Hand Gestures Recognition
Using 3D LiDAR Sensor

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CONTENT

Introduction

Objective:

- Explore and evaluate diverse technologies for enhancing user interaction via gesture recognition.

Approaches and Tools:

- Implement GestureEVK and advanced CNN models with GUI integration for real-time application.

Goals:

- Evaluate the effectiveness and accuracy of each approach.
- Identify the best methods for robust and accurate gesture recognition.

Three Approaches of Gestures Recognition

First Approach

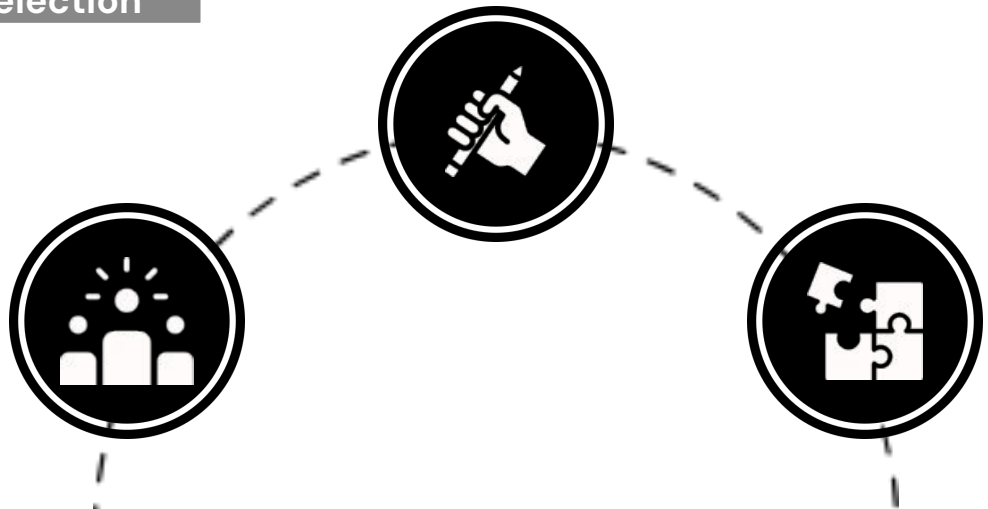
Gesture Kit & Hand Posture AI Model with User Selection

Second Approach

3D Convolutional Neural Network AI Model

Third Approach

STMicroelectronic Merged Solution



First Approach

Gesture Kit & AI Model with User Selection

First Approach

- Gesture Kit and Hand Posture AI Model with User Selection

Dynamic Gestures:

Palm Up	Palm Left	Tap
Palm Down	Palm Right	Double

Static Gestures:

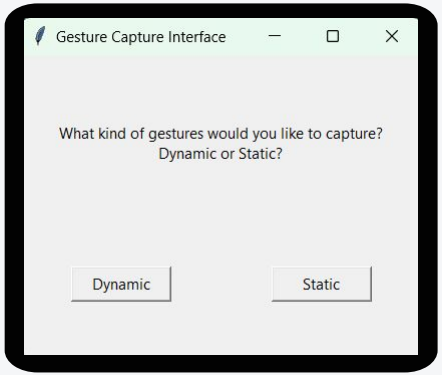
Palm	Thumbs Up	Heart
Stop	Thumbs Down	Cross
Fist		

