EMBEDDED SYSTEMS

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TRAFFIC ACCIDENT DETECTION AND IOT ALERT SYSTEM

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Start Now →

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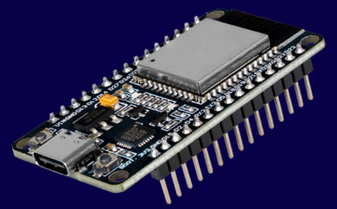
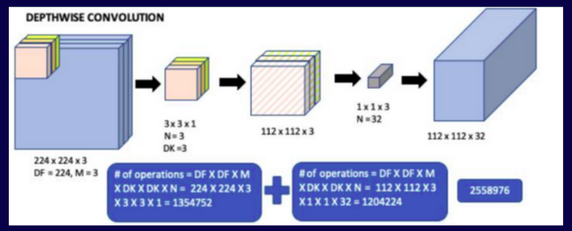
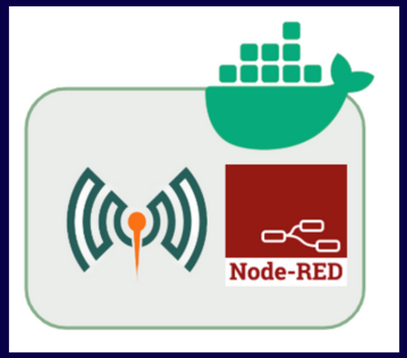
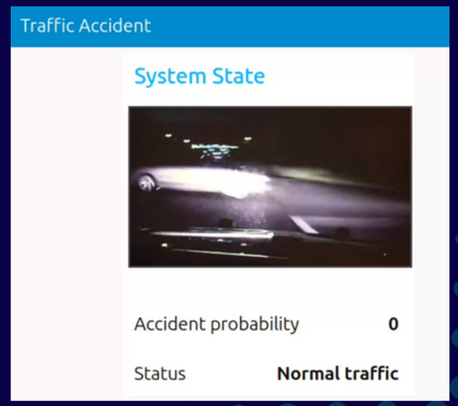
- Demo

SYSTEM ARCHITECTURE OVERVIEW









PHASE 1:

Pycharm & PlatformIO

IDENTIFYING TESTABLE UNITS

Inference side

- Image preprocessing
- Model inference wrapper
- Temporal debouncing logic
- LED state machine
- MQTT publishing behavior

Embedded side

- LED decision logic (pure function)
- MQTT command handling

Each component was designed to be testable before being integrated.

PHASE 1:

