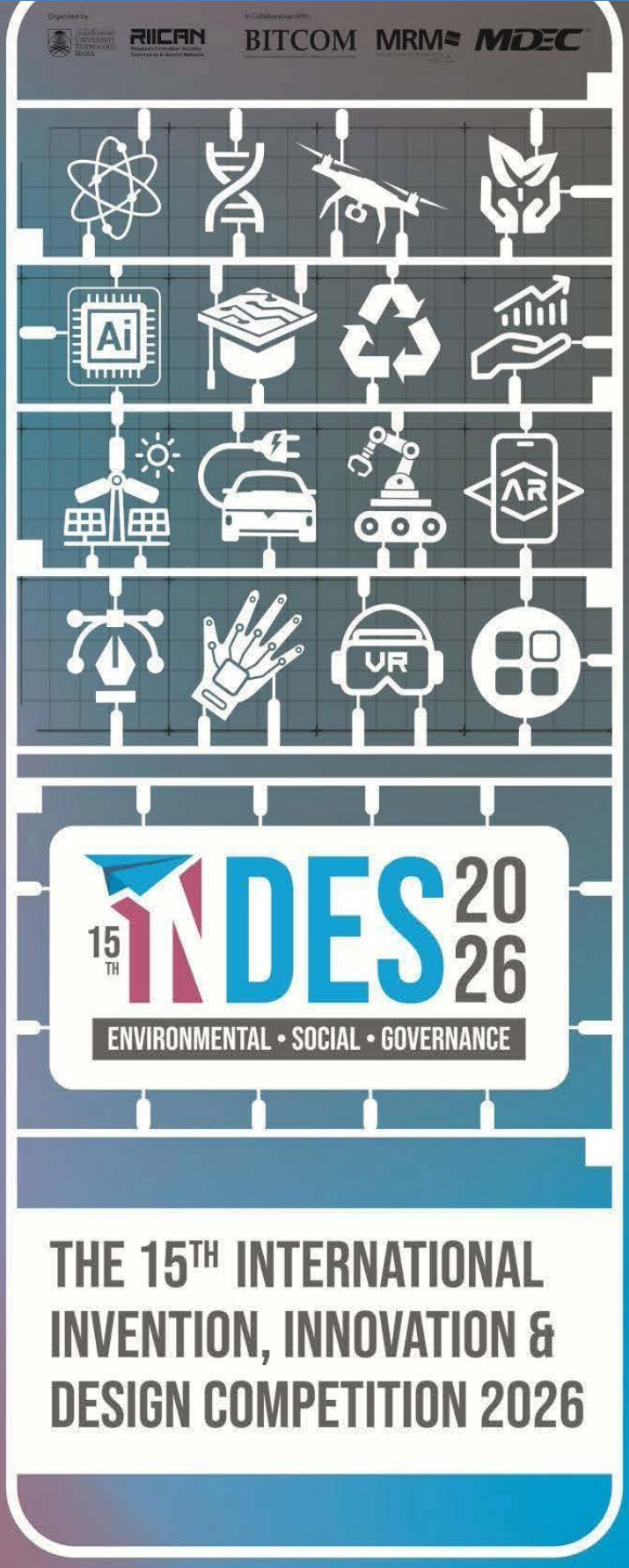

E-BOOK OF

EXTENDED ABSTRACT

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THE 15th INTERNATIONAL
INVENTION, INNOVATION &
DESIGN COMPETITION 2026

Organized by:
Office of Research, Industry,
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UiTM Perak Branch

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EMPOWERING COMMUNICATION BETWEEN THE DEAF COMMUNITY AND NON-SIGNERS THROUGH WEB-BASED MALAYSIA SIGN LANGUAGE REAL-TIME RECOGNITION SYSTEM

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ABSTRACT

This study proposed a web-based real-time recognition system for Malaysia Sign Language (MSL) that integrated gesture recognition models into a browser-based platform. The system recognised words, numbers, and alphabets using a hybrid Residual CNN-LSTM with an attention mechanism and webcam-based landmark keypoint extraction, eliminating the need for specialised hardware, such as sensor gloves. It provided real-time feedback and supported sentence formation. By embedding the trained models into a web interface, the system empowered non-signers to practise and learn MSL interactively, bridging communication gaps and enhancing inclusivity for the Deaf community.

