Cawangan Melaka

PCMJ

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volume 1

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Progress in Computing and Mathematics Journal
College of Computing, Informatics, and Mathematics
Universiti Teknologi MARA Cawangan Melaka, Kampus Jasin
77300, Merlimau, Melaka Bandaraya Bersejarah

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EDITORS

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PREFACE

Welcome to the inaugural volume of the **Progress in Computing and Mathematics Journal (PCMJ)**, a publication proudly presented by the College of Computing, Informatics, and Mathematics at UiTM Cawangan Melaka.

This journal represents a significant step in our commitment to fostering a vibrant research culture, initially providing a crucial platform for our undergraduate students to showcase their intellectual curiosity, dedication to scholarly pursuit, and potential to contribute to the broader academic discourse in the fields of computing and mathematics. However, we envision PCMJ evolving into a beacon for researchers both nationally and internationally. We aspire to cultivate a space where groundbreaking research and innovative ideas converge, fostering collaboration and intellectual exchange among established scholars and emerging talents alike.

The manuscripts featured in this first volume, predominantly authored by our undergraduate students, are a testament to the hard work and dedication of these budding researchers, as well as the guidance and support provided by their faculty mentors. They cover a diverse range of topics, reflecting the breadth and depth of research interests within our college, and set the stage for the high-quality scholarship we aim to attract in future volumes.

As editors, we are honored to have played a role in bringing this journal to fruition. We extend our sincere gratitude to all the authors, reviewers, and members of the editorial board for their invaluable contributions. We also acknowledge the unwavering support of the college administration in making this initiative possible.

We hope that PCMJ will inspire future generations of students and researchers to embrace research and innovation, to push the boundaries of knowledge, and to make their mark on the world of computing and mathematics.

Editors
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ENHANCING CRIMINAL IDENTIFICATION: SVM-BASED FACE RECOGNITION WITH VGG ARCHITECTURE

Nurrul Azleen Binti Roslan
2022771599@student.uitm.edu.my

Pn Zainab Binti Othman
zainab_othman@uitm.edu.my

Article Info

Abstract

This report introduces a Criminal Face Recognition System to address Royal Military Police (RMP) challenges in identifying criminals. The objective is to develop a reliable system for precise image matching, ultimately enhancing public safety and RMP capabilities. The reliance on manual identification processes during roadblocks poses a significant hurdle, being both time-consuming and error-prone. The absence of face recognition technology compounds these challenges, limiting authorities' ability to swiftly and accurately identify potential threats. In this study, a dataset comprising 1200 samples was utilized, and preprocessing techniques were employed to enhance its quality and relevance for effective model training. These preprocessing steps involved the application of dimensionality reduction techniques, such as Principal Component Analysis (PCA), to reduce the complexity of the dataset while retaining essential features. The methodology involves the utilization of deep learning techniques, specifically integrating a Support Vector Machine (SVM) with Visual Geometry Group (VGG) architecture. This integration has demonstrated significant enhancements in the system’s capabilities for recognizing criminal faces, positioning RMP at the forefront of innovation for heightened public safety and security. The reported accuracy of the Criminal Face Recognition System is 93.50%, showcasing proficiency in recognizing known criminals and robustness in handling new, unseen faces. The study concludes by emphasizing the potential for future work in improving public safety and RMP capabilities, opening avenues for enhancements and optimizations. For future work, the paper proposes the upgrade to high density camera webcams to enhance image quality and overall system performance. Improved hardware components, particularly the integrated camera, are anticipated to significantly boost accuracy and reliability in criminal face recognition.

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Keywords: Royal Military Police; Support Vector Machine; Principal Component Analysis; Visual Geometry Group;

INTRODUC TION

The Royal Military Police (RMP) is the primary law enforcement agency in Malaysia that is responsible for maintaining public order, preventing, investigating crimes, ensuring the safety and security of Malaysian citizens. Nowadays, criminal activities are increasing rapidly, and it has become a vital concern for the RMP to investigate criminals through these methods (Kumar et al., 2021). A recent example of such criminal activity is when the police were searching for a criminal who sexually assaulted two children in Section 19 (Muhaamad Hafis Nawawi, 2021). However, the rise of crime has become a serious challenge to the police to recognize criminals due to the lack of advanced technology and police officers. Although various technological solutions have been proposed for detecting criminals, they often fail to meet the required standards of accuracy and efficiency (Kumar et al., 2021).