Pycharm

TDD INFERENCE: EXAMPLE

Separate inference from decision logic

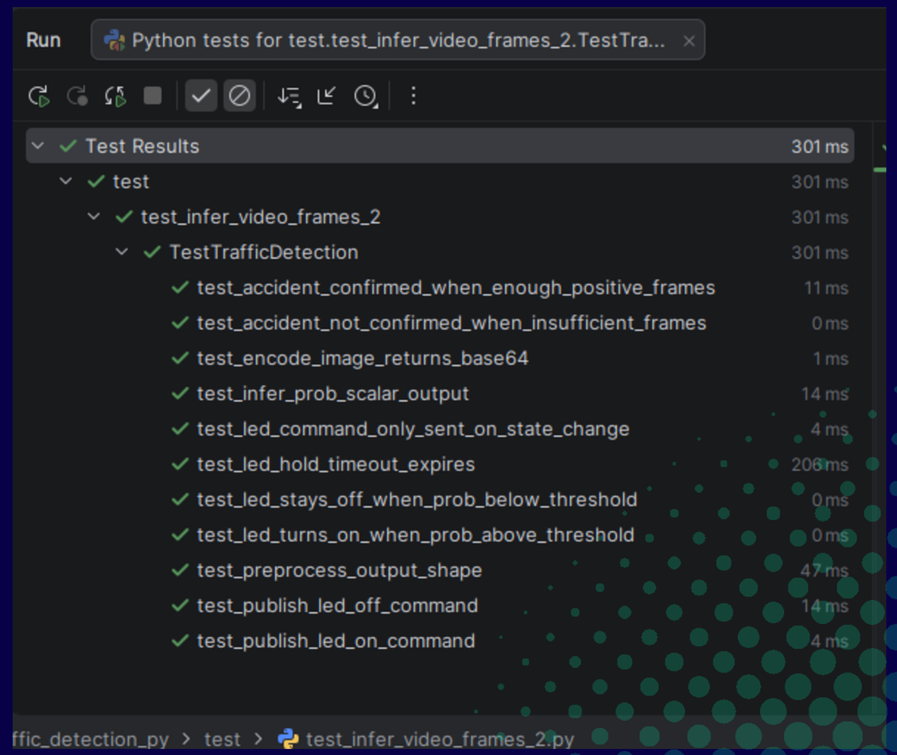
Red Phase

- preprocessing output shape
- probability bounds
- accident confirmation rules
- hold-time expiration