Keyword: Malaysia Sign Language (MSL), web-based real-time recognition, TensorFlow.js integration, browser-based deployment, multilingual live translation, Deaf community empowerment

1. INTRODUCTION

Malaysia Sign Language (MSL) plays a significant role in bridging communication between the Deaf community and non-signers. Despite increasing awareness, sign language is not widely taught. Besides that, the current MSL learning platform relies only on static, non-interactive materials such as images, videos, and repetitive games, and lacks real-time interactive features, which limits learners' ability to communicate effectively in sign language (Muniandy & Zaharudin, 2024). While AI-based recognition has advanced gesture interpretation, real-time web deployment for inclusive communication remains underdeveloped. This study addressed these limitations by introducing a web-based real-time MSL recognition platform that integrated trained gesture models into a browser interface with webcam input for accessible, low-cost deployment. The system provided instant feedback by interpreting gestures into text and, unlike one-time recognition tools, retained individual signs to build coherent sentences and spelling. By emphasising usability and inclusivity, the platform empowered non-signers to practise interactively and strengthened communication between the Deaf and non-signer communities. This study contributed a real-time browser-based MSL recognition system, a dual-language translation feature, and a low-cost, accessible learning platform.

2. METHODOLOGY

2.1 Model Training

The browser-based platform integrated three models, which were the alphabet model, the number model, and the word model. Each model was trained using a hybrid Residual CNN-LSTM model. Table 1 shows the dataset sizes for each model employed in training and testing. The training methodology involved data reshaping to isolate the spatial channels (x,y,z) for normalisation computation. Next, the training was conducted over 100 epochs with batch size of 16 using the Adam optimiser with a learning rate 0.0001. Early stopping with a patience of 10 and a reduce-on-plateau strategy helped to refine the

performance and prevent overfitting. The evaluation results showed that the alphabet and number models achieved 100% accuracy, while the word model achieved 99.5%.

Table 1 Dataset Distribution.

Dataset	No. of Classes	Total Sequence	Training Set (85%)	Testing Set (15%)
Alphabet	26	9,480	8,058	1,422
Number	10	3,750	3,187	563
Word	12	4000	3,400	600

2.2 Model Conversion for Web Compatibility

During the model integration process, the trained gesture recognition models were converted from Keras (.h5 format) into TensorFlow.js for web compatibility and to align with web browser standards. This conversion ensured lightweight deployment in a client-side environment because, during the conversion process, the model was split into smaller binary files, allowing the browser to cache the model more efficiently and load it over standard HTTP/HTTPS protocols without crashing the browser's memory (Thakur et al., 2023).

2.3 User Interface Design

The system's front-end was developed using ASP.NET Core, focusing on a "Practice Mode" that transformed sign recognition into an interactive learning experience. The UI was designed with four primary functional components. First, the interactive practice workspace provided a dual-layer video feed that captured real-time input while overlaying MediaPipe (MP) Holistic landmarks using HTML5. This provided users with visual confirmation of whether their gesture was recognised accurately or not. Second, the key functional innovation was the dual-language live translation feature, which provided simultaneous text output in both English and Bahasa Melayu. By interpreting signs into two languages, the system promoted broader inclusivity and local relevance within the Malaysian context. Third, the real-time feedback overlay monitored and displayed the recognised sign with the model's confidence score, which was streamed directly over the display. Lastly, to encourage consistent usage, the UI included a data-driven dashboard that monitored student engagement. It specifically tracked practice hours, showing the total time users had spent practising MSL and their daily streaks.

2.4 Client-Side Integration and Real-Time Pipeline

JavaScript managed the client-side pipeline and was responsible for the intelligence of the web system. This phase involved specific performance tuning to handle real-world browser constraints, including thresholding and stability, to ensure the model output was calibrated with a confidence threshold filter. This prevented flickering results during hand transitions, ensuring only clear and stable signs were recognised and translated into text. Next, temporal buffering for sentence generation was implemented as a text-retention buffer. Instead of recognising a sign and disappearing, the system retained successfully recognised signs in sequence, allowing non-signers practise sentence formation and spelling, as seen in the live translation box in Figure 2. Unlike static recognition systems, the platform retained individual signs to support sentence formation and spelling, thereby enhancing usability and empowering self-learning. Finally, for the low-latency pipeline, the system used asynchronous processing by separating camera input from the inference engine to maintain a high frame rate (FPS), ensuring that live translation felt natural and responsive to users, movements, as shown in Figure 1.

