram Equalisation (CLAHE) is critical in improving the contrast of grayscale input face pictures. Notably, CLAHE ensures that photos with high contrast remain grayscale. The extended LBP function, like the original LBP function, is intended to use only 8 arithmetic bits. The pixels in the selected sample areas are encoded as 8-bit binary strings in this way. This encoding scheme is consistent with the standard LBP method. The most important innovation, however, is the use of high-contrast grayscale images for feature extraction.

CLAHE is applied to the grayscale input face image to start the processing. This phase attempts to increase the contrast of the image, making the images more visible and informative to extract new features. This superiority is most evident in the perception of normal features, with an emphasis on the ability to capture relevant facial features. The use of a greater radius in the extended LBP while keeping the same number of sample points results in a more robust and informative feature extraction process. The resulting 8-bit binary strings encode fundamental facial traits, offering a comprehensive description of facial patterns.

Overall, the technique demonstrates the usefulness of combining CLAHE with an extended LBP operator, specifically with a radius size of two, for improved face feature extraction and identification performance.

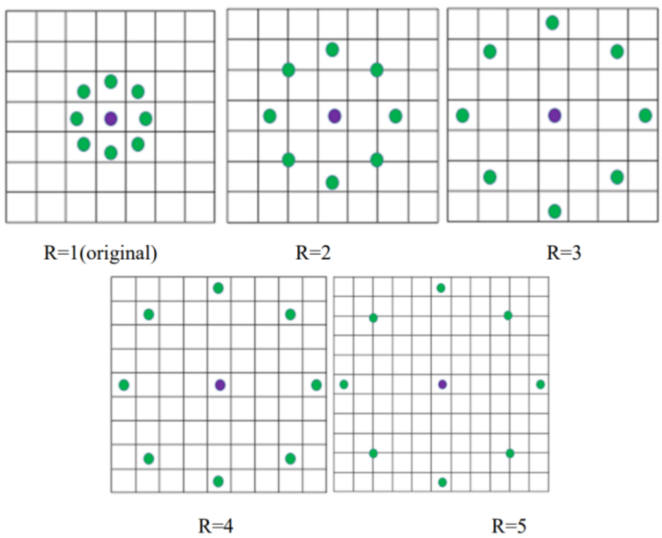

Fig. 2. LBP with different Radius size

Increasing the circle's radius effectively indicates prolonging the LBP circle like pattern outward. Within the blocks, the green colour specks indicate the pixels which will be sampled and decoded into a binary form. It denotes that the average pixel value is calculated from the adjacent pixels (diagonal) for the sample pixel located in between the blocks.