First Approach – Basic Concept

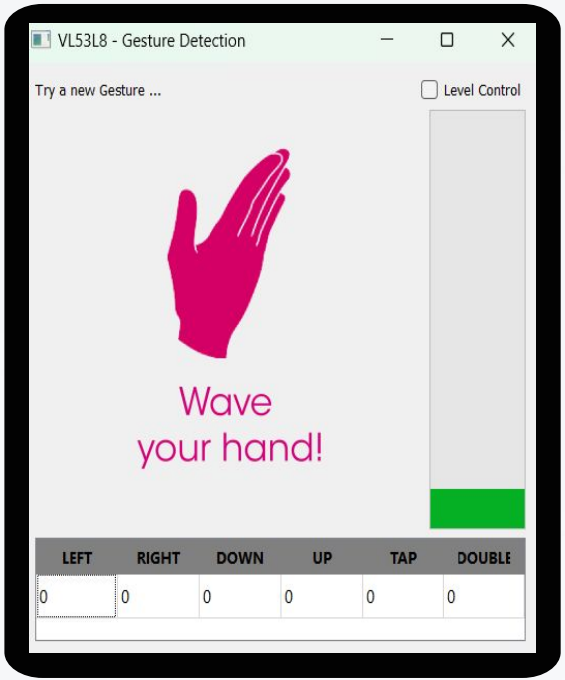
- Use software **GestureKit** to recognize dynamic gestures and **HandPosture AI** Model to recognize static gestues

- Combined two softwares using User Selection **Buttons – Dynamic and Static**, to switch between two softwares.

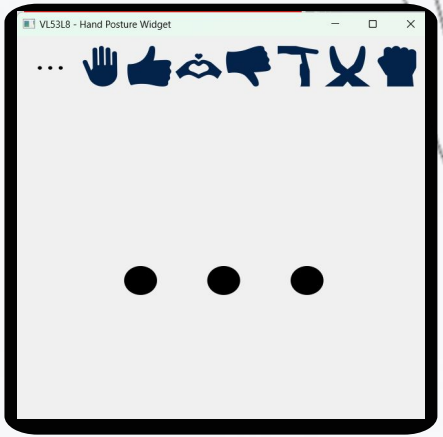
First Approach – Process



User Selection



Dynamic Gestures Detection



Hand Posture Widget

First Approach – Specification

Distance: The test subject is positioned at arm's length from the sensor. Hand gestures are performed 15 cm away from the sensor.

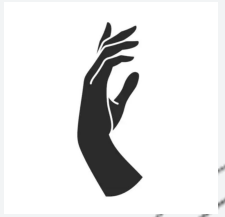
Duration: Each gesture demonstration lasts approximately 2 seconds.

Interval: There is a 3-second interval between demonstrations.

TEST ACCURACY

Dynamic Gestures ★★★★

Dynamic	
palm up	88.00%
palm down	99.00%
palm left	97.00%
palm right	96.00%
tap	95.00%
palm backward	92.00%



Static Gestures ★★★★★

Static	
thumb up	98.00%
tumb down	95.00%
heart	93.00%
stop	95.00%
cross	99.00%
fist	92.00%

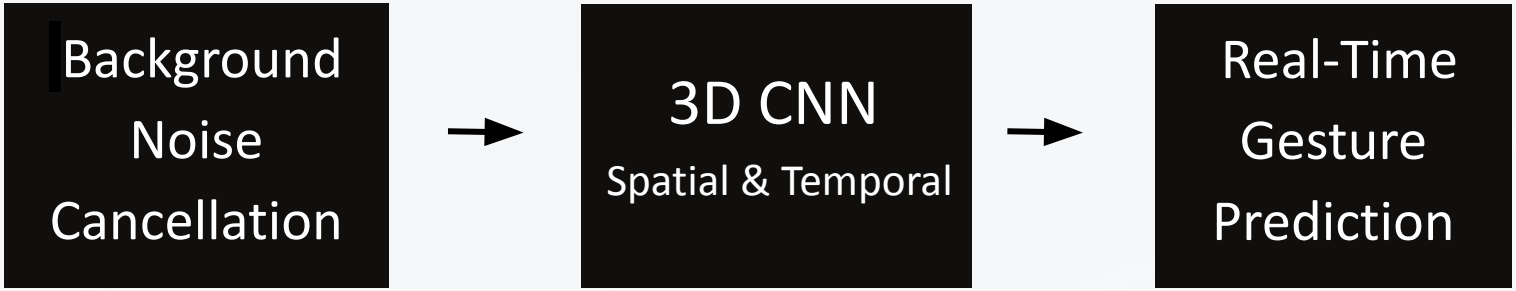
Demo

Gesture Kit & AI Model with User Selection

Second Approach

3D Convolutional Neural Network AI Model

3D CNN AI Model - Basic Logic and Process



3D CNN AI Model - Gesture Categories

Dynamic Gestures:

