Competence Center in Monitoring and Control (CCMC)

Guilherme Pereira

Jornadas 2024

Competence Center in Monitoring and Control

- Transversal LIP infrastructure that integrates **expertise** and **human resources** from various groups (e.g., ATLAS, DUNE, LZ, RPCs, IT) to **design, implement, and operate monitoring and control systems**;

- Leverage accumulated know-how and tools to **establish partnerships or contracts** with third parties (e.g., other laboratories, industry) where LIP's scientific deliverables can be applied;

- Facilitate knowledge sharing and support the implementation of solutions across other LIP groups;

- Provide training for human resources (e.g., Master's students);

- **LIP Contributors:**
  - Nuno Barros, Paulo Fonte, Francisco Neves (Coord.), Guilherme Pereira (LIP contract), João Silva, Vladimir Solovov, Filipe Veloso (former), Helmut Wolters.

- **Master Students:**
  - Gil Madeira (VITAL, LIP Master scholarship), Leonor Martins (STREAK)

- **Master Students (former):**
  - Rita Barradas, Carlos Neto (AST), Jose Rodrigues (Bosch Termotecnologia, Aveiro), Francisco Santos (TheLOOP), João Parente (MARE-ECOTOP).
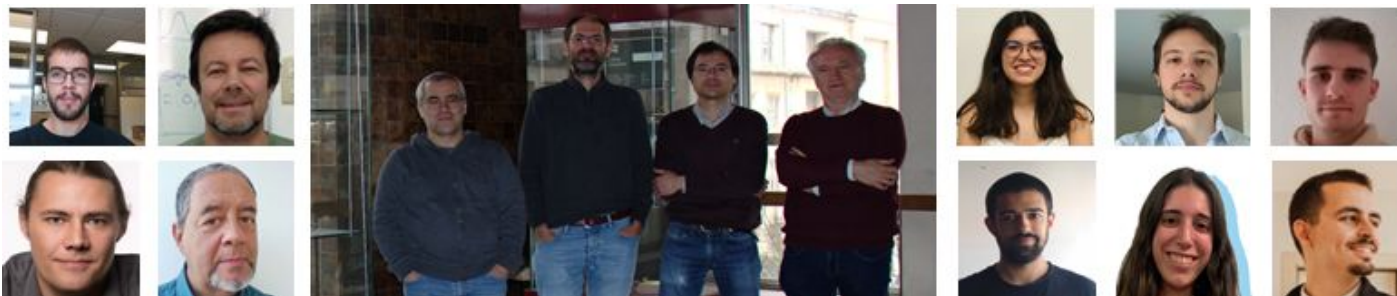
- Development of outreach instruments;
- Participation in the UC Summer Internship Program for undergraduate students.

NEI 2021 (In collaboration with the ECOTOP-MAREUS)
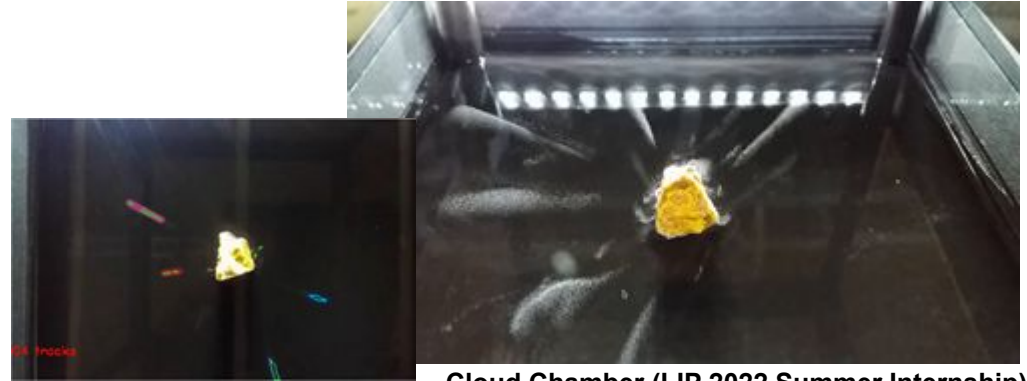
Cloud Chamber (LIP 2022 Summer Internship)

