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Application of the viola-jones algorithm method to recognize faces of Stmik Tegal students

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ABSTRACT

This study examines the application of the modified Viola-Jones algorithm for student facial recognition at STMIK YMI Tegal, aiming to improve the efficiency and safety of the student attendance system. By adapting the algorithm to address the challenge of facial recognition accuracy from different angles and lighting conditions, a quasi-experimental quantitative design involved collecting data through photographic sessions with student subjects, followed by preprocessing to improve the quality of the analysis. The modification was evaluated for its ability to handle variations in facial and lighting conditions, showing significant improvements with 60% accuracy and precision, recall, and an F1-score of 71.43%. These findings demonstrate the effectiveness of the modification in improving facial recognition, potentially contributing significantly to attendance management and safety practices in educational settings. This research not only strengthens the existing literature.

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Introduction

Facial recognition as an identity verification method has rapidly developed in the last decade, offering practical solutions for various applications, including security and presence systems (Sengupta et al., 2020). In an academic context, especially at STMIK YMI Tegal, the application of facial recognition technology can significantly contribute to increasing the efficiency and accuracy of the student attendance system and strengthening the campus security system (Kortli et al., 2020). However, challenges in implementing this technology include the need for high accuracy in recognizing faces from various angles and lighting conditions and processing large and diverse facial data (Samadiani et al., 2019).

The Viola-Jones algorithm, known for its efficiency in face detection, is the focus of this study, in which we propose modifications to improve its performance in specific contexts (Goswami et al., 2019). The object of this study is a student of STMIK YMI Tegal, with a facial dataset explicitly collected for research purposes (Kosinski, 2021). Through this method, we strive to overcome accuracy issues often encountered in facial recognition applications in attendance and security systems (Andrejevic & Selwyn, 2020). The main objective of this study is to evaluate and improve the effectiveness of the Viola-Jones algorithm in recognizing students' faces, with the hope of strengthening the attendance and security system at STMIK YMI Tegal (Alacovska et al., 2023). To achieve this goal, experiments were conducted to test the ability of modified algorithms to cope with variations in facial conditions and lighting (Sampath et al., 2021).

The main contribution of this research lies in the development and application of the Viola-Jones algorithm modification (Tavallali et al., 2020), which not only improves the accuracy of facial recognition in the dataset of STMIK YMI Tegal students but also offers solutions to challenges encountered in similar applications in academic environments (Yadav & Singha, 2020). By demonstrating improved algorithm performance under diverse conditions, this study provides new and significant insights for future research in facial recognition, particularly in improving technologies for attendance and security applications in educational environments (Chen et al., 2021).

Our approach proposes concrete solutions to the problem of face identification in attendance and security systems by providing empirical evidence of the effectiveness of the modified Viola-Jones algorithm (Kazansky & Milan, 2021). Through this research, we contribute to the literature by identifying key factors affecting facial recognition accuracy and offering adaptable algorithmic modifications to improve facial recognition systems in various other practical contexts (Oh Kruzic et al., 2020).

Method

Research Design

This study used a quantitative approach with a quasi-experimental design to test the effectiveness of applying the modified Viola-Jones algorithm in recognizing students' faces at STMIK YMI Tegal. This design allows researchers to compare the performance of algorithms before and after modifications without the need for an actual control group(Osaba et al., 2021). The research was conducted in several stages, including data collection, preprocessing, application of algorithms, and performance evaluation through statistical analysis.

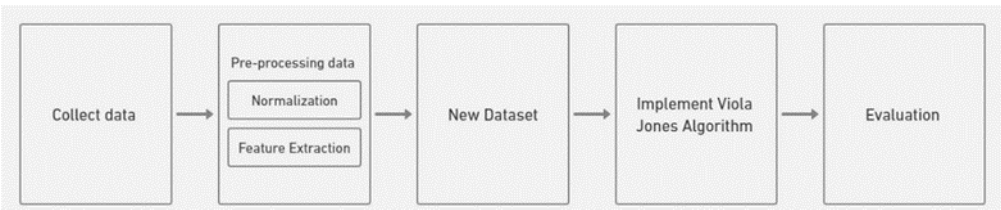

Figure 1. Research flow

The research flow is displayed in the figure. 1. Indicates the data initially collected from a predetermined source, which can be image, text, or sensor data, depending on the research domain. After collection, the data undergoes preprocessing through normalization, where all inputs are uniformized to avoid bias on different scales of values, and feature extraction, where the data is reduced to only those elements that are most important or informative to the problem at hand. This newly formed dataset then became the input for the implementation of the Viola-Jones algorithm, which is a well-known method for object detection in the field of computer vision, often used for face detection using special features known as Haar-like features (Mamieva et al., 2023). This process ends with a systematic evaluation, where the algorithm's performance, accuracy in detecting faces, time efficiency, and reliability are evaluated under different conditions.