Palm Up **Palm Left** **Palm Forward**

Palm Down **Palm Right** **Palm Backward**

Static Gestures:

Thumbs Up **Thumbs Down**

Guidelines For Performing Gestures

Gesture	Distance (cm)	Specifications
Palm Up	10~30	Move upward steadily. Centered entry and exit.
Palm Down	10~30	Move downward steadily. Centered entry and exit.
Palm Left	10~30	Move left steadily, no vertical movement.
Palm Right	10~30	Move right steadily, no vertical movement.
Palm Forward	10~30	Push forward steadily, no swaying.
Palm Backward	10~30	Pull backward steadily, no swaying.
Thumbs Up	25~35	Stationary, thumb up. Tilt hand slightly to sensor for clear heatmap. Left hand preferred.
Thumbs Down	25~35	Stationary, thumb down.

TEST ACCURACY

Dynamic Gestures ★★★★★

Gestures	Accuracy
palm right	94.00%
palm left	93.00%
palm up	96.00%
palm down	95.00%
palm forward	98.00%
palm down	98.00%

Static Gestures ★★★★

Gestures	Accuracy
thumb up	91.00%
thumb down	83.00%

Demo

3D Convolutional Neural Network AI Model

Third Approach

STMicroelectronic Merged Solution

STMicroelectronic Merged Solution

Limitation of First approach = Motivation for third approach

In reality we would want both the static and dynamic gestures to be recognized without any user intervention or user having to select which gesture they would want to perform. Having this in mind we have implemented a merged solution **using the state of the art** solution.

Gesture

Prediction

STMicroelectronics Merged Solution

Logic

Sensors feeds data to Static and Dynamic models

If dynamic gesture == True{ parse }
Else{ Parse static }

STATIC 0 == No Gesture / Idle
If STATIC != 0 then parse

- Static Gestures are like images. Every frame in a video/feed will have a static gesture predicted.
- Dynamic Gesture is predicted only when the model detects change in motion
- So for this solution is a simplified solution using both static and dynamic models.

STMicroelectronic Merged Solution

STMicrocontroller Merged Solution

Dynamic Gestures:

Left	Forward	Double Tap
Down	Right	Backward

Static Gestures:

Flat Hand	Thumbs Up	Heart
BreakTime	Thumbs Down	Cross Hands
Fist		

Demo

STMicroelectronics Merged Solution

Comparison of Test Accuracy

Approach	Dynamic Gestures Accuracy (Avg)	Static Gestures Accuracy (Avg)	Key Strengths	Limitations
User Selection	~70%	~85%	Easy integration with GUI	Manual calibration needed
3D CNN AI Model	~95%	~87%	Advanced motion tracking high accuracy	Further improvements
STMicroelectronics Merged Solution	~80%	~90%	Advanced motion tracking	Higher computational complexity

Fourth Approach

Prompt Based Gesture Recognition (using GPT API)

Prompt Based Gesture Recognition

This project implements a gesture recognition system that uses real-time data from sensors to identify hand gestures. It combines:

- Sensor Data Collection
- Data Preprocessing and Analysis using pattern recognition methods
- Gesture Prediction with Prompt based solution
- Tkinter-Based GUI for Visualization

Prompt Based Gesture Recognition

Key Components

1. Data Parsing and Frame Handling
    a. Collects and parses raw sensor data into 8x8 frames.
2. Preprocessing
    a. Extract meaningful features from collected frames
        i. Mean, Std deviation, max, min distances
        ii. Center of gravity
3. Real-Time Data Collection and Processing
    a. Connects to serial port to collect and preprocess frames in real-time
4. Gesture Detection with Trends
    a. Analyzes trends in CoG values for gesture prediction
    b. Recognizes motion based on slopes
    c. Identifies static and proximity-based gestures
5. GPT Integration

