Journal of Artificial Intelligence and Engineering Applications

Website: https://ioinformatic.org/

15th October 2025. Vol. 5. No. 1; e-ISSN: 2808-4519

Implementation of a Biometric-Based Authentication System on a Website Using Face Recognition Technology

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Abstract

Biometric technology, especially facial recognition, has become a promising solution in improving the security of authentication systems in the ever-evolving digital environment. Traditional authentication methods such as passwords and PINs are vulnerable to cyber attacks, while Face Recognition technology offers individual identification based on unique facial characteristics, which are difficult to forge, and more convenient to use. With the support of machine learning algorithms such as Haar Cascade Classifier and Convolutional Neural Networks (CNN), this system is able to recognize faces in real-time with a high level of accuracy. The implementation of this technology in a web-based authentication system allows for a fast and efficient verification process, and is supported by biometric data encryption and user activity log recording to enhance security. However, challenges such as low lighting and fast facial movements are still aspects that need to be optimized to ensure system reliability.

Keywords: *Biometrics, Face, Face Recognition*

1. Introduction

Security and convenience in accessing a system are crucial for operational sustainability, especially in the rapidly evolving digital environment [1]. Currently, many websites still use traditional authentication methods such as passwords and PINs; however, these approaches have significant weaknesses, one of which is vulnerability to cyberattacks such as data theft or brute force attacks. Users often choose weak and easily guessed passwords, thereby increasing the risk of unauthorized access. Therefore, a more secure and efficient authentication method is needed to ensure that access is granted only to authorized individuals [2].In recent years, biometric technologies such as facial recognition have emerged as promising solutions for enhancing the security of authentication systems [3]. This technology enables individual identification based on unique facial characteristics, which are difficult to forge or duplicate. The implementation of facial recognition technology on websites can provide safer, faster, and more convenient authentication compared to conventional methods [4]. Moreover, this method can improve the user experience since it eliminates the need for manual input such as entering a password.

Face Recognition technology, supported by machine learning algorithms and facial feature detection models such as Haar Cascade Classifier or Convolutional Neural Networks (CNN), has proven effective in recognizing faces in real time with high accuracy. Various studies have shown that this technology can be successfully implemented for a wide range of applications, from access control to payment systems [5].Based on this background, this study aims to develop and implement a biometric-based authentication system on a website using facial recognition technology. This research is expected to make a significant contribution to improving both security and convenience in the authentication process on web-based platforms. Therefore, the author is interested in addressing this issue as the final project, entitled “Implementation of a Biometric-Based Authentication System on a Website Using Face Recognition Technology.”

2. Literature Review

2.1. Design

The word "design" originates from the verb "to design," which means to arrange or plan something. The term “design” is often interpreted as a noun that represents the process of arranging or creating. In this context, the term “system design” may refer to the act of planning or developing a system or an object [6]. The purpose of design is to improve technical, theoretical, conceptual, and moral skills through training that aligns with specific needs. This design process is organized logically and systematically to ensure that potential and competence can be optimally developed. Essentially, research in design aims to create new products or improve the quality of existing

ones to achieve better results.The initial step in developing a system is the design process. This stage involves developing new specifications based on recommendations obtained from system analysis.

The design phase aims to create a new system that can solve organizational problems by selecting the best available alternatives. System design requires a working team capable of preparing specifications in accordance with end-user needs using standardized design tools. At this stage, the specifications must align with requirements so that the designed system can function optimally. In general, design is a process that involves detailed planning before implementation. It is the visual representation of creative ideas that have been structured. The design process begins with concepts or unstructured ideas, which, after refinement, result in a structured outcome that functions according to requirements.In design, each separate element is illustrated, planned, and unified through the creation of sketches, forming a coherent whole. Thus, the result of the design process can fulfill its intended function and usability [7].

