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Hand Gesture driven Smart Home Automation Leveraging Internet of Things

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Session 7 – Enabling technologies

Paper S7.3

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Outline

- Motivation
- Background and Related Technologies
- Overview of the Proposed System
- System Architecture
- Algorithm
- Implementation Overview
- Experimental Results
- Conclusion

Motivation

Smart Homes Environment

- Gestural control **offers hands-free, intuitive interaction** with home appliances
- **IoT** facilitates seamless device communication in a **cohesive ecosystem**

Gesture Recognition as an Ideal Interface

- Natural, intuitive method for controlling devices **without physical touch** or **voice commands**
- Particularly useful in **noisy environments** where voice commands might fail

Need for a Sophisticated Approach

- Exploration of **3D tensor representations** and deep learning models
- Need for a better **attention mechanism** and **transfer learning** to enhance accuracy and reduce latency

Background & Related Technologies

ITU-T Recommendations

- J.1612 defines functional requirements for a smart home gateway
- J.1611 deals with the architecture for a smart home gateway

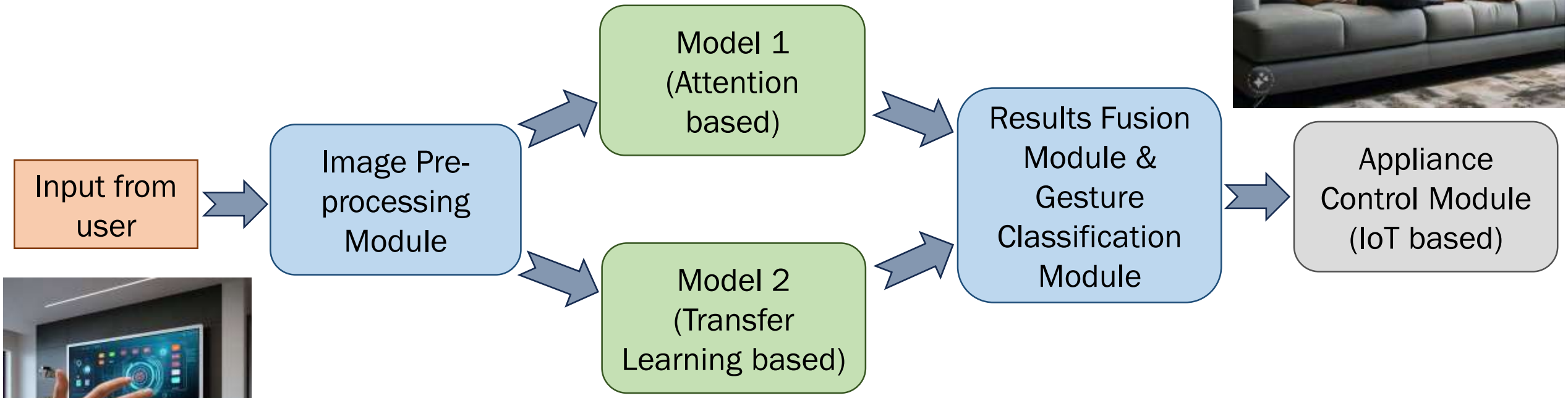
Deep Learning in Gesture Recognition

- Extended Convolutional Neural Networks to extract **spatial features** from gestures
- Attention-based models for **improved focus** on relevant features