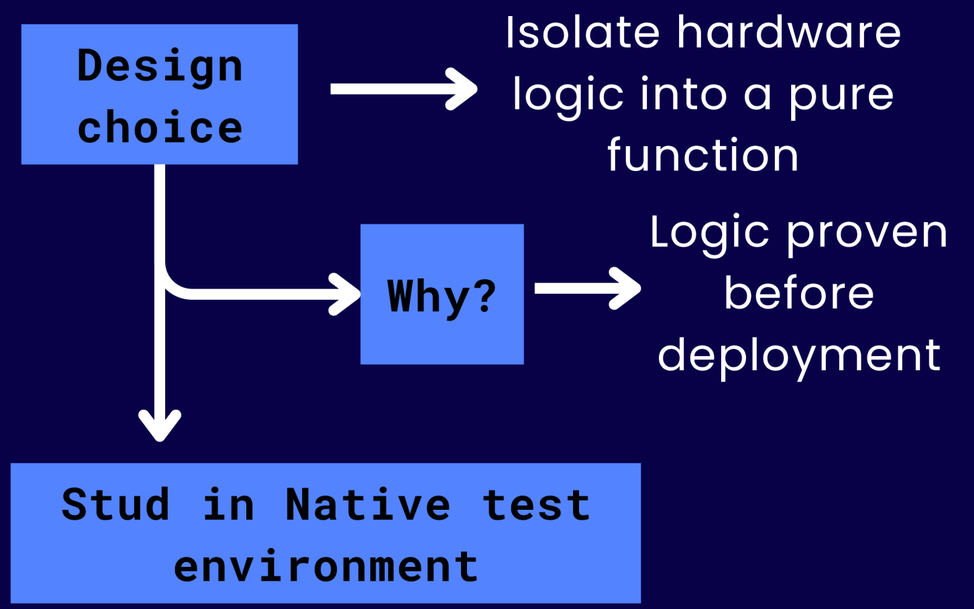
Green Phase

implement minimal logic to pass tests

Refactor Phase



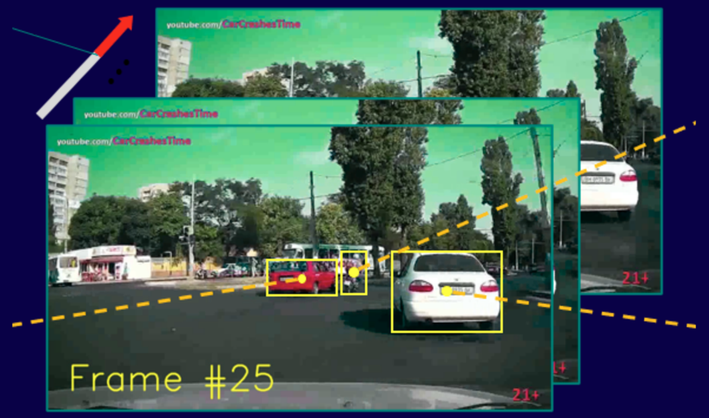
TDD IN EMBEDDED CODE: EXAMPLE

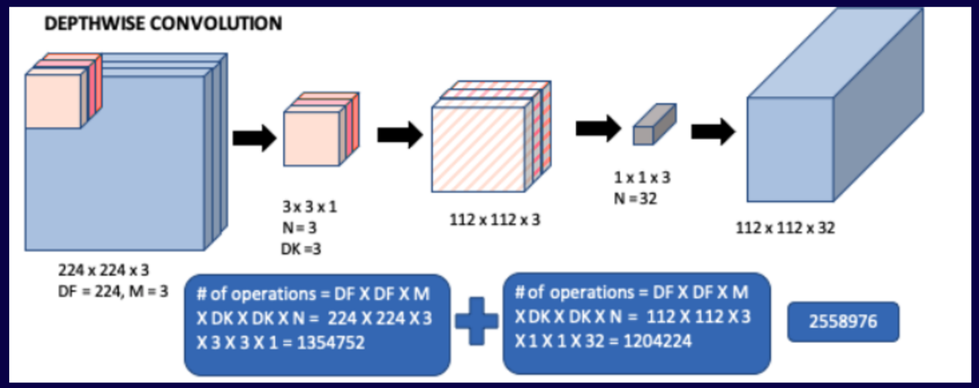



```
Testing...
test/test_led_logic.cpp:27:test_led_changes_when_requested_differs:PASS
test/test_led_logic.cpp:28:test_led_does_not_change_when_requested_is_same:PASS

-----------------------
2 Tests 0 Failures 0 Ignored
OK

----------------- native:* [PASSED] Took 1.31 seconds -----------------

================================ SUMMARY ================================
Environment    Test    Status    Duration
-------------  ------  --------  ------------
esp32dev       *       SKIPPED
native         *       PASSED    00:00:01.307
============== 2 test cases: 2 succeeded in 00:00:01.307 ==============
```

PHASE 2

Collab





TRAFFIC ACCIDENT RECOGNITION

- MobileNET (CNN)
- Car Crash Dataset (CCD)

PHASE 2

Collab

MOBILENET V2

Depthwise Separable Convolutions

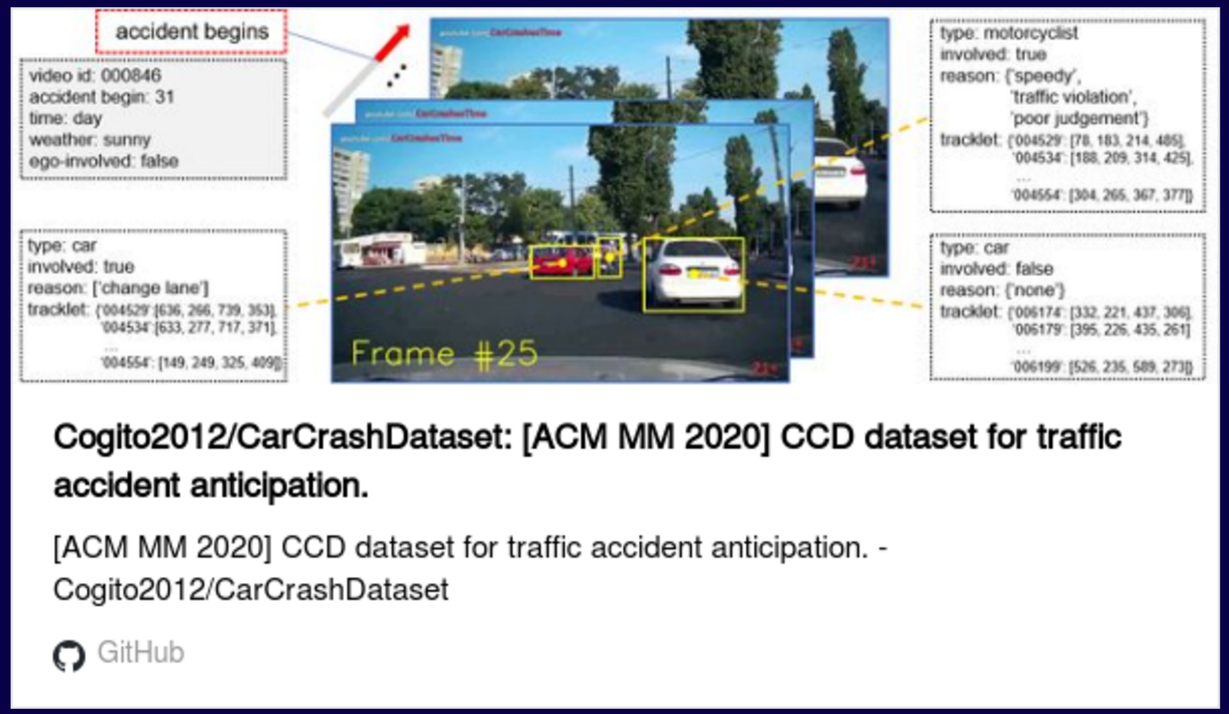
- Depthwise convolution (per-channel spatial conv).
- Pointwise convolution (1x1 conv to mix channels)

