GESTLINK

Architectural Design Diagram

Application	Gesture Classification Logic (A)	Local Feedback Mapping (B)	MQQT Data Staging (C)	System Monitoring (D)
Drivers	Sensor (E)	GPIO (F)	TCP/IP Stack (G)	OS Layer (H)
HAL	I2C / SPI (I)	GPIO (LEDs) (J)	TIM (K)	Ethernet MAC (L)
STM 32 (M)				

Interactions

M --> I

M --> J

M --> K

M --> L

I --> E

J --> F

E --> A

F --> B

K --> H

L --> G

G --> C

H --> A

H --> B

H --> C

H --> D

A --> B

A --> C

B --> J
C --> G
D --> G
D --> F
D --> E

Layer 2 : Hardware Abstraction Layer (HAL)

Component	Role	Upstream Interaction
I (I2C / SPI)	Handles low-level serial communication protocols necessary to transfer raw data between the STM32 and the PAJ7660 Sensor.	Feeds the Sensor Driver (E).
J (GPIO - LEDs)	Provides direct control over the physical pins used to drive the High-Luminosity LEDs.	Controls the GPIO Driver (F), which handles local feedback.
K (TIM)	Manages system timers, interrupts, and scheduling ticks.	Crucial for the reliable operation of the OS Layer (H).
L (Ethernet MAC)	Manages the physical link and data framing required for all network traffic (Wired Ethernet).	Feeds the TCP/IP Stack (G).

Layer 3 : Middleware / Drivers

Component	Role	Upstream/Downstream
E (Sensor Driver)	Manages the specific initialization, configuration, and data retrieval for the PAJ7660 sensor. It retrieves the pre-classified Gesture ID from the sensor.	Interfaces with HAL I2C/SPI (I) and supplies data to Classification Logic (A).
F (GPIO Driver)	Provides simple, logical functions (e.g., set_leds_by_count(N)) to control the LEDs. It maps the abstract request from the application to the physical pin toggles via the HAL.	Interfaces with HAL GPIO (J) and takes commands from Feedback Mapping (B) and System Monitoring (D).
G (TCP/IP Stack - LWIP)	The Lightweight Internet Protocol stack. It handles the necessary TCP and IP layers to enable reliable, routable communication over Ethernet.	Interfaces with HAL Ethernet MAC (L) and supports the MQTT Staging (C) block.
H (OS Layer - FreeRTOS)	The Real-Time Operating System that manages concurrency. It ensures tasks (A, B, C, D) run reliably with necessary priority,	Built on HAL TIM (K) and provides task scheduling services to all blocks in the Application Layer (A, B, C, D).

	crucial for the <=200 ms latency requirement.	

Layer 4 : Application Layer

Component	Role	Inputs / Outputs
A (Gesture Classification Logic)	The main control task. It retrieves the pre-classified Gesture ID from the Sensor Driver (E), validates it, and triggers the necessary outputs.	Input: Sensor Driver (E). Output: Feedback Mapping (B) and MQTT Staging (C).
B (Local Feedback Mapping)	Implements the low-latency visual confirmation. It receives the classified ID and calls the GPIO Driver (F) to display the corresponding LED pattern immediately.	Input: Classification Logic (A). Output: GPIO Driver (F) (via J).
C (MQTT Data Staging)	Handles the protocol translation and network communication. It formats the Gesture ID into a reliable QoS 1 MQTT payload and initiates transmission.	Input: Classification Logic (A). Output: TCP/IP Stack (G).

D (System Monitoring)	Manages high-level system checks, including network status, sensor health, and watchdog timer maintenance. It triggers fault indicators upon failure.	Monitors TCP/IP Stack (G) and Sensor Driver (E). If failure, triggers the alert via the GPIO Driver (F).