2.2. Computer Vision

Computer Vision is a technology that enables machines to recognize objects in their surroundings. In this study, Computer Vision technology is optimized in robots designed to move objects based on color. The robotic system includes the recognition and relocation of colored balls according to detected colors. Using the Pixy 2 Camera, this technology is capable of detecting colored objects in real-time with high optimization, achieving detection within 0.2 seconds. Testing was conducted three times for each object color, and the results showed an accuracy level of up to 100%. This optimization allows robots to recognize colored objects with very high precision [13].
Computer Vision also enables applications to identify objects, convert them into digital formats, and display them visually. This technology has been proven to support the automation of human tasks. The study explores how Computer Vision works in detecting objects based on color markers in real time using cameras. In simple terms, Computer Vision is a technology that allows computers or machines to "see." This technique analyzes data in the form of images or videos with the goal of enabling computers to mimic or even surpass human visual perception. One of the most widely used libraries is OpenCV, initially developed by Intel, which has undergone many updates up to its latest version.

The integration of Computer Vision and Human-Computer Interaction (HCI) techniques can produce new input devices. Computer Vision technology can be improved according to future needs, transforming computers from mere image capture devices into systems capable of performing color segmentation (e.g., RGB, HSV, or YUV) through new algorithms.However, color segmentation techniques still face difficulties in distinguishing similar colors, such as skin tones, indicating that the technology requires further development. Background Subtraction is one method used to distinguish objects from the background. With the Background Compensation Method algorithm, this technique can detect objects such as faces and hands with greater accuracy.

Color marking techniques on objects are also used to detect hand and finger positions geometrically, by assigning different colors. Nevertheless, the technology remains limited. Computer Vision methods involve steps such as data acquisition, processing, analysis, and image interpretation to extract information from the real world. In this study, Convolutional Neural Network (CNN) algorithms, specifically the LeNet-5 and MobileNet architectures, are applied, as CNNs are known for their efficiency in pattern recognition with a high level of accuracy [14].

2.3. Haar Cascade

The Haar Cascade object detection method using a cascade classifier was developed by Paul Viola and Michael Jones. In 2001, they introduced this technique in their paper entitled “Rapid Object Detection Using a Boosted Cascade of Simple Features.” Haar Cascade is a combination of multiple Haar-like functions integrated into a classifier. The main feature of this method is the difference in values between white and black pixels in specific regions [15].The Haar-like Feature function, also referred to as the Haar Cascade Classifier, is a rectangular function that provides certain indications in an image. This classifier is formed from the combination of black and white pixels arranged in rectangular patterns, allowing the detection of contrast differences within an image.

To detect masks, the Haar Cascade algorithm is often employed as a base technique. The Haar function is commonly applied for detecting objects in digital images. The name “Haar” itself refers to a mathematical function shaped like a square, or the Haar wavelet. Initially, image processing relied only on the RGB values of each pixel, which was considered inefficient. The Haar-like Feature method, developed by Viola and Jones, simplified image processing by dividing images into pixel-filled rectangular blocks. Each block is then processed to generate values representing light and dark regions in the image.

3. Method

In the currently implemented system, the user authentication process is carried out by recording every individual who accesses the website using biometric technology, specifically facial scanning. This process involves recognizing the user’s face and recording authentication data into the system. Although the system is designed to automatically detect users, challenges arise in terms of the accuracy and security of the authentication process. Referring to the first problem formulation, designing and implementing a biometric-based authentication system on a website using Face Recognition technology requires the development of a more efficient and responsive system. Users who wish to access the system must undergo an accurate and fast face detection process. However, the current system still has limitations in detecting faces in real time, which can cause delays in user authentication.

Meanwhile, in response to the second problem formulation, ensuring the accuracy and security of the authentication process through the implementation of Face Recognition technology is crucial. The system must be able to detect users’ faces in real time with a high level of accuracy so that the authentication process can run smoothly. If the system fails to accurately detect faces, it could potentially create security risks and disrupt the user experience. Therefore, improvements in face detection technology and algorithms are essential to ensure that the authentication process is not only accurate but also secure.

This study employs the Haar Cascade method for face detection in the biometric-based authentication system. At this stage, several steps are carried out to design an object detection system capable of automatically identifying users. The following figure illustrates the system diagram:

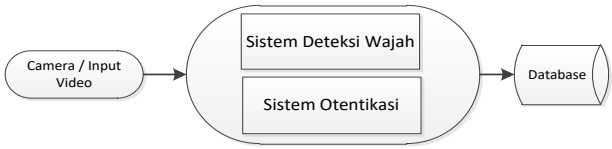

Fig.1: System Diagram

The flowchart illustrates the workflow of the biometric-based authentication system using video-based object detection technology. The following is an explanation of each stage in the flowchart:

Camera/Input Video: At this stage, a camera or other input video device captures footage of a specific area, such as an entrance for user authentication. The camera serves as the source of visual data that will be used by the system to detect and recognize user faces. The images or videos captured by the camera are continuously streamed into the system for analysis.
Face Detection System: At this stage, the face detection system analyzes the video captured by the camera. This technology utilizes Computer Vision or Artificial Intelligence (AI) algorithms to detect and recognize faces within the video. Each individual appearing in the video is automatically identified and tracked by the system. Detection allows the system to determine whether a user's face matches the stored data for authentication.
Authentication System: Once the user's face is detected, the authentication system verifies the user's identity. This process involves comparing the detected facial features with facial data stored in the database. If a match is found, the user is authenticated and granted access. If no match is found, the system denies access and may provide a notification to the user.
Database: The data generated from the authentication process is stored in a database. This database serves as an organized repository of user identity information, authentication times, and other relevant data. The database can be accessed by administrators or management for analysis, reporting, or decision-making purposes. By storing authentication data in the database, the information can be further processed for security and access management needs.

4. Research Results

The results of the research conducted by the researcher are presented in the following explanation:
1. Initial Menu Display

Fig. 2: Website Interface

This website provides various menus designed to facilitate face similarity detection through a webcam or images. The available menus are as follows:

a. Start Webcam: Start streaming through the laptop's connected webcam and perform face similarity checks step by step.
b. Choose File: Manually select an image to detect face similarity from the uploaded photo.
c. Upload and Detect: Upload an image and detect the similarities contained within it.
d. Clear Screen: Clear all previously recorded detection data.
e. About: Display information about the application.

2. Process Display
The process display shows the experiments conducted by the researcher. The experiments were carried out by performing detection on 11 images, as shown in Figures 3 through 12. In these tests, the program successfully detected faces with varying similarity levels as calculated by the system.

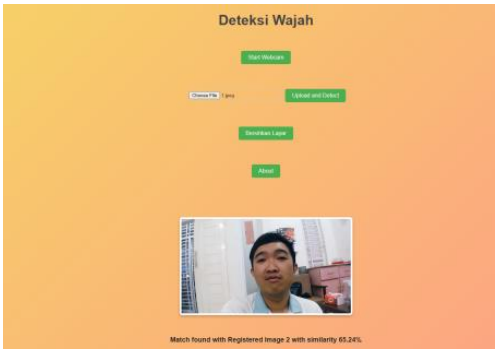

Fig.3: Experiment 1

In the first experiment, with the face directly facing the camera, the system detected a similarity of 65.24%.

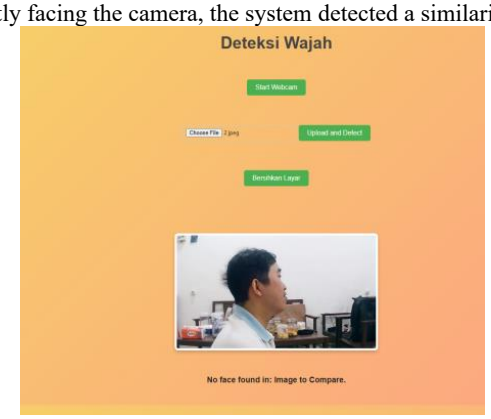

Fig.4: Experiment 2

In the second experiment, with the face turned to the right of the camera, the system failed to detect a face.

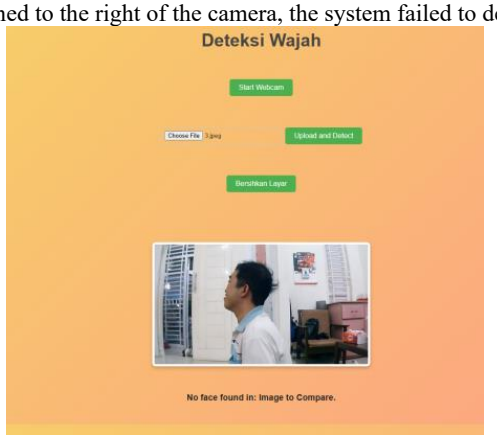

Fig.5: Experiment 3

In the third experiment, with the face turned to the left of the camera, the system failed to detect a face.

