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System Design and Development for Early Detection of HFMD Symptoms Using AI and Infrared Thermometer Sensor

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Abstract

Hand, Foot, and Mouth Disease (HFMD) is a highly infectious disease that mainly occurs in children under six years of age and frequently breaks out in Malaysia, making it a major public health concern in those regions. For this project, an automated screening system is introduced using a combination of Artificial Intelligence and an infrared sensor to detect symptoms at an early stage. The project uses an MLX90614 infrared sensor to scan body temperatures without direct contact, and a YOLOv8 object detection algorithm to identify skin rash on a child's hand using a digital camera. Using IoT capabilities, the real-time scan results and notifications are stored in a cloud Firebase Realtime database and can also be viewed in a Streamlit application interface. The application of this system will serve as a proactive "first line of defence" in childcare centres or kindergartens to effectively control HFMD.

1. Introduction

Hand, Foot, and Mouth Disease is a contagious viral infection caused primarily by Coxsackievirus A16 and Enterovirus 71, and it affects children 6 years of age or younger [1][2]. The disease has reached a point of cyclic epidemics in Malaysia, with over 100,000 cases recorded in 2022 [3]. It typically presents with high fever, painful oral ulcers, and specific erythematous macules or blisters on the hands and feet. Its primary mode of transmission, through direct contact with contaminated saliva, mucus, or infected objects, allows the virus to spread throughout the kindergarten [4].

Despite the severity of the disease, today's screening in all educational institutions remains heavily manual and dependent on contact thermometers. Such reliance on human intervention introduces a lot of challenges faced in diagnosis due to subjectivity-early-stage symptoms are often overlooked-and a risk of cross-contamination via contact with thermometers. Moreover, manually recorded records lack standardisation and real-time synchronisation, making it very hard for health administrators to monitor localised outbreaks. Therefore, there is an urgent need for an objective, non-contact screening system capable of automating the detection of thermal and visual signs of the virus.

To resolve the above-mentioned shortcomings of conventional health screening methods, which are inefficient and time-consuming. This project offers an automated, contactless health screening solution that combines infrared thermal imaging and Artificial Intelligence. The solution uses an ESP32 microcontroller and an MLX90614 infrared thermal sensor for detecting fever, and a YOLOv8 Computer Vision Model for automated detection and classification of skin rashes related to HFMD. Using a Firebase Realtime Database solution and a Streamlit-based IoT dashboard solution. This technological solution thus serves as a crucial “first line of defence”,

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providing high diagnostic consistency, no risk of cross-infection, and immediate patient isolation to prevent a community outbreak.

2. Materials and Methods

The integrated screening system was developed in line with the three-tier IoT architecture: hardware integration, AI model training, and cloud-based data management. The aforementioned architecture is shown in Fig. 1. The perception layer, which serves as the main data-acquisition layer, utilised the ESP32 microcontroller as the primary unit of computation. The MLX90614 infrared thermometer sensor was interfaced to the ESP32 using the non-contact body-temperature measurement protocol, with a distance of 2–5 cm. In parallel, a high-definition camera module was adopted to log visual data of hands and feet. Such a dual-sensor strategy provides the system with both physiological (thermal) and physical (visual) signs of HFMD with no possibility of cross-contamination during the initial check-up.

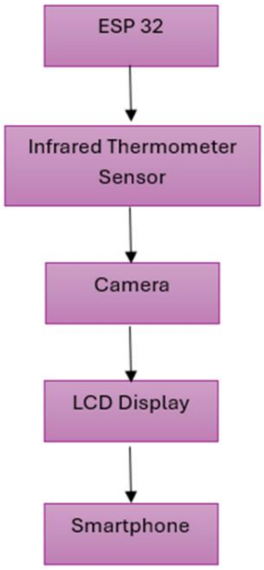

Fig. 1 *Block Diagram of Early Detection for HFMD Symptoms*

The intelligence in the system is based on the YOLOv8 (You Only Look Once) object detection model architecture, which delivers fast speed and high accuracy for real-time tasks. The AI development life cycle included a rigorous data curation phase in which a dedicated dataset for HFMD lesions was assembled and labelled using the Roboflow platform to support AI development. The AI system was trained to locate erythematous macules and vesicles in a lesion by leveraging color gradient, contrast along edges, and morphological features. To ensure its efficiency in a school setting, the reasoning logic is tuned to a 50% confidence level.