Inverted Residual Blocks

First expands (1x1 conv), applies depthwise convolution (3x3), and then projects back to a lower dimension (1x1 conv).

Bottleneck Structure

After the final 1x1 convolution the model doesn't apply activation function, to keep the projection layer linear.



DATASET

CAR CRASH (CCD)

Composition

- 1,500 accident (positive)
- 3,000 normal (negative)
- Videos are 50 frames each

Frame-level binary classification

PHASE 3

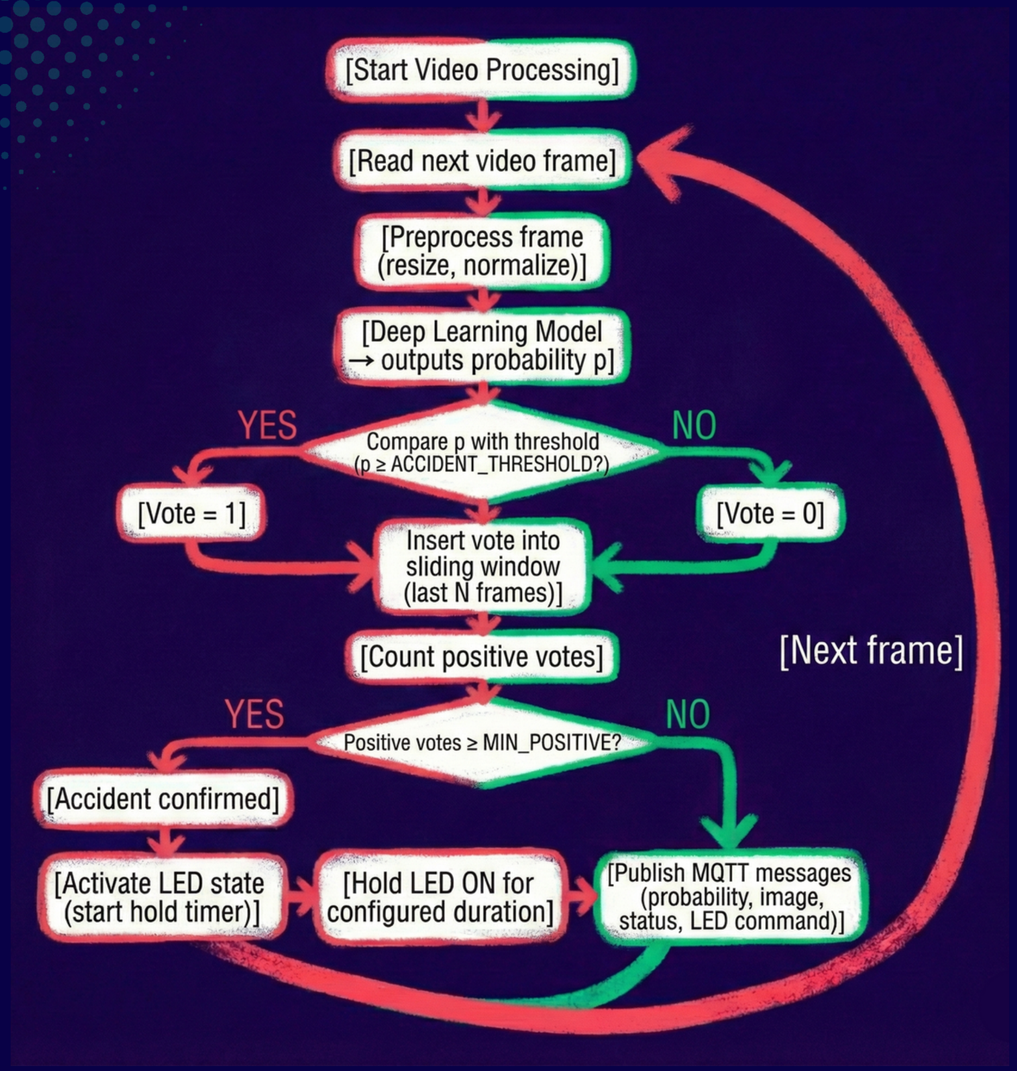
INFERENCE PIPELINE (PYTHON)