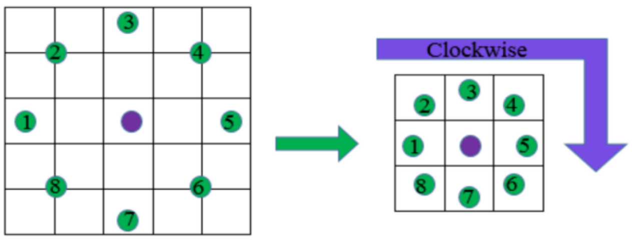

Fig. 3. LBP Operator of Radius 2

B. Process Flowchart

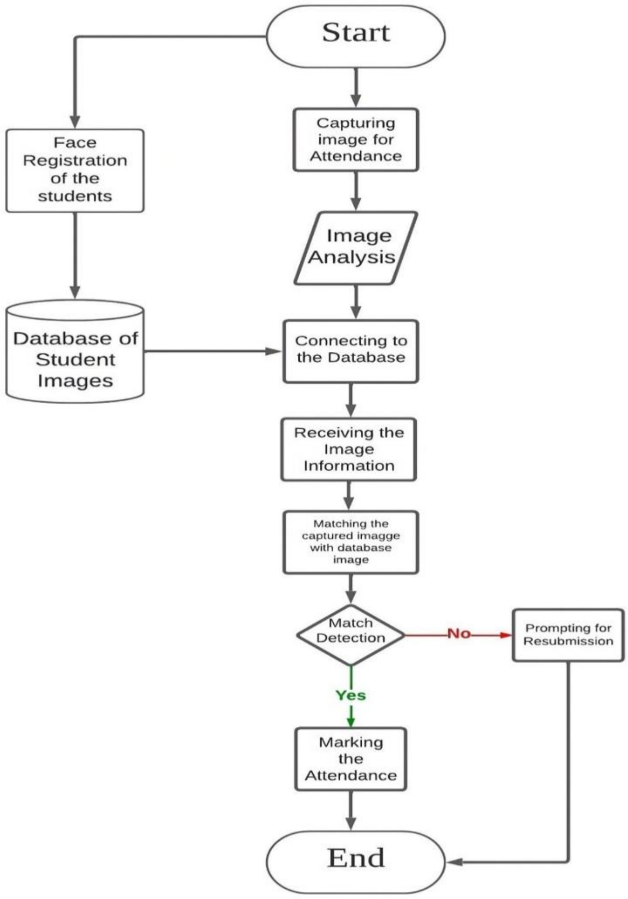

Fig. 4. Process Flowchart of the Automated Attendance System

IV. Experimental Results

The experimental results section has been categorised into 3 sections based in each objectives. The objectives of this research project is firstly, registration of the facial image, secondly, landmarking and encoding the geometrical values of the facial image and deriving facial graph, lastly, developing of an automated attendance system based on facial recognition.

A. Registration of the student face

The Face Registration system, which incorporates live video feed integration and powerful image processing algorithms, is a critical component of the project. This system captures high-resolution facial images in real time as students enter their name and student ID, resulting in an interactive and visually verifiable registration process. The personalised dataset, which connects pupils' facial data to profiles, improves recognition specificity and overall system reliability. The technology provides two registration methods: live camera feed interaction and image upload, giving users more options.

Modern image processing techniques, such as standardising lighting conditions and facial alignment, improve photo quality. This standardised dataset will be used to build robust facial recognition algorithms in following project rounds. Aside from data gathering, the system is critical in developing a centralised store of facial data, which is required for effective data retrieval and administration. The capacity of the system to register faces via live interaction and image upload enables flexibility for a variety of circumstances.

For registration of the facial image, a dedicated python program is developed to capture the face of the student and collect the name and id of the student and store the facial image of the student in the database. For this research project, Google's firebase is designed to act as a database which stores the data of the student's facial image, name and identification number. The below image illustrates the registration of the student's face.

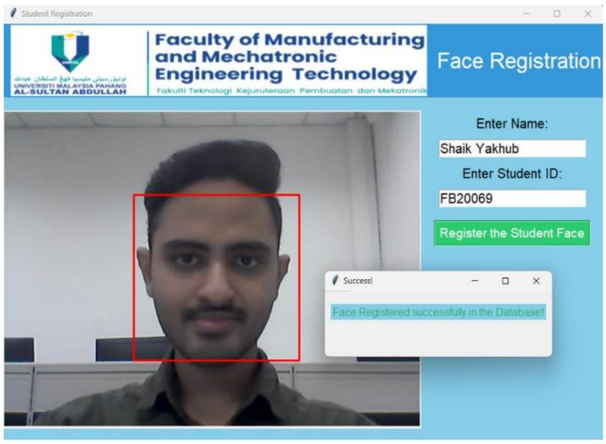

Fig. 5. Registration of the Facial Image

After entering the student details and clicking the "Register the Student Face" button the system will capture the facial image and upload it to the database. This project involves another method to register the student face which is by uploading the high quality image of the student face for better accuracy. Once the face registration is done, the system is capable of recording and maintaining the attendance of the respective student when the student enters the classroom.

Ultimately, the Face Registration system combines user input, live camera feed interaction, and powerful image processing in a seamless manner, considerably contributing to the effectiveness of facial recognition technology for student attendance tracking. Its importance in the whole project is shown by its function in producing a standardised dataset and serving as a centralised repository.

B. Encoding the Facial Geometrical Dimensions

The "Facial Geometry Encoder" software program which is developed in this project is a cutting-edge solution that is set to transform the landscape of student attendance tracking. We investigate two critical aspects in this complete system, the visual presentation of student facial pictures with the encoding points and lines on the facial image with the extraction of critical facial geometrical parameters and plotting the Graph for the facial features using the encoding values for increased identification.

This tool not only simplifies location tracking, but also provides important insights into the complex aspects of facial recognition. This tool will record and search the facial geometric values of the face images stored in the database to obtain the student's facial image. The following figure represents the landmarking's of the face image and obtains the geometric dimensions of the character's face.