Detecting and identifying criminals is difficult when they do not leave any genetic evidence or fingerprint traces (Menon, 2023). Because the process of investigation is complicated and time-consuming, limited investigations constitute a big challenge for law enforcement agencies, especially the RMP. The primary objective is to design a Criminal Face Recognition System capable of detecting criminal faces accurately. Additionally, the project seeks to develop this system by integrating Support Vector Machine (SVM) and Visual Geometry Group (VGG) methodologies, enhancing its functionality and precision. Furthermore, the project aims to rigorously test the functionality and accuracy of the Criminal Face Recognition System to ensure its reliability and effectiveness in real-world scenarios.

The scope involves developing a criminal face recognition system to detect and identify six criminals using deep learning algorithms. The system will focus on individuals active within the last five years and provide real-time notifications to the RMP upon identification, ultimately improving public safety and national security. The significance lies in advancing RMP capabilities with a criminal face recognition system integrating SVM and VGG. It enhances precision, efficiency, and accuracy in criminal identification, assisting in swiftly apprehending suspects and proactively preventing crimes, thus contributing to public safety and security.

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LITERATURE REVIEW

Traditionally, the RMP carried out the detection of criminals manually, which was time-consuming and prone to error. In recent years, a few technological solutions have been developed in response to the demand for a more effective and precise method of detecting criminals or crime suspects. The RMP demands a certain level of accuracy and efficiency, but many of these solutions have failed to meet the criteria, causing persistent issues in the field. The research indicates that there are numerous answers to this issue. Figure 1 shows a literature review diagram carried out to have a better understanding of the information and knowledge available on this issue.

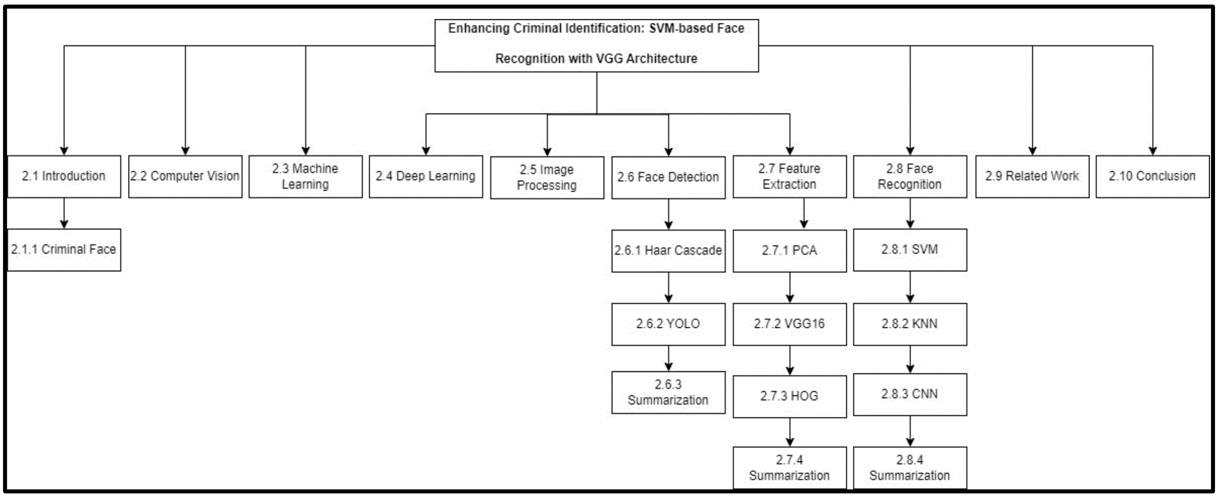

Figure 1: Literature Review Diagram

Face Detection

Face detection is a technique used by computers to identify people in digital images and videos using computer vision and machine learning algorithms. The algorithms employ several techniques, such as edge detection, feature extraction, and pattern recognition, to find probable face areas in an image or video frame, and then apply additional criteria to decide whether these regions are indeed faces. Face detection is a subdomain of object detection, which is the detection of instances of objects from a specific class in an image or video such as people, automobiles, buildings, or faces (Dang & Sharma, 2017).

Haar Cascade was chosen over YOLO as the preferred technique for system development based on a comparative analysis presented in Table 1 shows the analysis of various research studies highlighted Haar Cascade's performance and suitability for the project objectives. Thus, Haar Cascade was selected as the primary approach for system development.