Outputs = MQTT Topics

TorchScript export keeps inference self-contained and easy to deploy.

The publish layer is intentionally thin:
compute → decide → publish.

PHASE 3



TEMPORAL STABILIZATION WITH VOTING LOGIC

Hold: Minimum Alarm Duration

- The LED is immediately turned ON
- The system enforces a minimum ON duration
- During this time, the LED remains ON even if predictions fluctuate

Post-Video Hold (Safe Shutdown)

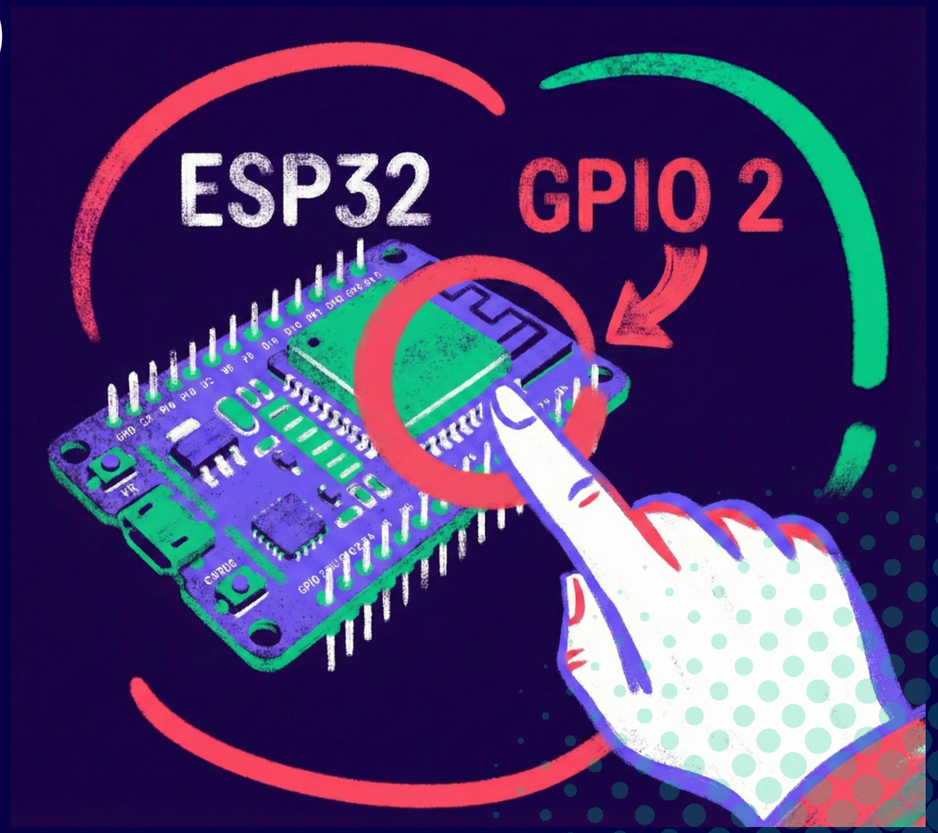
- If an accident was detected, the LED remains ON for a short final period
- The system then explicitly turns the LED OFF
- MQTT connections are closed cleanly