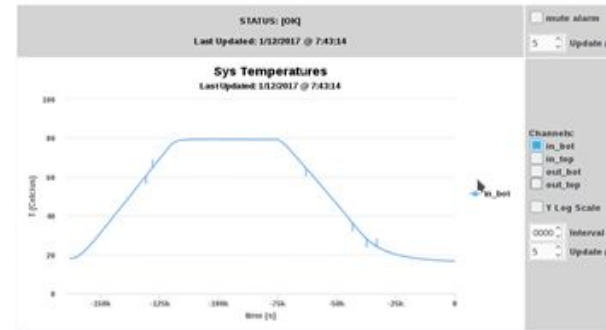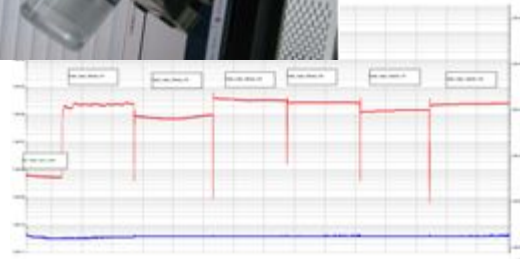**Pairing card game for outreach activities (Created for ECOTOP-MAREUC)**

Machining container. (MW)

Collaboration between the Mechanical Workshop (MW), Detectors Laboratory (DL) and CCMC!

Home made oven with temperature sensors for control (MW).
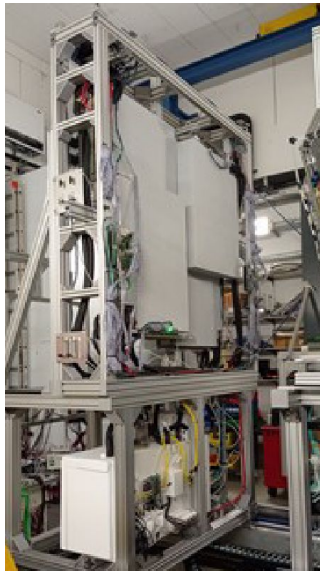
Vacuum tightness test (DL)

Controlled temperature profile during the test (~48h)
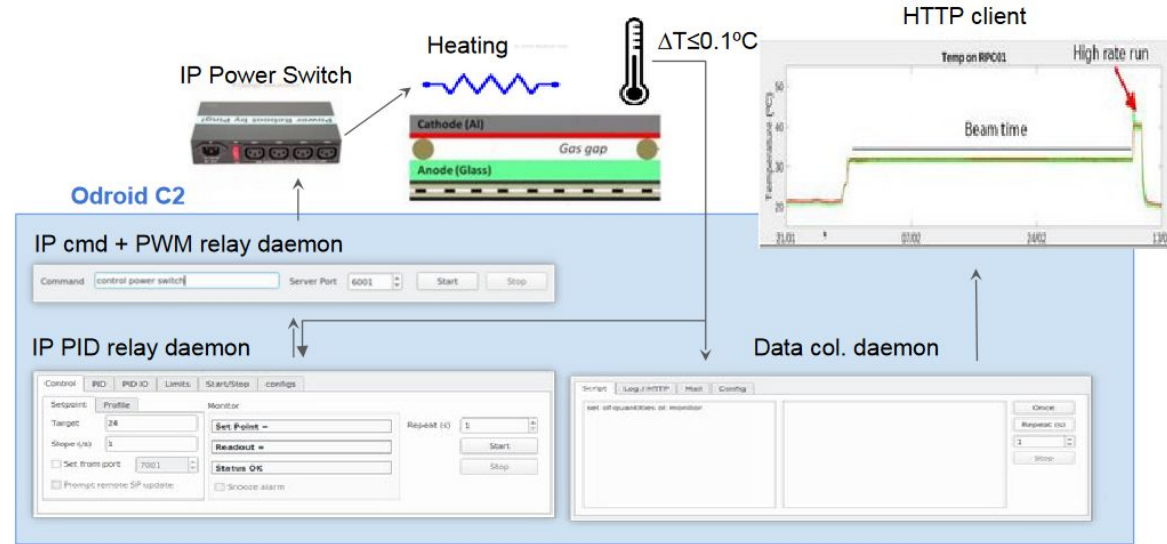
(CCMC: LXe/LUX/LZ tools)

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- Check efficiency and timing accuracy (as a function of the detector working temperature) of the future TOF detector for the forward region of the HADES spectrometer


HADES, Forward RPC

- **Modular framework** allowing to virtually "assemble" **any monitor+control** infrastructure (LXe Group);
- **Plots/alarms** readily available through a HTTP Client for any quantity collected;

- Development of non-invasive **devices for the monitoring of the temperature and heart rate** of birds during nesting in their natural habitat.