Table 1: Face Detection Comparison

Method	Author, Year	Advantages	Disadvantages
Haar Cascade	Kumar et al., 2022	High accuracy in face detection, Efficient detection of multiple instances, and utilization of positive and negative training sets.	Limited capacity for non-frontal faces
YOLO	Li & Cao, 2020	Real-time object detection, High speed, and precision, Accurate identification, Flexibility in resolution	Difficulty in detecting small objects

Feature Extraction

Table 2 presents a feature extraction comparison. In the feature extraction analysis, the VGG16 and PCA were selected over HOG for feature extraction owing to their inherent advantages, encompassing overfitting reduction, location-invariant feature detection, nonlinearity, expedited training, dimension reduction, operational efficiency, and resilience to variations and distortions. The preference for VGG16 was influenced by its swift response time and impressive accuracy, establishing it as a versatile and efficient strategy that elevates feature extraction to meet specific requirements and attain superior performance when contrasted with PCA and HOG.

Table 2: Feature extraction comparison

Method	Author, Year	Advantages	Disadvantages
PCA	Salih & Adnan Mohsin Abdulazeez, 2021	Dimensionality reduction, retaining critical information, handling high-dimensional data, data visualization, and noise reduction	Interpretability of reduced features, dependency on linearity assumptions, sensitivity to outliers.
VGG-16	Chen, 2019	VGGNet excels in high feature extraction capabilities, uniform architecture for simplicity, effective transfer learning, and robust performance in image recognition.	Suffers from high computational complexity, elevated memory requirements, susceptibility to overfitting, and challenges in training on small datasets.
HOG	Aleka Melese Ayalew et al., 2022	Robust feature representation, straightforward computation, a compromise between accuracy and complexity, noise resistance, and compact representation.	Limited spatial information, sensitivity to image scale and orientation, limited representation of complex textures

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Face Recognition

Table 3 outlines a revised face recognition comparison, wherein SVM has been selected over CNN and KNN. The decision to opt for SVM is driven by a strategic emphasis on effective classification, interpretable models, memory efficiency, and flexibility with complex data. SVM, known for its prowess in accurate classification, offers more interpretable models, facilitating a clearer understanding of the decision-making process. Additionally, SVM's minimal memory requirements align well with the need for efficient resource utilization. The flexibility exhibited by SVM in handling complex data further underscores its suitability for addressing the intricacies of facial features and patterns. Considering these considerations, SVM has been chosen to optimize the balance between accuracy, interpretability, memory efficiency, and adaptability to complex facial data in the context of face identification tasks.

Table 3: Face recognition comparison

Method	Author, Year	Advantages	Disadvantages
SVM	Sarker, 2021	Effective classification, interpretable models, memory efficiency, flexibility with complex data	Sensitivity to noisy data, parameter sensitivity, scalability to large datasets
KNN	Guo, 2021	No training phase, Robust to noisy data, Simple and intuitive.	Computational complexity, sensitivity to feature scaling, memory-intensive.
CNN	M Kalaivani & Anitha Senthilkumar, 2020	Highly accurate, efficient facial recognition, hierarchical representation, and automatic feature extraction.	Computational complexity and datasets can be time-consuming, and interpretability challenges.

Related Work

Several researchers have developed a criminal face recognition system. Various techniques, approaches, and procedures have been researched and deployed as part of these studies, to improve the accuracy, efficiency, and overall performance of criminal face recognition systems. The work of a few researchers and experts in this field will be reviewed in this section along with some other related work. Table 4 shows a comparison of related works and proposed system.

Table 4: Comparison of related works and proposed system

Related Work Title	Author, Year	Techniques & Algorithms	Accuracy
Criminal Identification System Using Facial Recognition	Nagnath B. Aherwadi, Deep Chokshi, Dr. Sagar Pande, Aditya Khamparia, 2021	PCA, LBPH, Haar Cascades	99.38%
Biometric Facial Detection and Recognition Based on ILPB and SVM	Shubhi Srivastava, Ankit Kumar, Shiv Prakash, 2021	Haar Cascades, ILBP, SVM	97.90%
Recognition of Criminal Faces from Wild Videos Surveillance System using VGG-16 Architecture	Rahul Bhatt; Suraj Malik, Rishabh Arora, Gaurav Agarwal, Shilpa Sharma, Anishkumar Dhablia,2023	CNN, ResNet, and VGG16	90.1%