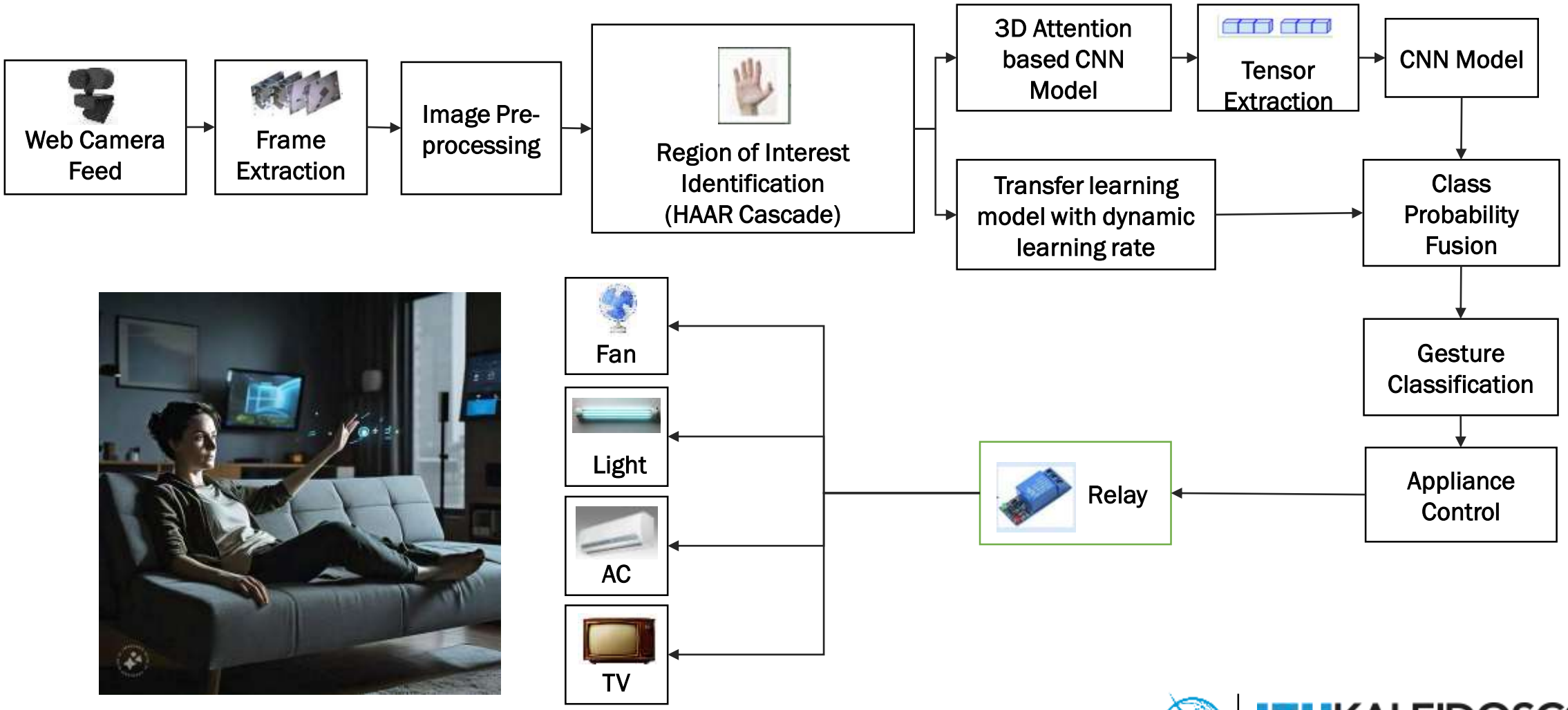
IoT in Smart Home Automation

- IoT bridges the gap between gesture recognition and device control
- Use of **Raspberry Pi** for integrating the recognition model with home appliances