PHASE 3

ESP32 FIRMWARE

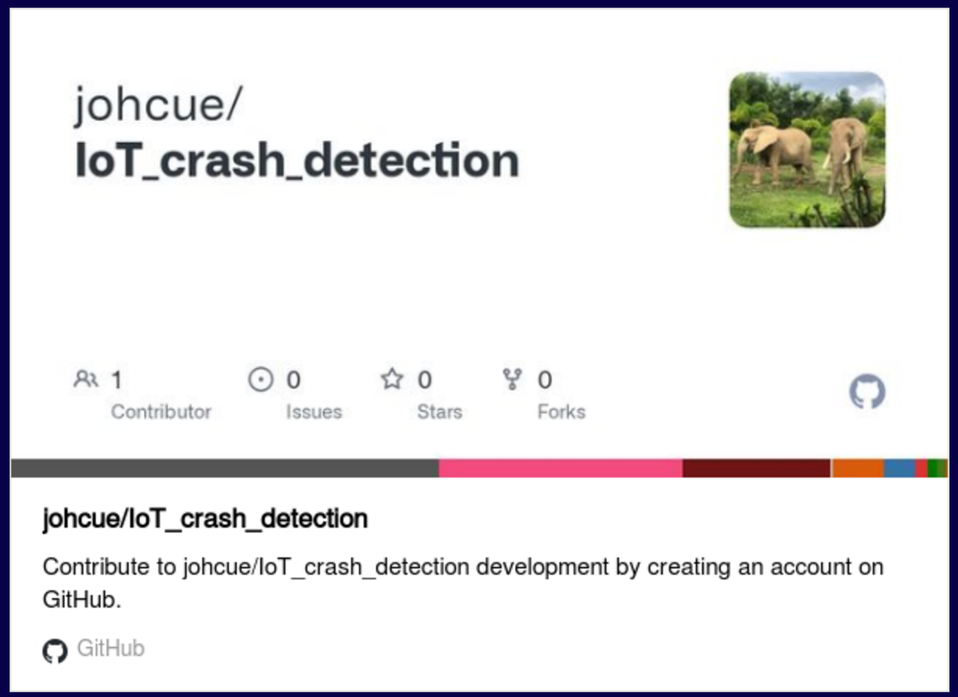
(PLATFORMIO)

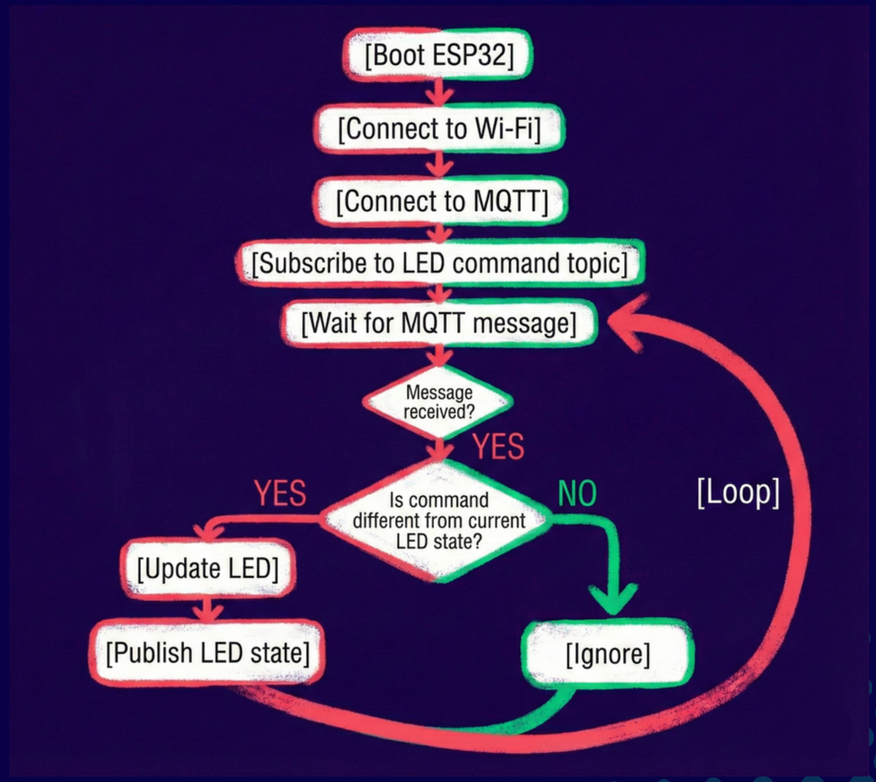
- Subscribe to MQTT topic to toggle GPIO 2.
- Ignore redundant ON/OFF commands.
- Publish state as retained (dashboard sync).
- Reconnect-safe: on MQTT connect, re-publish current state.