Prompt Based Gesture Recognition

Highlights

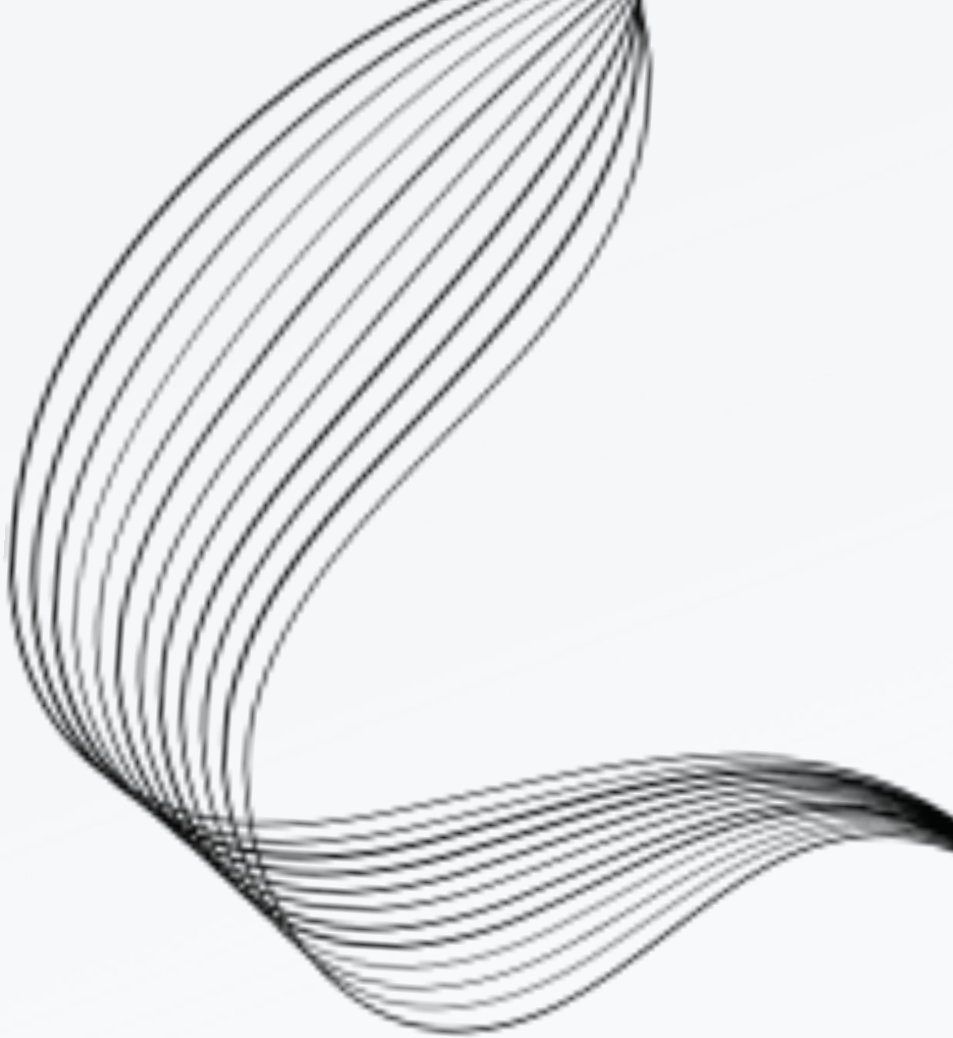
1. Real-Time Gesture Analysis: Efficient frame collection and preprocessing pipeline
2. Trends and AI Refinement: Combines statistical analysis with GPT for high accuracy