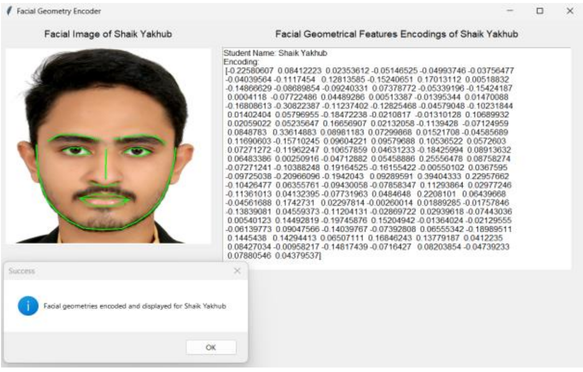

Fig. 6. Deriving the facial geometrical dimensions and landmarking the Encodings on Face

Subsequently, the "Facial Geometry Encoder" software program will also plot the values of the encodings on the graph using the Matplot library from Matlab. The execution of the software program will encode the Geometrical Dimensions and display the encoding values and the facial graph of the facial image of the student in the database and store the encoded values in the pickle file in the attendance system workspace. The following image illustrates the graph plotted by the Matplot, python library for the facial image of the Author.

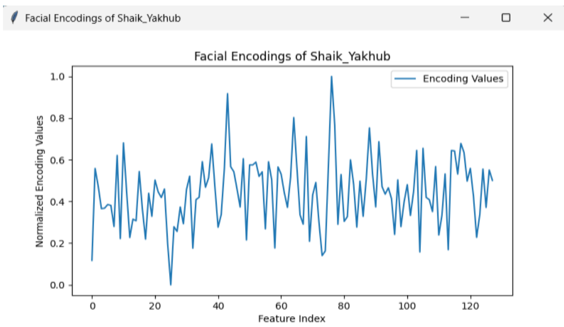

Fig. 7. Deriving the Facial Graph

Displaying landmarking of student facial images, The "Facial Geometry Encoder" 's initial component focuses on the visual representation of student face pictures. The application visits a selected folder containing student photographs in a methodical manner, picking the first image for presentation. This visually appealing method forms the basis for the following processes, resulting in a smooth and dynamic user experience. Extracting Facial Geometrical Dimensions: The application's core resides in its capacity to extract precise face mathematical characteristics. These measurements capture detailed data about the shape and features of the face, allowing for a more nuanced knowledge of each student's facial traits. Not only is the method technologically advanced, but it is also scientifically significant.

C. Automated Facial Attendance System

Automated attendance tracking systems are a major advancement in educational technology that aims to revolutionize the way traditional attendance marks are used. At heart, the system involves a hard boot process that lays the foundation for trouble-free operation. This requires you to install Google Firebase, which is a staple of a robust backend system. The authentication credentials from the ".json" file are loaded into the Firebase Admin SDK, forming an important interface for the Firebase Realtime Database and Storage services This not only provides efficient data management, it does foundation for storing and accessing vital student information, attendance records and multimedia resources

An equally important aspect of the system's setup is the initialization of the camera, which is essential to realize face time. The system uses OpenCV, a powerful computer vision library that sets the camera resolution to 640x480 pixels to balance video quality, functionality and usability This initial phase lays the foundation for capturing video images, steps which is important in the subsequent face recognition process. The inclusion of the background image from the 'Resources/background.png' file serves a dual purpose by improving the visual appeal and functionality of the user interface.

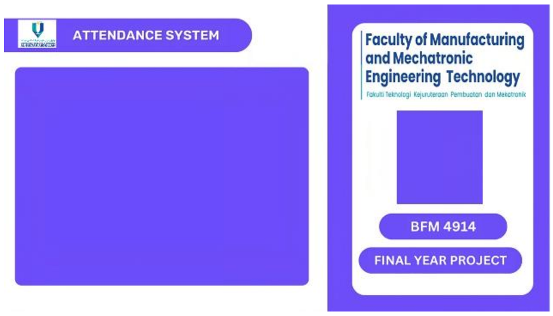

Fig. 8. GUI of the Automated Attendance System

This dynamic backdrop image serves as a canvas for video images, student comments, and program feedback in real time. These intentional additions contribute to better organization and more information, allowing users to participate when managing attendance.