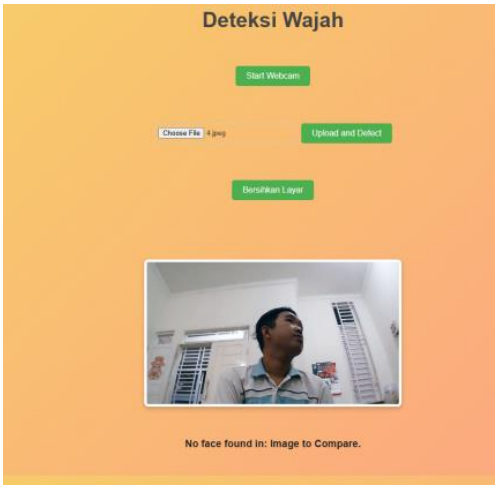

Fig.6: Experiment 4

In the fourth experiment, with the face tilted upward to the right of the camera, the system failed to detect a face.

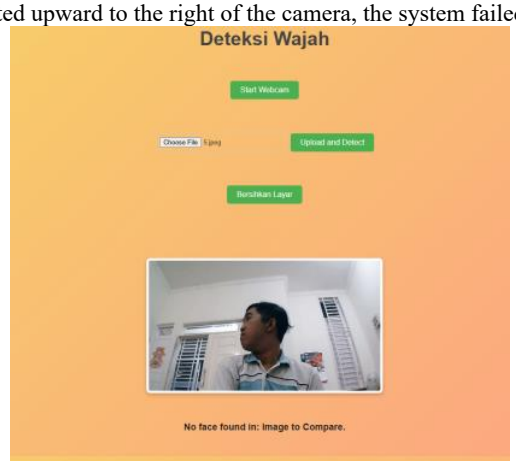

Fig.7: Experiment 5

In the fifth experiment, with the face tilted upward to the left of the camera, the system failed to detect a face.

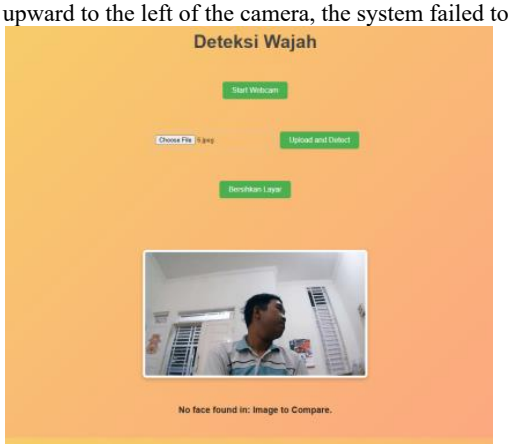

Fig.8: Experiment 6

In the sixth experiment, with the face turned to the right of the camera, the system failed to detect a face.

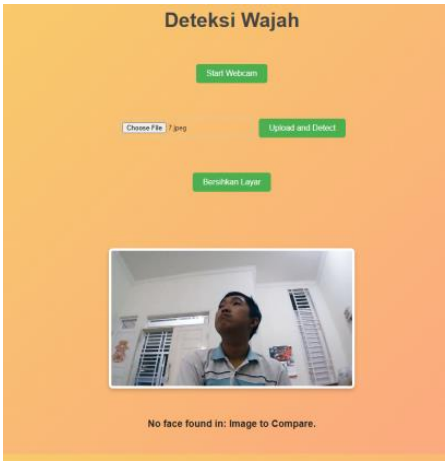

Fig.9: Experiment 7

In the seventh experiment, with the face tilted upward to the left of the camera, the system failed to detect a face.

Fig.10: Experiment 8

In the eighth experiment, with the face turned to the right of the camera, the system detected a similarity of 51.56%.

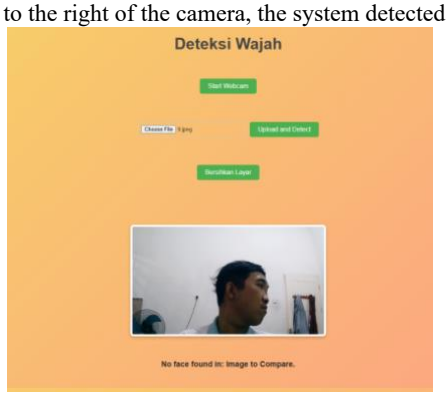

Fig.11: Experiment 9

In the ninth experiment, with the face turned to the right of the camera, the system failed to detect a face.