Real-Time Gesture Prediction

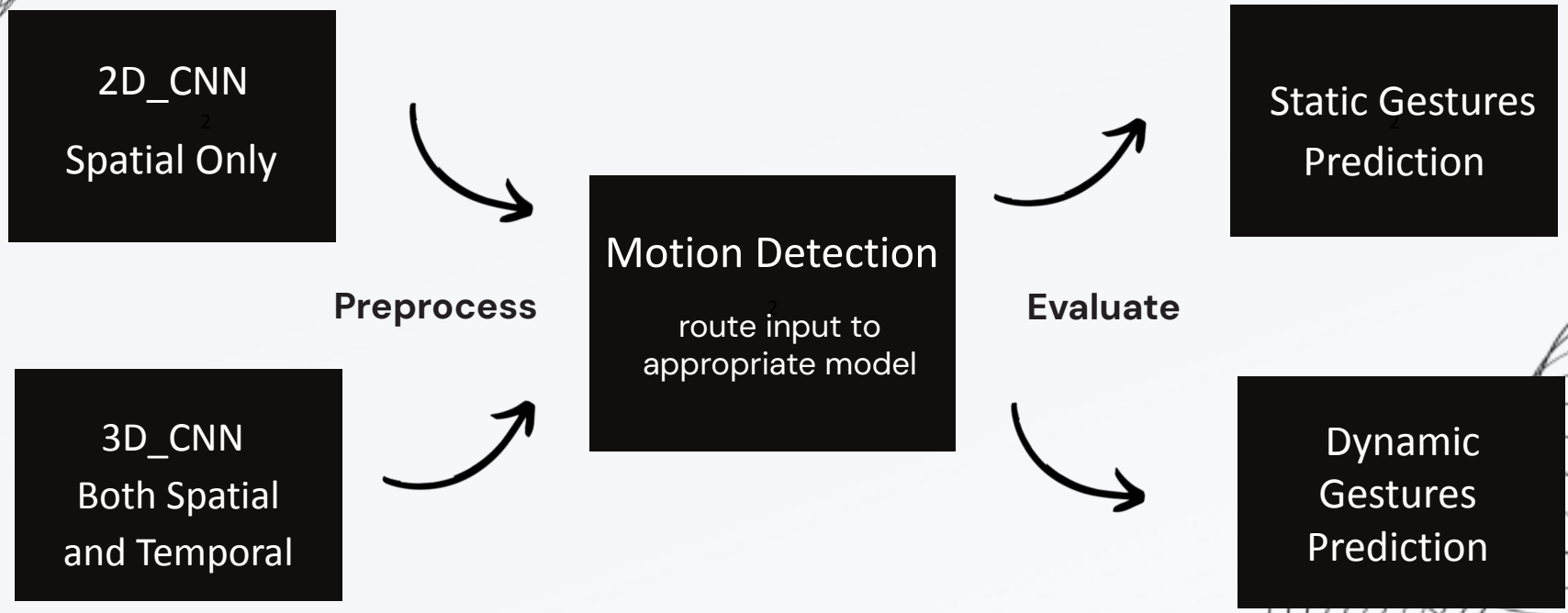
Example Gestures

1. Upward motion: Detected when CoG moves significantly upward
2. Palm Forward: Identified based on proximity to the sensor.
3. Static Gesture: Small fluctuations with clear trends

THANKS



2D&3D CNN AI Models - Basic Logic and Process



TEST ACCURACY

Dynamic Gestures ★★★

Gestures	Accuracy
palm right	91.00%
palm left	83.00%
palm up	100.00%
palm down	91.00%
palm forward	71.00%
palm down	88.00%

Static Gestures ★★★

Gestures	Accuracy
thumb up	0.91%
thumb down	0.77%

Presentation slides:

1. Project of Gesture Recognition

   By : name

2. 3 Approaches of Gesture Recognition:

   a. STMicroelectronics' STSW-IMG035_EVK and STM32CubeAI combined source code with GUI

   b. STMicroelectronics' STSW-IMG035_EVK and STM32CubeAI with Prompt

   c. 3D CNN & 2D CNN Model

3. Combined source code with GUI

4. Real-time test accuracy

5. STMicroelectronics' STSW-IMG035_EVK and STM32CubeAI with Prompt