METHODOLOGY

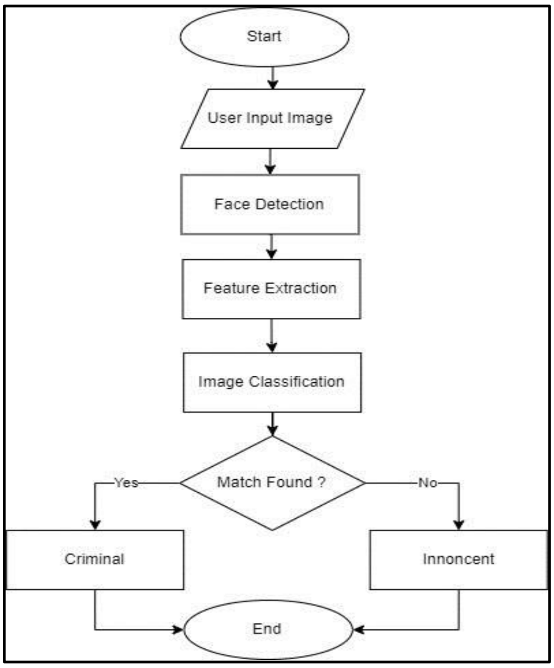

Figure 2: Flowchart of this system

Figure 2 illustrates a flowchart depicting the criminal face recognition system. The flow starts with the system being opened and involves the comparison of the detected face with a dataset containing numerous images of criminals. If a match is found between the detected face and an image in the dataset, the system will retrieve and provide the related data associated with that image. On the other hand, if no match is found, the system concludes that the recognized person is innocent.

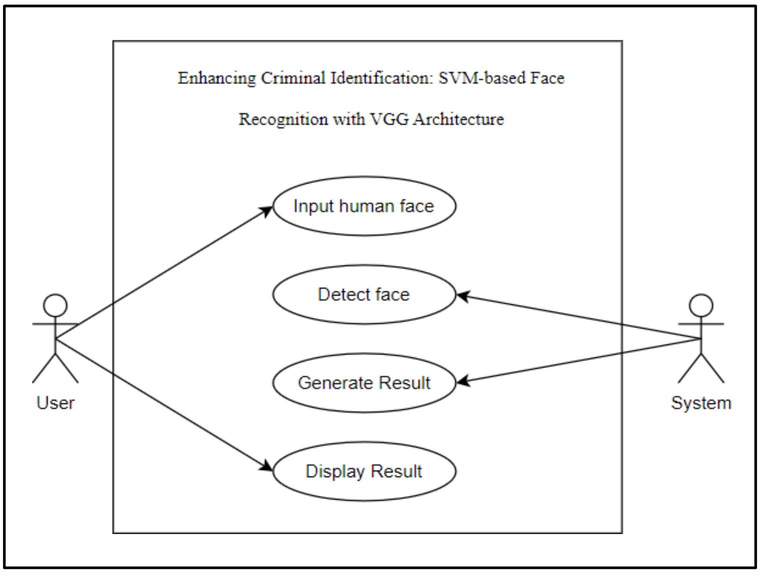

Figure 3: The use case of the system

Figure 3 illustrates the use case diagram, providing a visual representation of the interactions between the user and the system. The diagram showcases the main use case of uploading an image, along with the subsequent processes of image analysis and suggestion generation. By referring to Figure 3, users can gain a clearer understanding of the system's functionality and the roles played by different actors in achieving the intended objectives.

Figure 4: Interface of the system

In Figure 4, the interface features an 'Upload Image' button, offering users functionality tailored for face detection and classification into 'criminal' or 'innocent' categories. Upon detecting a reliable match, the displayed feedback is anticipated to indicate 'criminal,' providing pertinent details about the individual such as their name, gender, date of birth, father's name, and specifics of any committed crimes. This UI design is crafted to ensure a user-friendly experience, aiming to minimize potential challenges in interacting with the system.

RESULT AND DISCUSSION

A dataset comprising 1,200 images was utilized for training and testing purposes. The training set consisted of 1,067 images, which accounts for 90% of the total dataset, while the testing set comprised 133 images, making up the remaining 10%. The choice of a 90-10 split for training and testing was driven by the constraint of limited dataset availability. The testing phase was conducted 22 times for each, allowing for a comprehensive assessment of the system's performance. The dataset is categorized into six classes, each representing a specific criminal. Table 5 provides a detailed breakdown of the system's accuracy in identifying individuals labeled as Criminal 1 through 6 across the twenty-two tests. Each row in the table corresponds to a specific test, and each column represents one of the six criminals. The accuracy values in the table are manually calculated to evaluate the effectiveness of the system.