The network and application layers are responsible for synchronising and visualising the data. After detection, the ESP32 sends the temperature data and AI processing results to the Firebase Realtime Database over Wi-Fi. The end-user interface was created using the Streamlit framework, enabling the school administrator to receive real-time notifications via a web interface. The notification is sent only when the temperature ≥37.5°C is recorded or if at least one skin lesion is detected.

The integrated screening system is implemented through a deterministic sequential logic framework, as depicted in the system flowchart shown in Fig. 2. The process initiates with the ESP32 microcontroller establishing a secure handshake with the local Wi-Fi network and authenticating communication with the Firebase Real-time Database (RTDB. Following successful network synchronisation, the MLX90614 sensor performs thermometry via non-contact infrared sensing. Captured thermal data are forwarded to the cloud layer via the I^2C protocol, where they are compared against a preset threshold of 37.5 °C for fever. A corresponding visual acquisition is triggered through the Streamlit interface, capturing high-resolution imagery of the subject's extremities.

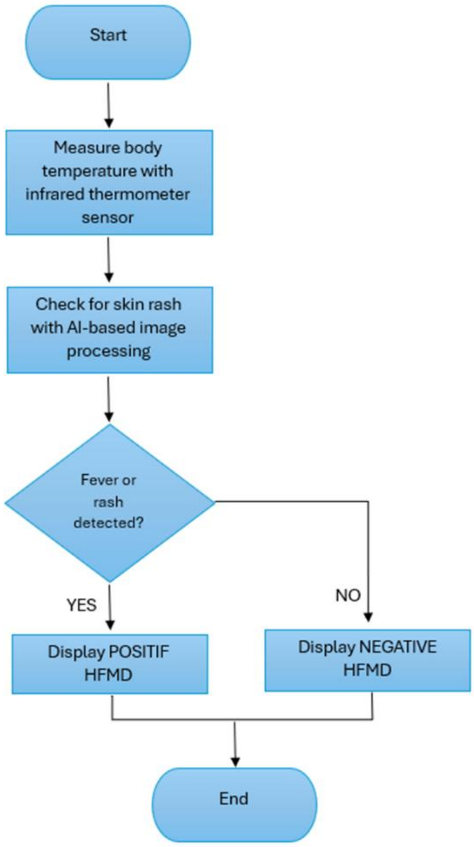

Fig. 2 *Flowchart of the work*

2.1 Comparison of Proposed System with Existing Literature

As shown in Table 1, there is a clear divergence between the conventional approach to clinical diagnostics and the proposed automated screening approach. Indeed, whereas conventional approaches, such as those discussed critically in [5] with regard to the work of Liu et al., focus on digital records of events experienced by children undergoing procedures in health facilities, they are necessarily reactive rather than preventive. Indeed, with the use of MLX90614 infrared sensors and YOLOv8-based computer vision, it is possible to perform instantaneous screening for fever and skin lesions. This is in stark contrast to conventional IT systems, which necessarily incur significant processing lags. Indeed, with IoT, it is possible to isolate immediately, which is useful for containing high-risk groups in communal spaces.

Table 1 *Comparison between existing clinical research and the proposed automated screening system*

Feature	Previous Research (Liu et al., 2017)	Proposed Project (This Study)
Main objectives	Classifying severe vs mild HFMD in hospitalised patients.	Early screening and detection of HFMD symptoms in schools.
Methodology	Retrospective analysis of Electronic Medical Records (EMR).	Real-time IoT-based sensing and AI computer vision.
Algorithm used	Random Forest (RF).	YOLOv8 (You Only Look Once).
Primary input	16 Clinical variables (Heart rate, WBC count, etc.).	Body Temperature (°C) and Digital Images of skin rashes.
Hardware	None (Software/Database only).	ESP32, MLX90614 Infrared Sensor, Camera.
Data accessibility	High dependency on clinical/laboratory tests.	Non-invasive, requires only visual and thermal scanning.
Operating Platform	Offline data processing.	Cloud-integrated (Firebase & Streamlit Dashboard).