- Work developed for the **ECOTOP-MAREUC** group and includes development of firmware, tools to analyse the acquired data, technical support and training of users;

- Software tools and interface to extract and process information from the temperature and heart rate monitors:
  - filter ambient noise;
  - detect the presence of birds;
  - measure the heart rate.

- Implements 2 different heart beats analysis methods:
  - Sliding window threshold finder;
 - Pulse Finder developed for LZ by the LIP DM Group;
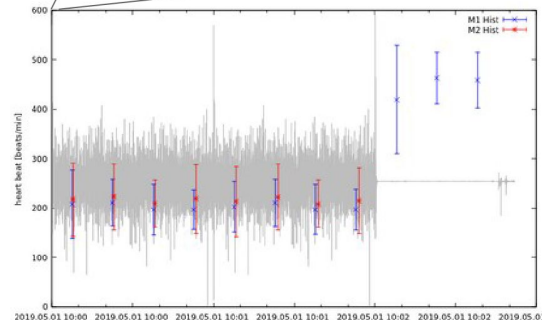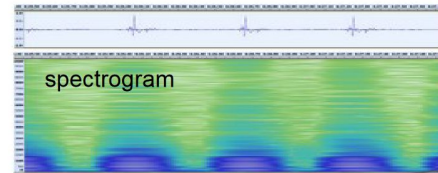
  LIP is co-author of the published analysis.

spectrogram

- Master thesis (<u>João Parente − 2023</u>): development of ML tools for the characterisation of behavioural and physiological parameters of nesting birds in their natural environment:
  - Classification: detect if the bird in the nest?
 - Regression: measure the heart rate.
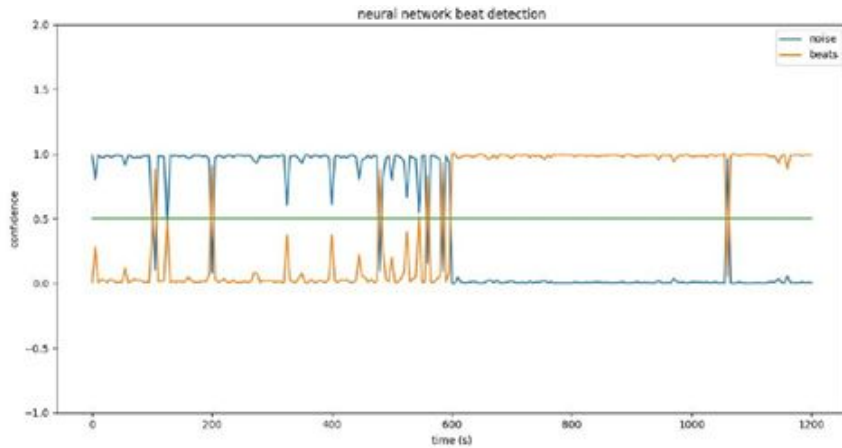
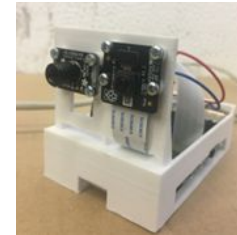**Deep Neural Network** to classify ambient noise vs heart beats
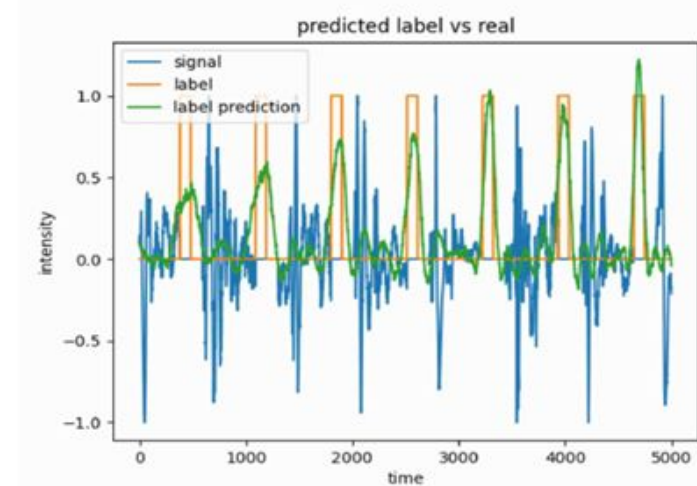
Recurrent Neural Network to count heart beats

- Master thesis (José Rodrigues): development of ML algorithms to analyse room occupancy in real-time.
  - partnership with Bosch;
  - low-cost embedded systems using an IR camera;
  - control HVAC (heating, ventilation, and air conditioning) systems;

