NSIEX+RS 2025
NEGERI SEMBILAN INTERNATIONAL EXPOSITION

# HARMONY IN PROGRESS:

## INTEGRATING SCIENCE, TECHNOLOGY, AND SOCIAL INNOVATION FOR SUSTAINABLE DEVELOPMENT GOALS

e-Book of Extended Abstract
Negeri Sembilan International (NSIEx) & Research Symposium
2025

# YST009 - INTEGRATING IMAGE ENHANCEMENT WITH YOLO FOR IMPROVED LOW-LIGHT FACE DETECTION

Farah Safiyyah Md Zahidan[1], and Farizuwana Akma Zulkifle[2*]

[1]Fakulti Sains Komputer dan Matematik (FSKM), Universiti Teknologi MARA Cawangan Shah Alam, Selangor
[2]Fakulti Sains Komputer dan Matematik (FSKM), Universiti Teknologi MARA Cawangan Negeri Sembilan, Kampus Kuala Pilah

*Corresponding author: farizuwana@uitm.edu.my

## ABSTRACT

The paper introduced an innovative to enhancing face recognition performance in low-light environments using the You Only Look Once (YOLO) framework. Low light conditions pose a significant challenge to accurate facial identification, often degrading the reliability of conventional recognition systems. To address this issue, the study integrate image enhancement techniques, specifically Retinex and Zero-DCE, to strengthen the YOLO algorithm's effectiveness. Through extensive experimentation, the YOLOv8m.pt model, optimised using Stochastic Gradient Descent (SGD) at the 30th epoch, emerged as the most effective configuration. The proposed system was rigorously evaluated for both speed and accuracy, demonstrating its suitability for real-time applications. Notably, the Zero-DCE method consistently outperformed Retinex, offering faster processing times and improved recall across most test images. Under optimal conditions, the YOLO-based system achieved a mean Average Precision (mAP) of 75.8%, a Precision of 76.5%, and a Recall of 66.4%, marking a substantial advancement in face recognition capabilities for security and surveillance in low-light scenarios. Future research might be aimed at expanding scope of the data to cover more diverse situations and creating high quality API to enable broader usage and continuous learning.

***Keywords: YOLO-based approach; low-light environments; face recognition; image enhancement; Zero-DCE***

## INTRODUCTION

Modern biometric systems rely heavily on face recognition technology, but the performance of this technology depends heavily on environmental factors like low-light conditions (Zhang et al., 2024). The You Only Look Once (YOLO) architecture has entirely transformed the field of object detection and recognition, where it allows real-time processing and high accuracy levels in detection (Chen et al., 2023). However, traditional face recognition systems still face significant limitations in low-light environments due to reduced visibility, increased image noise, and diminished facial feature clarity. These factors collectively degrade recognition accuracy and increase the likelihood of false positives (Shrivastav et al., 2023). Although image enhancement techniques such as Generative Adversarial Networks (GANs) and deep convolutional neural networks have

shown promising results, their deployment in real-world applications remains limited due to the high computational demands they impose (Kim et al., 2022).

## OBJECTIVE

This study aims to enhance face recognition performance in low-light environments by leveraging a YOLO-based model. The study is guided by the following objectives:

- To identify effective image enhancement techniques for improving face recognition in low-light conditions.
- To design a face recognition system using a YOLO model optimised for different lighting conditions.
- To evaluate deep learning models for real-time low-light face recognition for better accuracy and processing speed.

## DESCRIPTION OF THE PROJECT

The final prototype uses the YOLOv8 model combined with the Deep Curve Estimation with Zero-References (Zero-DCE) improvement in order to address the problems of low-light conditions.

The main interface is split into three categories of interaction:

i. **Detection Interface**: This is the main page of face recognition. There are two modes in which a user can insert images:
   - **Image Upload**: The system allows users to easily upload and browse image files from their local device for analysis.
   - **Webcam Integration**: It supports seamless connection to a local webcam as depicted in Figure 1, enabling real-time face recognition. The system automatically detects low-light conditions and applies Zero-DCE enhancement when necessary, indicated by the tag “Low-Light Enhanced: Yes”; otherwise, the tag reads “Low-Light Enhanced: No.”

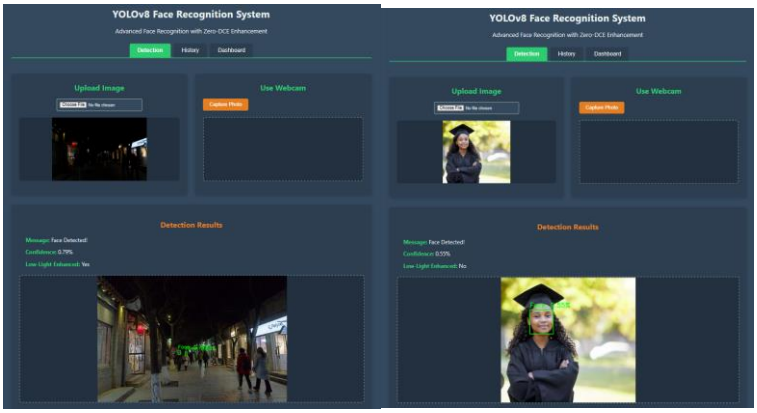


Figure 1: Face Detection Result with Low-Light vs Normal Light

ii. **Detection History Log:** As depicted in Figure 2, the tab displays is a chronological record of all past detection activities. Each log entry includes the timestamp, input type (e.g., webcam capture or uploaded image), face detection status, confidence level, application of low-light enhancement, and processing time.

Figure 2: Detection History Log

iii. **Analytics Dashboard:** In Figure 3, the dashboard shows overall performance indicators, including the total image uploads, detection rate, average confidence, and average processing time. These indicators are complemented by visual plots for intuitive analysis and monitoring.

Figure 3: Analytics Dashboard

## NOVELTY

The core innovation of this study lies in the effective integration and optimization of the YOLOv8m.pt model with the Zero-DCE image enhancement technique, addressing a notable gap in current face recognition research. This combination enables a robust real-time system that significantly improves detection accuracy and processing speed under low-light conditions. The proposed solution holds practical value for security forces and law enforcement agencies by enhancing operational capabilities in environments with limited visibility. The resulting journal article contributes meaningfully to the field of Intelligent Systems Engineering and advances the development of resilient, deployable face recognition technologies for complex, real-world scenarios.

## CONCLUSION

In conclusion, this study successfully designed and developed a YOLOv8-based face recognition system integrated with Zero-DCE image enhancement to address the challenges of low-light environments. The system features a user-friendly web interface that delivers real-time visual feedback, maintains transparent detection records through a history log, and provides clear performance metrics via an analytics dashboard. These elements collectively enhance user experience and system usability. While the proposed solution significantly improves recognition accuracy under poor lighting conditions, the results also affirm that images captured in low-light settings may still fall short of the performance achieved under normal lighting. Nonetheless, the system represents a

meaningful advancement in practical, deployable face recognition technologies, particularly for security and law enforcement applications in low-visibility scenarios.

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