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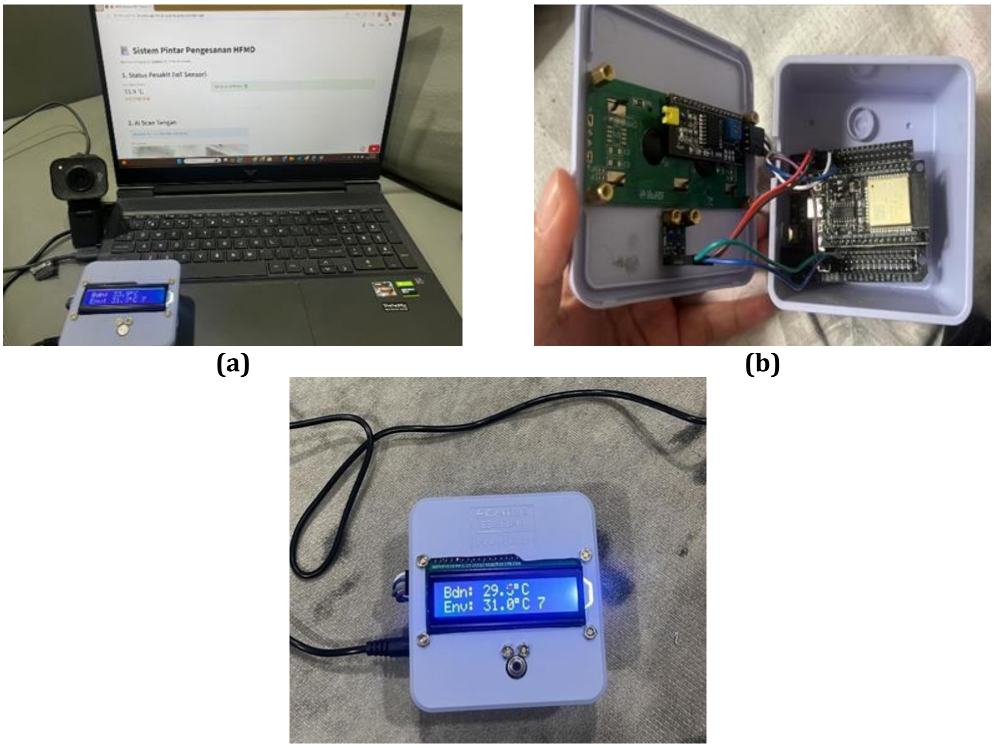
3. Result and Discussion

3.1 Prototype of The System

The developed system comprises an IoT health monitoring system that uses an ESP32 microcontroller, an MLX90614 infrared thermometer, and a high-definition camera module. As depicted in Fig. 3, the system design provides a non-contact system interface to the user. The infrared sensor measures body temperature when placed within a 2-5cm range on a user's hand, arm, or other body part, while a camera captures visual information for AI image analysis. The system status is displayed on both the local and the web interfaces.



(a) **(b)** **(c)**

Fig. 3 *(a) Overall System Assembly (b) Hardware Integration (c) User Feedback Interface*

3.2 AI Model Performance and Feature Extraction

The YOLOv8 model has been tested for its efficacy in detecting erythematous macules and vesicles. The precision, recall, and mAP@50 metrics indicate that the model achieved excellent diagnostic accuracy during the 200-epoch training process. As described in the technical analysis, the model detects the lesions by using gradients in terms of color and boundary contrast. Fig. 4 shows the results of the validation batch, confirming that the model has appropriate sensitivity to lighting.