The heart of the system is the facial recognition module, which comes with several steps for real-time detection and location tracking. The first step is to load the encoding file ('EncodeFile.p'), which contains the necessary facial geometric measurements and eye spacing necessary to detect them. The following face detection loop captures, resizes and encodes the video frames in real time so that the system can compare the identified faces with known encodings.

The (GUI) comes to live after successful execution, presenting background images, a live camera feed, and the status quo. The face recognition system then analyzes the distance between eyes and extracts facial geometric features from the live video stream to match faces in and out of the database Careful comparison, with a threshold for recording differences the, make sure there is a high mark.

This phase is instrumental in assessing the system's adaptability and accuracy under real-world conditions. The GUI and output affirm the successful marking of attendance for the chosen individuals, showcasing the system's reliability and effectiveness in diverse educational settings.

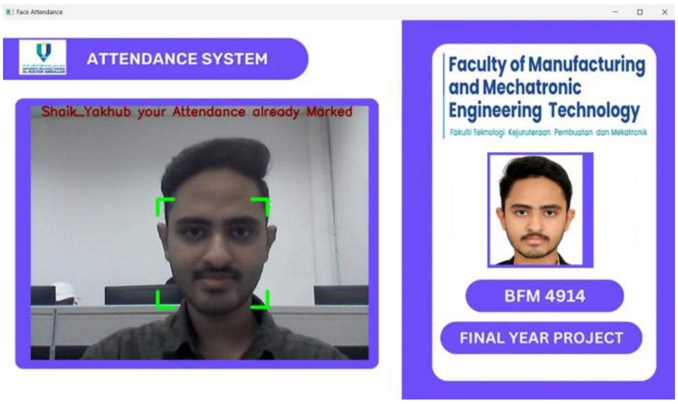

Fig. 9. Attendance System Detected the Face of the Student

The GUI represents that the system has started the Imaging device (camera) along with the background image. Thereafter, the system loaded the encoding file which have the facial geometrical features of the student facial images and the system started matching the face present in the live camera feed with the images present in the database of the attendance system.

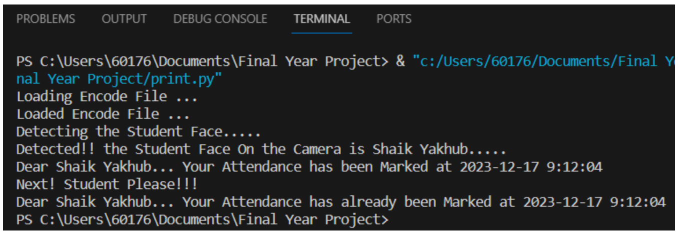

Fig. 10. Output of the Attendance System

The output of the python program illustrates that the system loaded the encoding file and started matching the image with the image of the database. While matching the face from the live camera feed it extracts the facial geometrical features of the facial image present on the live camera feed.

Thereafter, the system will match both facial geometrical features and calculate the error between the live camera face and all the facial images in the database of the attendance system.

If the difference between the encodings of face of live camera feed and the encoding of facial image in the database is less than 0.05 pixels then it identifies the facial image present on the camera belongs to the facial image present in the database and it marks the attendance. The following image is the result of the Attendance System if the student facial image is not registered in the database. The graphical depiction serves as a visual cue, indicating that the estimated difference between encodings exceeds the specified threshold (0.05 px), causing the system to recognise the absence of the student's facial image in the database.

This user-friendly interface improves transparency by allowing administrators to easily manage anonymity and preserve both the reliability and accountability of the automated attendance tracking system when a student's facial image is missing database, and the Attendance System creates the specified image. An active background image and a live camera provided in the graphical user interface (GUI) indicate that the system is enabled.

Notably, the absence of registered facial images is reported via a separate notification or status message, ensuring clarity in the system response to the unknown individual Python program the results show the general methodology used in such cases.

V. Conclusion

In conclusion, the "Quantification of Facial Geometrical Dimension for Student Attendance Tracking" study is revolutionary in automated attendance tracking since it revolutionises current methods by utilising state-of-the-art facial recognition technology. The project's success depends on the creation and integration of a thorough Automatic Attendance Tracking System, which consists of the Face Registration system, the Facial Geometry Encoder programme, and the Facial Recognition & Attendance Marking module.