Overview of the Proposed System



System Architecture



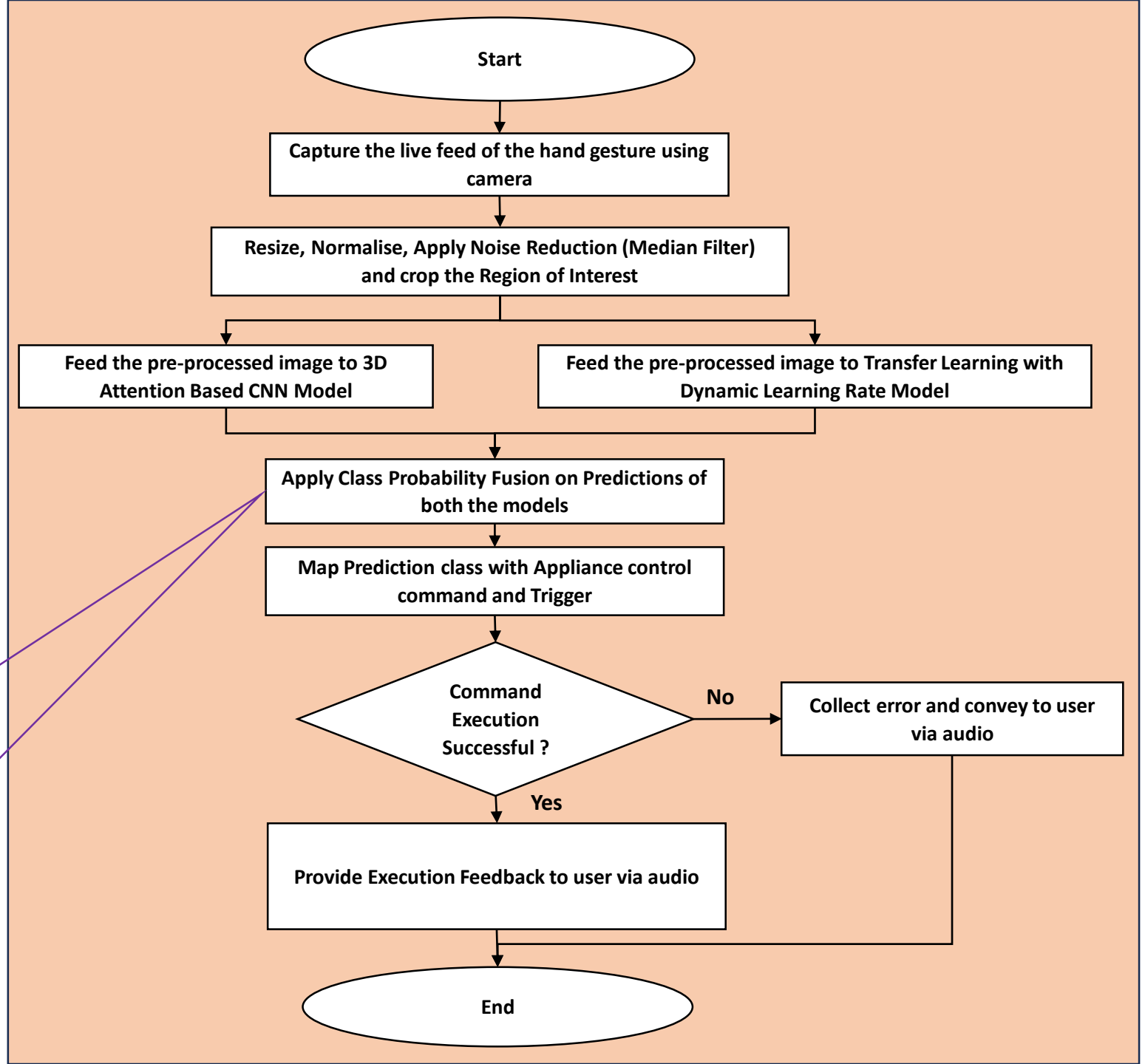
Algorithm

Input : Live Camera Feed

Output : Application Control Execution

$$\textbf{Final gesture} = \textbf{ArgMax}\left(\textbf{max}\left(\mathbf{P}(\boldsymbol{i}), \mathbf{P}(\boldsymbol{j})\right)\right)$$

P(i) - probability of class *i* predicted by Attention based CNN Model (Model 1)
P(j) - probability of class *j* predicted by CNN Model with Dynamic learning (Model 2)
[*i*, *j* = 1,2,3,4,5,…*n* where *n* is the number of classes]