Table 5: Testing of Confusion Matrix

Test	Criminal 1	Criminal 2	Criminal 3	Criminal 4	Criminal 5	Criminal 6
1	21	0	0	0	1	0
2	0	22	0	0	0	0
3	1	0	21	0	0	0
4	1	0	0	20	0	1
5	1	0	0	0	21	0
6	0	0	0	3	0	19

Table 6 shows that TP is when the system correctly recognizes individuals as criminals. In Test 1, Criminal 1 had 21 accurate identifications. However, FN occurs when the system fails to detect a criminal or incorrectly identifies details of a different criminal, and when it wrongly identifies an innocent person as a criminal, as seen in the Test 1 row.

Table 6: Result of Confusion Matrix

Criminal	TP	FN

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1	21	1
2	22	0
3	21	1
4	20	2
5	21	1
6	19	3

To calculate individual accuracy percentages, assess each person's performance by dividing the number of correct tests they answered by the total number of tests taken. Multiply the result by 100 to obtain the accuracy percentage for everyone.

$$\boldsymbol{Accuracy\ Percentage\ for\ Individual} = \left(\frac{\boldsymbol{Number\ of\ Correct\ Tests}}{\boldsymbol{Total\ Number\ of\ Tests}}\right) \boldsymbol{X\ 100} \quad (1)$$

Table 7: Result of Accuracy

Criminal	Accuracy(%)
1	95
2	100
3	95
4	90
5	95
6	86

After calculating the accuracy percentage for everyone, the next step is to aggregate these individual results to obtain the overall accuracy for the entire group. This is accomplished by adding up the accuracy percentages for everyone.

$$\boldsymbol{Accuracy\ Percentage\ for\ Individual} = \left(\frac{\boldsymbol{Number\ of\ Correct\ Tests}}{\boldsymbol{Total\ Number\ of\ Tests}}\right) \boldsymbol{X\ 100} \quad (2)$$

Having obtained the sum of individual accuracy percentages, the final step is to determine the overall accuracy for the entire group. This is achieved by dividing the sum of individual accuracy percentages by the total number of individuals in the group.

$$\boldsymbol{Overall\ Accuracy} = \frac{\boldsymbol{Sum\ of\ Individual\ Accuracy\ Percentages}}{\boldsymbol{Number\ of\ Individual}} \quad (3)$$

$$\boldsymbol{Overall\ Accuracy} = \frac{\boldsymbol{561}\%}{\boldsymbol{6}} \quad (4)$$

$$\boldsymbol{Overall\ Accuracy} \approx \boldsymbol{93.50}\% \quad (5)$$

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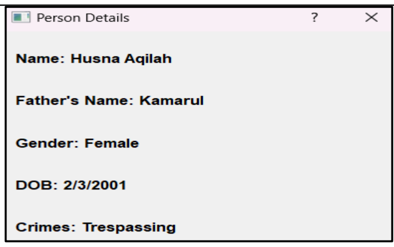
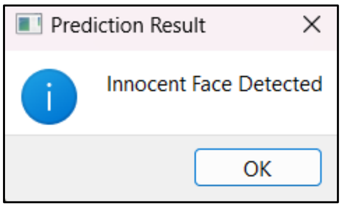
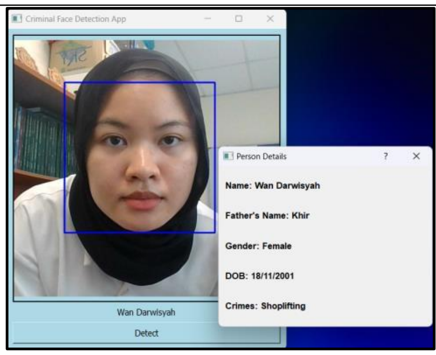
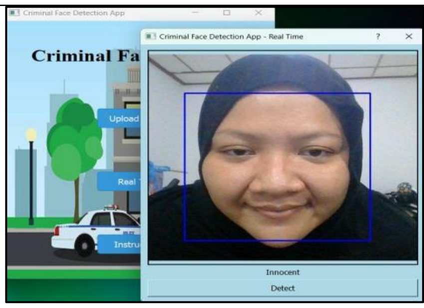
The resulting percentage signifies the overall accuracy for the entire group, providing a synthesized perspective on the group's performance. For more detailed information about the selected testers, Table 8 offers insights into demographics and expertise.

Table 8: Results of Functionality Testing

Individual	**Result**
Husna Aqilah	
Innocent	
Wan Darwisyah	
Innocent	

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