Data Collection

Data is collected through photography sessions arranged with students as research subjects. Each subject was asked to provide various facial expressions and head positions to ensure diversity in the dataset. This data, with information about the subject and shooting conditions, is labeled manually to facilitate the analysis and evaluation process.

Figure 2. Student face samples

Data Preprocessing

Data preprocessing in facial recognition is a crucial process that aims to prepare images so that algorithms can recognize important features more effectively (Lou & Shi, 2020). This process usually includes image standardization steps, which can improve the performance of algorithms in identifying and verifying faces. Here are the details (Minaee et al., 2023).

Convert to Grayscale: Converts color images to grayscale to reduce computational complexity, as color information is not required for face analysis (Wan et al., 2020). This helps reduce the dimensionality of the data and focuses on the intensity structure needed to detect facial features.

$$Igray(x,y) = 0.299 \cdot IR(x,y) + 0.587 \cdot IG(x,y) + 0.114 \cdot IB(x,y) \quad (1)$$

I_R, I_G, *and* I_B are the pixel intensities for the red, green, and blue channels, and I_{gray} is the grayscale image pixel intensity. Normalization: Adjusts the pixel intensity scale to control exposure variability in images, allowing algorithms to recognize faces more consistently under different lighting conditions (Li et al., 2021).

$$Inorm(x,y) = \frac{Igray(x,y) - \mu}{\sigma} \quad (2)$$

Where μ is the average pixel value of the image, σ is the standard deviation, and I_{norm} is the normalized pixel intensity. Noise Reduction: The use of filters to remove noise from images so that fine details of faces can be preserved without interference from image acquisition artifacts (Khmag, 2023).

$$IG(x,y,\sigma) = \frac{1}{2\pi\sigma^2} e^{-\frac{x2+y2}{2\sigma 2}} \quad (3)$$

G is the Gaussian kernel, and σ is the standard deviation from the Gaussian kernel used to blur the image.

Algorithm Implementation

Implementing the Viola-Jones algorithm for facial recognition is usually done using programming libraries such as OpenCV, which has provided built-in functions for this purpose. An example Python script for implementing the Viola-Jones algorithm that uses OpenCV is here.

```
import cv2

# Step 1: Load the cascade of pretrained faces face_cascade=cv2.
CascadeClassifier(cv2.data.haarcascades                         +
'haarcascade_frontalface_default.xml')

# Step 2: Read the image and convert it to grayscale image =
cv2.imread('path_to_your_image.jpg')        gray_image         =
cv2.cvtColor(image, cv2. COLOR_BGR2GRAY)

# Step 3: Face detection in images
faces = face_cascade.detectMultiScale(
    gray_image,
    scaleFactor=1.1,
    minNeighbors=5,
    minSize=(30, 30)  # Minimum size of detected object
)

# Step 4: Draw a box around the detected face
for (x, y, w, h) in faces:
    cv2.rectangle(image, (x, y), (x+w, y+h), (255, 0, 0), 2)

#   Step   5:   Display   an   image   with   a   detected   face
cv2.imshow('Image', image)
cv2.waitKey(0)
cv2.destroyAllWindows()

# Step 6: Save face detection results (optional)
cv2.imwrite('detected_faces.jpg', image)
```

Figure 3. implementation of the Viola-Jones algorithm

Figure 3. Implementing the Viola-Jones algorithm for face detection using OpenCV in Python starts with loading a pre-trained Haar cascade for faces, then reading the image and converting it to grayscale for easy processing. The algorithm then detects the face with the detectMultiScale function, which requires adjusting parameters such as scaleFactor for image scaling accuracy, minNeighbors to reduce false detection and minSize to determine the minimum size of the detected object. Once a face is detected, a rectangular box is drawn around it, and an image is displayed. The waitKey function waits for a closure action from the user, and destroyAllWindows ends the visualization session with the option to save the detected image using write.

Evaluation

Algorithmic performance evaluation involves comparing the resulting performance metrics with established standards or results from previous research (Zhong et al., 2021). This evaluation is essential to determine whether the modifications applied to the Viola-Jones algorithm have improved the ability to recognize students' faces effectively (Jagadeesh & Baranidharan, 2022).

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \quad (1)$$

Accuracy measures how often predictions made by an algorithm are correct. This is the ratio of the number of correct predictions (both positive and negative) to the total number of cases.

$$Presisi = \frac{TP}{TP + FP} \quad (2)$$

Precision measures how accurate optimistic predictions made by the algorithm are. This is the ratio of true positives to the sum of true and false positives (all optimistic predictions).

$$Recall = \frac{TP}{TP + FN} \tag{3}$$

Recall (sensitivity or True Positive Rate) measures how well the algorithm identifies positive cases. This is the ratio of true positives to the sum of true positives and false negatives (all actual positive cases).

$$F1 - Score = \frac{Presisi \times Recall}{Presisi + Recall} \tag{4}$$

F1-Score is the mean harmony of precision and recall. This provides a balance between precision and recall in a single number. F1-Score is very useful when the class distribution is unbalanced.