Implementation Overview

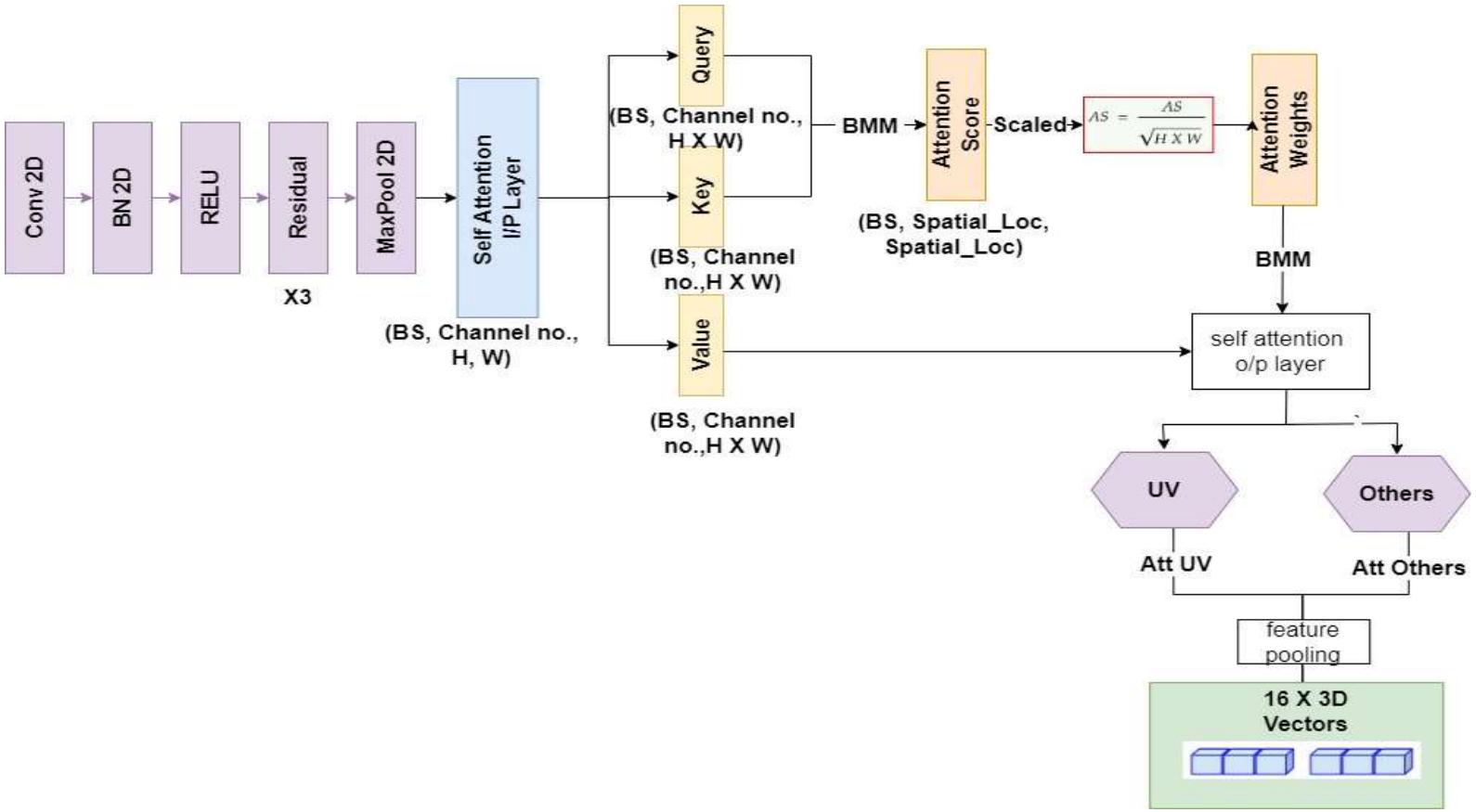


Fig. Attention based CNN Model

Software Packages and Libraries

- ✓ OpenCV 4.8
- ✓ Tenserflow 2.16
- ✓ Python v3.11

Computing Hardware and OS

- ✓ Raspberry Pi 4 with 4GB RAM
- ✓ Raspbian OS v2.9

Fig. Experimental Setup

Experimental Results

Table 1 - Comparison with existing

Sl. No	Model Name	Training Accuracy	Testing Accuracy
1	Standard CNN model	82.36%	66.18%
2	Baseline CNN Model for Gesture Classification	98.6%	72.62%
3	Gesture Classification using Tensor extraction (Attention based model-proposed)	99.53%	83.2%
4	Transfer Learning Model with dynamic learning rate (proposed)	99.16%	98.24%

The proposed model achieves an overall training and testing accuracy in access of 99% and 98% respectively with an average latency of 0.195 seconds.