PHASE 3

DEMO





Firmware Flowchart of ESP32

Wed Jan 21 12:52

Node-RED : Video | Embedded Systems

Not secure 10.42.0.1:1880/ui/#!/0?socketid=Ou3IGL-bal92rwnE

Embedded Systems Project

System State Video

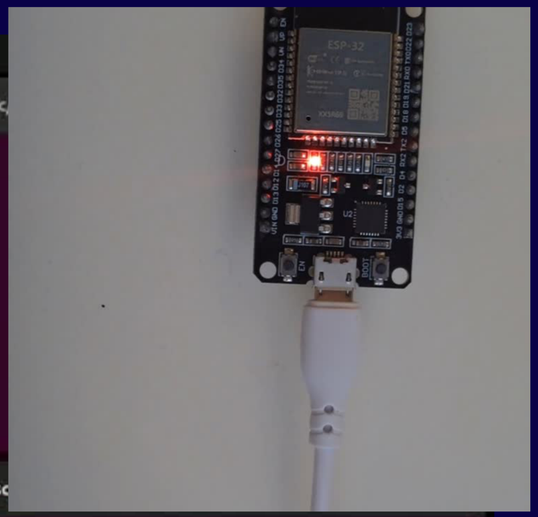
Accident probability	**0.997**
Status	**Accident detected**

wiwi@wiwi-Victus-by-HP-Gaming-Laptop-15-fa2xxx: ~/Documents/Msc/

```
Connecting to MQTT...
MQTT connected
Subscribed to iot/led/cmd
[MQTT] Topic: iot/led/cmd
[MQTT] Payload: ON
[MQTT] Topic: iot/led/cmd
[MQTT] Payload: OFF
[MQTT] Topic: iot/led/cmd
[MQTT] Payload: ON
[MQTT] Topic: iot/led/cmd
[MQTT] Payload: OFF
```

wiwi@wiwi-Victus-by-HP-Gaming-Laptop-15-fa2xxx: ~/Documents/Msc/

```
(phase2) wiwi@wiwi-Victus-by-HP-Gaming-Laptop-15-fa2xxx:~/Documents/Msc/Embedded_Systems/proyecto/help/traffic-accident-iot/data_phase4$ python infer_video_frames_2.py --video ../data_phase4/videos/000001.mp4
Processing video...

--- Video finished ---
Post-video alert hold: keeping LED ON for 5 seconds
Post-video shutdown: turning LED OFF
--- System shutdown complete ---

(phase2) wiwi@wiwi-Victus-by-HP-Gaming-Laptop-15-fa2xxx:~/Documents/Msc/Embedded_Systems/proyecto/help/traffic-accident-iot/data_phase4$ python infer_video_frames_2.py --video ../data_phase4/videos/000001.mp4
```



Open | Inicializacion y esctructura.md

```
### INIt
cd /home/wiwi/Documents/Msc/Embedded_Systems/proyecto/help/traffic-accident-iot docker compose -d

source ~/miniconda3/etc/profile.d/conda.sh

conda activate phase2
```

Questions

THANK YOU FOR ATTENTION

See You Next →