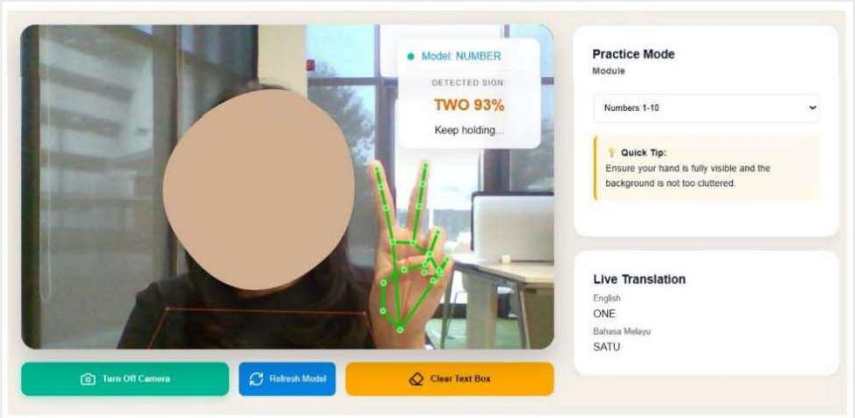

Figure 1 Sign Recognition Process.

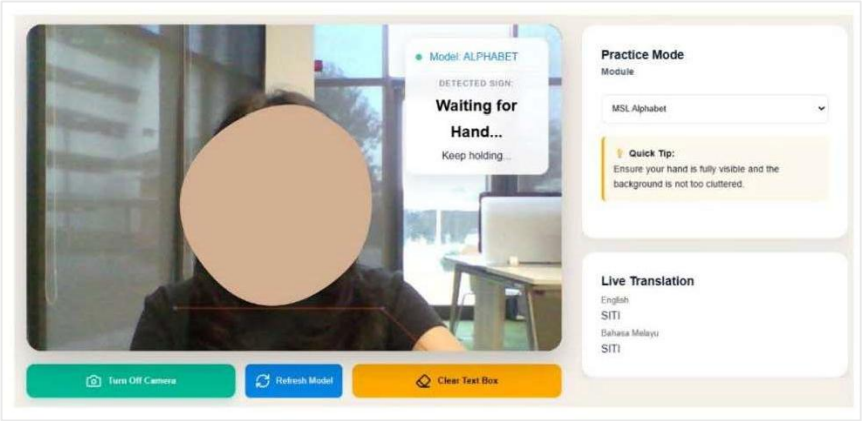

Figure 2 Sentence Formation.

3. FINDINGS

The web-based deployment successfully validated all gesture labels across the Alphabet, Number, and Word datasets during real-time interaction, as summarised in Table 2. The system achieved an average recognition accuracy of 90.6% across all datasets, with response latency below 118ms (8.5 FPS). Number recognition showed the highest accuracy (100%), followed by Alphabet (88.46%) and Word datasets (83.33%). The system maintained stable real-time performance, demonstrating robustness despite environmental variability. This validation further demonstrated the feasibility of low-cost, accessible deployment using standard webcams, enabling non-signers to practise interactively and supporting sentence formation. Overall, the findings highlighted the system's potential to bridge communication gaps and empower inclusive learning for the Deaf community.

Table 2 Summary of Successfully Validated Gesture Labels.

Dataset	Labels (Actions)	**Recognition accuracy (%)

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UNIT PENERBITAN UITM PERAK

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Alphabet	A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, Z	**88.46**
Number	ONE, TWO, THREE, FOUR, FIVE, SIX, SEVEN, EIGHT, NINE, TEN	**100**
Word	DAD, DRINK, EAT, GOOD, HELLO, HELP, I, MOM, NAME, SORRY, THANKS, YOU	**83.33**

***Recognition accuracy values were based on real-time user input trials.*

4. CONCLUSIONS

This study developed a web-based recognition system for MSL, with all gesture labels achieving an average accuracy of 90.6%. However, lighting conditions, hand occlusion, and camera quality may affect the performance across all gesture labels in the Alphabet, Number, and Word datasets during real-time validation. In future work, the model could be trained on a larger and more diverse dataset to improve generalisation by focusing on user variability, thereby improving accuracy and inclusivity for wider acceptance among non-signers practising MSL.

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