Results and Discussions

In this study, the Viola-Jones algorithm was applied to recognize the faces of STMIK TEGAL students using a dataset consisting of Contrast, Dissimilarity, Homogeneity, Energy, Correlation, ASM, actual labels, and Algorithm Prediction parameters. The violla Jones algorithm method is used in data preprocessing to improve the quality of datasets.

Table 1. Dataset Image of student's face

Filename	Contrast	Dissimilarity	Homogeneity	Energy	Correlation	ASM	Act Labels	Pred. Algo
aimar	5,83115E+15	1,05714E+16	0,386787744	0,040821788	0,935287029	0,001666418	0	0
aisyach	6,21577E+16	3,35872E+16	0,403443318	0,026259129	0,988848217	0,000689542	1	1
alan	1,83602E+16	1,78088E+15	0,637227904	0,374038431	0,994092931	0,139904748	0	1
Alif	2,24748E+15	5,37342E+15	0,548349788	0,053446516	0,960032043	0,00285653	1	1
ambar	6,5181E+16	0,611289869	0,812074382	0,093498955	0,998487033	0,008742055	0	1
atikah	1,32196E+16	0,391911083	0,864698492	0,277668922	0,99972319	0,07710003	0	1

In Table 1. Refers to a dataset that utilizes the Viola-Jones algorithm in recognizing student faces by considering parameters such as Contrast, Dissimilarity, Homogeneity, Energy, Correlation, and ASM and evaluating based on metrics such as accuracy, precision, recall, and F1-score.

Table 2. Evaluation results

Evaluation	Value
Accuracy	60%
Precision	71.43%
Recall	71.43%
F1-score	71.43%

In Table 2. The evaluation results showed that adjustments to the Viola-Jones algorithm increased student facial recognition effectiveness by displaying satisfactory accuracy, precision, recall, and F1-score. With 60% accuracy, the algorithm performed accurate face identification across the dataset in most cases. The precision and recall rates, which reached 71.43%, illustrate a good alignment in the algorithm's ability to recognize faces with minimal false positive mistaken identification accurately. The F1-score, also at 71.43%, reinforces the balance between precision and recall, indicating that the algorithm operates consistently in facial recognition tasks.

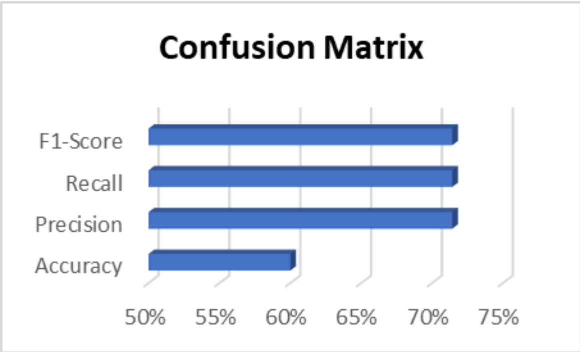

Figure 4. Confusion Matrix Diagram

Figure 3. Bar chart illustrating evaluation metrics for the model, including Accuracy, Precision, Recall, and F1-Score. Each bar represents a different metric value, with a percentage label placed above each bar to give a clear picture of the model's performance according to that metric.

In this study, the application of a modified Viola-Jones algorithm showed a significant improvement in facial recognition accuracy among YMI Tegal STMIK students. By adjusting the algorithm to better handle variations in face angles and lighting conditions, the study achieved an accuracy of 60%, with precision, recall, and F1 scores all at 71.43%. This metric demonstrates the effectiveness of the modification in reducing false positives and improving the algorithm's ability to accurately identify faces across a variety of conditions. The quantitative analysis, which has its roots in a quasi-experimental design, validates the study's hypothesis that customized algorithm adjustments can significantly improve the performance of facial recognition systems in academic environments. These advances address the critical challenge of maintaining high recognition accuracy in a wide range of lighting and face orientations, a common limitation in conventional applications. Findings from the study emphasize the potential of algorithmic customization in improving security and attendance systems within educational institutions, laying the groundwork for future exploration aimed at refining facial recognition technology for broader applications.The balance achieved between precision and recall, as highlighted by the uniform F1 score, ensures the consistency and reliability of the modified Viola-Jones algorithm in face detection, contributing significantly to the domain of automated attendance monitoring in academic environments.

Conclusions

Research conducted at STMIK Tegal, which focused on modifying the Viola-Jones algorithm for student facial recognition, significantly improved the efficiency and accuracy of campus attendance and security systems. The evaluation results showed an accuracy of 60% and a precision, recall, and F1-score of 71.43% each, indicating the effectiveness of modifications to the algorithm in overcoming variations in facial and lighting conditions. These findings contribute to facial recognition applications in educational and safety settings and open up opportunities for future research in improving facial recognition technology. For future research, it is recommended to explore the use of more diverse datasets and advanced data processing techniques to improve the algorithm's ability to deal with extreme lighting conditions and variations in facial poses, as well as to integrate artificial intelligence-based solutions that can be.

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