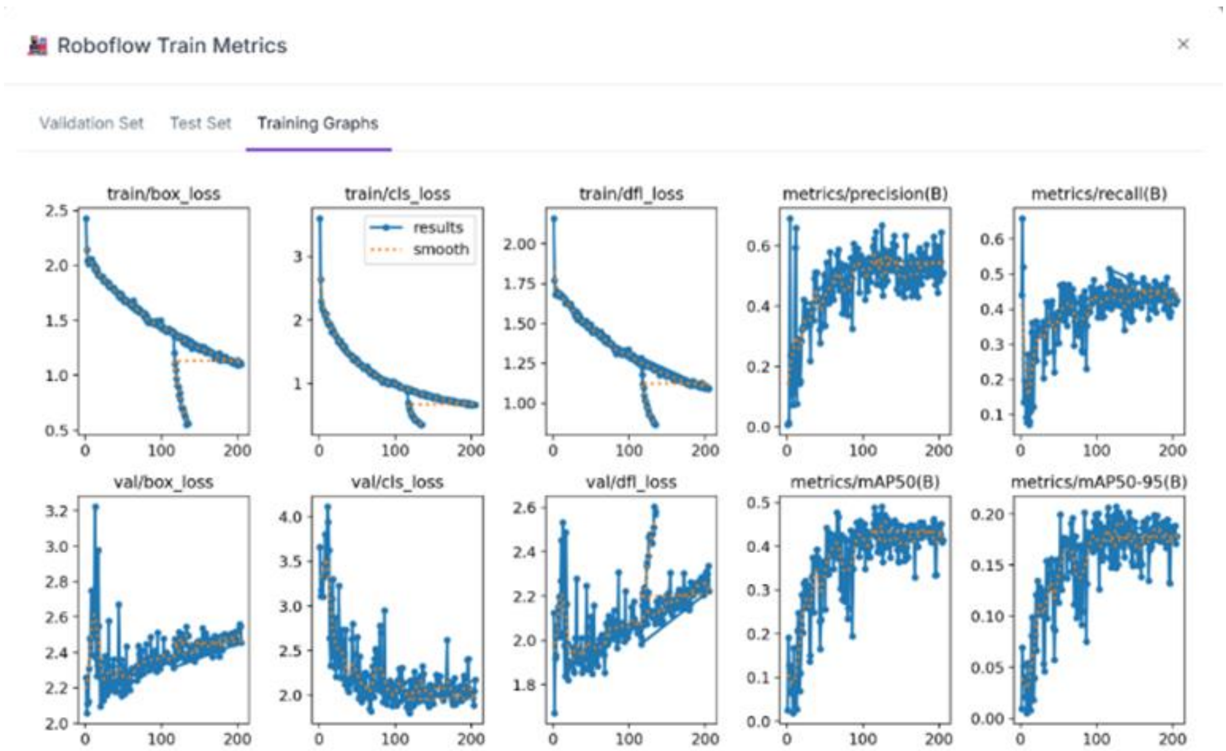


Fig. 4 *Display the confusion matrix, confirming the model's high accuracy in distinguishing HFMD lesions from background noise*

3.3 Thermal Sensor Calibration and Accuracy Testing

The accuracy of the MLX90614 infrared sensor was verified by comparing its readings to a medical-grade digital thermometer across a range of temperatures. As reflected in Table 2, five trials were conducted for each at a fixed distance of 2 cm. The results showed high precision, with the MLX90614 sensor returning a MAE of just 0.26. This is well within the acceptable limit for initial health screening, validating the feasibility of this system for detecting feverish conditions at 37.5∘.

Table 2 *Comparison of measurements between the digital thermometer and MLX90614*

Trial	Digital Thermometer (∘C)	MLX90614 Reading (∘C)	Variance (∘C)
1	36.5	36.3	0.2
2	36.7	36.4	0.3
3	37.2	37.0	0.2
4	37.8	37.4	0.4
5	38.0	37.8	0.2
Average	**37.24**	**37.00**	**0.24**