The project's cornerstone, the Face Registration system, uses strong image processing algorithms and a well-designed graphical user interface to enable real-time attendance tracking. This foundational module creates a standardised dataset, which is essential for accurate facial recognition later in the project, and guarantees a consistent and smooth user experience.

In the history of facial recognition technology, the Facial Geometry Encoder program's launch represents a turning point. By extracting delicate mathematical components and visually displaying student face photos, this program significantly enhances the identification process. Improved accuracy and reliability are achieved by providing a comprehensive foundation for facial identification through the extraction of complicated geometrical data.

The project's crowning achievement is the Facial Recognition & Attendance Marking module, which excels in real-time identification and attendance marking even in challenging circumstances such covered noses or significant facial tilting.

This module establishes itself as the project's key to success in automating attendance tracking by showcasing the system's extraordinary adaptability and dependability. Together, the project's three main components create a sophisticated automatic attendance tracking system. Every element is essential to the project's success, from the standardised dataset of the Face Registration system to the revolutionary Facial Geometry Encoder program and the remarkable real-time identification powers of the Facial Recognition & Attendance Marking module. The system's intuitive interface adds even more usefulness, making it a complete and innovative automated attendance monitoring solution.

The project's benefits extend beyond advancements in technology. Facial recognition technology reduces administrative cost, enhances accuracy, automates identification, and for real-time monitoring. The user-friendly interfaces of the Face Registration and Attendance Marking modules increase the overall effectiveness and adoption of the system.

In conclusion, this experiment finds that the eyes are visible enough to enable facial recognition, which is the foundation of this attendance system. The project, which offers a solution that combines technological innovation, user-friendly design, and enhanced dataset standardisation, represents a turning point in the development of automated attendance tracking systems. The project's progressive methodology acknowledges its achievements, but it also points out limitations and offers a roadmap for further advancements in the rapidly evolving field of automated attendance tracking.

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Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

References

[1] Qian, J, (2020). Image decomposition based matrix regression with applications to robust face recognition. *Pattern Recognition, 102,* 107204.

[2] G. Soo, S. (2019). *Object detection using Haar-cascade Classifier*. Institute of Computer Science, University of Tartu.

[3] Bohringer, S. (2019). Quantification of facial traits. *Frontiers in Genetics. 10.*

[4] Paul, S. K., Bouakaz, S., Rahman, C. M. and Uddin, M. S. (2021). Component-based face recognition using statistical pattern matching analysis. *Pattern Analysis and Applications*, *24*(1), 299-319.

[5] Singh, A., Kalra, A., Teotia, R., & Mamgain, S. (2024). *Smart Campus: Smart Attendance Management System using Face Recognition.* https://www.semanticscholar.org/paper/Smart-Campus%3A-Smart-Attendance-Management-System-Singh-Kalra/b22783c7054f86c7198ba5074c97c9d3a4787a90.

[6] S., Hegde, P. S., & A. (2020). Face recognition based attendance management system. *International Journal of Engineering Research and Technology*. https://doi.org/10.17577/ijertv9is050861.

[7] Chin, H. (2018). *Face recognition based automated student attendance system*. https://www.semanticscholar.org/paper/Face-recognition-based-automated-student-attendance-Chin/a7d1d098236c91c32ac75f85dbe2e9a3bd8fb005#citing-papers.

[8] Ghafoor, S., Khan, K. B., Tahir, M., & Mustafa, M. (2019). *Home automation security system based on face detection and recognition using IoT*. https://www.semanticscholar.org/paper/Home-Automation-Security-System-Based-on-Face-and-Ghafoor-Khan/481be03230c93c9c94b65245fa99ab5fda4c955b.

[9] Bhatti, K., Mughal, L., Khuhawar, F., & Memon, S. (2018). *Smart attendance management system using face recognition*. https://www.semanticscholar.org/paper/Smart-Attendance-Management-System-Using-Face-Bhatti-Mughal/0c3bd917060f33beeb9c0d08940ba236e55c17a8.

[10] Sylaj. (2022). *Student attendance system using face recognition.* University for Business and Technology-UBT. https://knowledgecenter.ubtuni.net/cgi/viewcontent.cgi?article=2465&context=etd.

[11] Rahim, Md & Hossain, Md & Wahid, Tanzillah & Azam, Md. (2013). *Face Recognition using Local Binary Patterns (LBP)*.