Experimental Results cont.

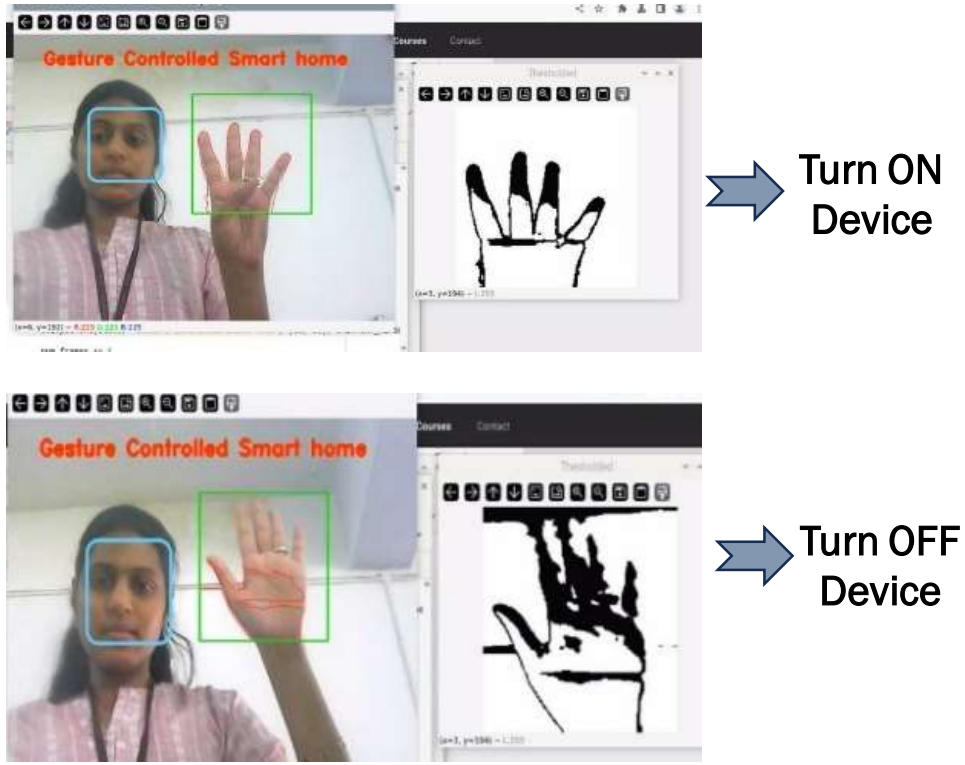


Fig. Snapshots during testing

Class Label	Gesture	Appliance Control
4		Light ON
5		Light OFF

Fig. Gesture identification

Conclusion

- The proposed system achieves gesture-driven smart home automation, integrating IoT and advanced ML techniques
- Utilizes Deep Learning, Transfer Learning, and Attention Mechanisms for real-time, high-accuracy gesture recognition
- Modular architecture supports continuous **camera feed, gesture modules, and IoT device control,** ensuring efficiency and adaptability in real-world scenarios
- Testing accuracy in access of 98% with an average latency of 0.195 seconds.
- Enhances Human-Computer Interaction in smart homes

Thank you!