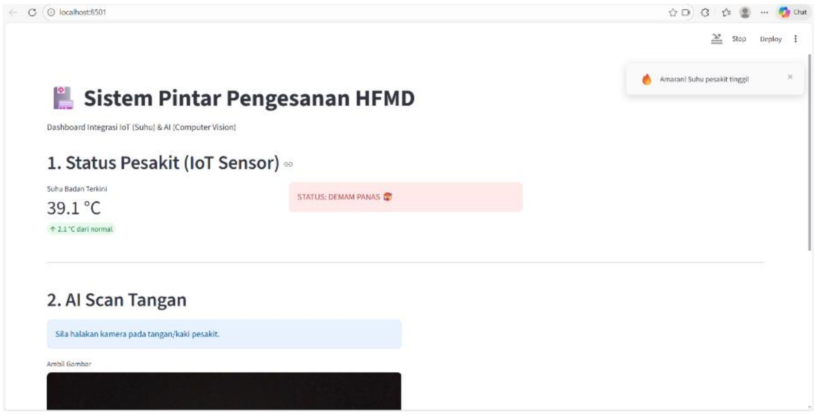
3.4 AI Detection and False Positive Analysis

The effectiveness of the proposed YOLOv8 model was tested with various skin artifacts to assess the discriminative ability of this technique. As shown in Fig. 5, the solution correctly identified the erythematous macule on the patient's hand with high confidence. During the primary experiment, some issues, like "Feature Extraction Overlap," were recognised, where the colour of certain cosmetic products, such as lipstick, was incorrectly flagged due to the colour gradient and contrast of the edges; this situation necessitated the development of the component that integrates an image of the background.

Fig. 5 *System alert "POSITIF HFMD DIKESAN" with quantitative lesion count (1 bintik) and medical recommendation*

3.5 IoT Synchronisation and Streamlit Interface

The correctness of the overall end-to-end functionality has been verified by checking the flow of the results from the hardware to the cloud. Fig. 6 illustrates the updated results on the Streamlit dashboard in real-time upon a positive detection. "POSITIVE HFMD DIKESAN" has been correctly triggered with the accurate synchronisation of lesion counts and temperature results within the Firebase database within 2 seconds following a scan. Such a rapid response is necessary for a high-throughput entry point in a school setting.



(a)

(b)

Fig. 6 *(a) Sensor detects the body temperature (b) result shows POSITIVE HFMD*

Penerbit UTHM

4. Conclusion

In this project, a non-contact screening method for early detection of HFMD symptoms has been successfully developed. As can be seen, the method has successfully combined the power of YOLOv8 computer vision with the reproducibility of MLX90614's infrared sensors. Moreover, the use of Firebase and Streamlit has streamlined the digitisation of health information. Although the challenge that arose with the method related to the issue of false detection triggered by external factors, there are many steps that can be taken with the proposed method. The method presented can create a proactive first line of defense against the spread of HFMD.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors attest to having sole responsibility for the following: planning and designing the study, data collection, analysis and interpretation of the outcomes, and writing the paper.

Reference

[1] Ministry of Health Malaysia, "Kenyataan Media YBMK - Situasi Terkini Hand, Foot, Mouth Disease (HFMD) di Malaysia," May 26, 2022. [Online]. Available: https://www.moh.gov.my

[2] BERNAMA, "5,335 kes HFMD dilaporkan di Pulau Pinang," Astro Awani, Sep. 14, 2023. [Online]. Available: https://www.astroawani.com/berita- malaysia/5335-kes-hfmd-dilaporkan-di-pulau-pinang-437389

[3] Ministry of Health Malaysia, "Kenyataan Media YBMK Penyakit Tangan, Kaki dan Mulut / Hand, Foot and Mouth Disease (HFMD)," Aug. 27, 2018. [Online]. Available: https://jknjohor.moh.gov.my/hsi/

[4] "Selangor tops HFMD cases as Malaysia sees 266% rise," The Star, May 13, 2025. [Online]. Available: https://www.thestar.com.my

[5] G. Liu et al., "Developing a Machine Learning System for Identification of Severe Hand, Foot, and Mouth Disease from Electronic Medical Record Data," Sci. Rep., vol. 7, no. 1, p. 16341, 2017. doi: 10.1038/s41598-017-16521-z.