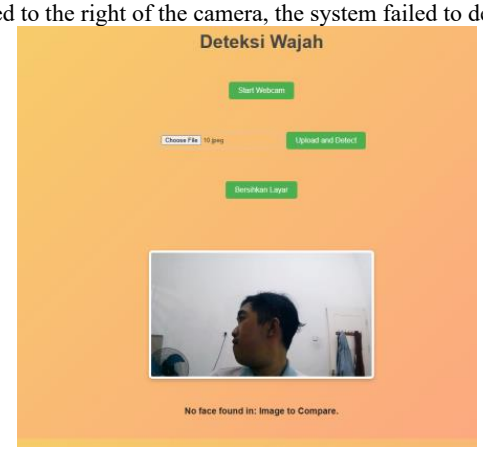

Fig.12: Experiment 10

In the tenth experiment, with the face turned to the right of the camera, the system failed to detect a face.

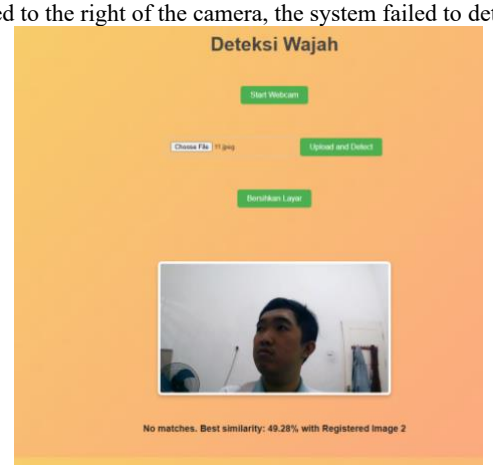

Fig. 13: Experiment 11

In the eleventh experiment, with the face turned to the left of the camera, the system detected a similarity of 49.29%.

3. About Page Display

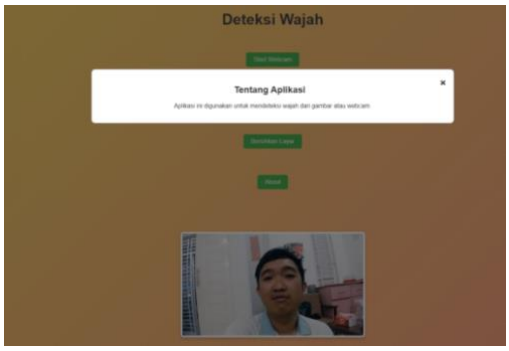

Fig. 14: About Page

This website also provides an About page that displays information about the application.

5. Conclusion

The conclusions obtained by the author in designing this thesis are as follows:

1. Based on the evaluation, the Face Recognition–based authentication system has proven effective in performing real-time face verification with high accuracy, ensuring that user identities can be confirmed quickly and precisely.
2. The system ensures biometric data security through the use of encryption and audit logs, which significantly reduce the risks of data leakage and identity misuse.
3. With its intuitive interface, the system simplifies operation for users without requiring specific technical expertise, although improvements are still needed to handle fast-moving objects or environments with suboptimal lighting conditions.
4. The potential for integration with other technologies such as IoT and machine learning demonstrates that the system has the flexibility and scalability to be further developed to support larger-scale applications.
5. Overall, despite its many advantages, efforts to improve the system through algorithm optimization and enhancing input quality (camera and lighting) remain necessary to overcome existing limitations and improve the system's overall performance.

Acknowledgement

First and foremost, the author would like to express profound gratitude to Almighty God for His blessings, wisdom, and guidance, which enabled the author to complete properly and on time.

In completing this, the author received assistance, guidance, and support from many parties. Therefore, the author would like to sincerely extend appreciation and thanks to: Mr. Jackri Hendrik, S.T., M.Kom for his valuable guidance and direction during the writing of this thesis. Mr. Hendri, M.Kom for his advice, support, and guidance throughout the process of completing this thesis.

The author is fully aware that this thesis still has many shortcomings and is far from perfect due to the author's limited knowledge and time constraints. Therefore, constructive suggestions, criticisms, and feedback are greatly welcomed for the improvement of future research.

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