- Master thesis (Carlos Neto): development of algorithms to **detect traffic lights in real time** for Automated Guided Vehicle.
  - collaboration with Active Space Technologies (AST).
  - identification of the traffic light set and current status (green, yellow, red);
  - quality of the identification to help on decision making
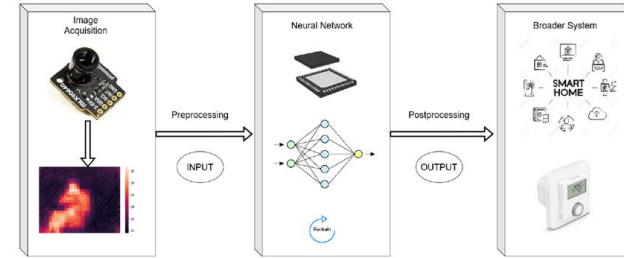
- Master thesis (<u>Rita Barradas</u>): **non invasive temperature monitoring** device that uses **visible+IR cameras** for image (e.g face/object) recognition.
  - Uses cases include airport portals (pandemic context) or industrial conveyor belts;
  - Forehead temperature measurement (distance corrected);

(raspberry)

(Overlap of the images from the visible and IR cameras)

- Master thesis (Francisco Santos): ML deep learning algorithms for the detection and localization of leakages in water distribution systems.
  - collaboration with TheLoop in the context of their work with Águas da Figueira.

confusion matrix illustrating the location of leaks (all studied sizes) along a grid of nodes distributed across the water distribution system.
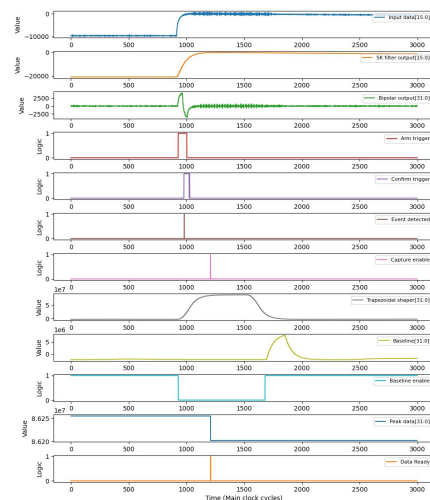
THE LOOP CO.

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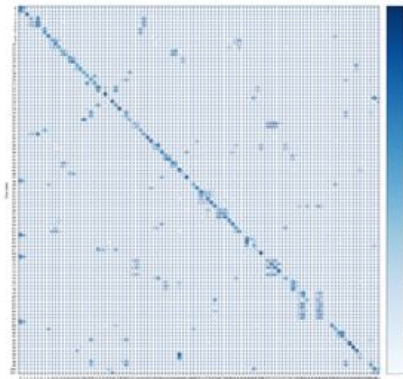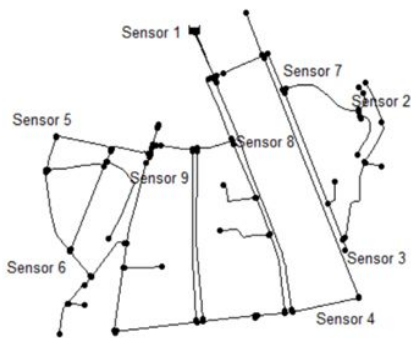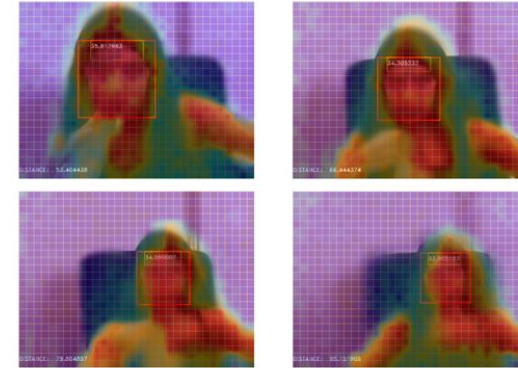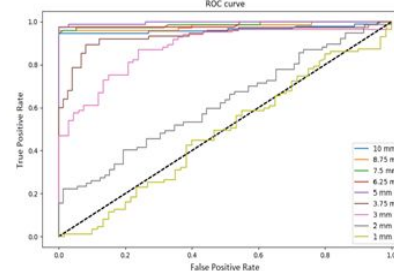
- Development of a **digital nuclear MCA** (Multi Channel Analyser) suitable for HPGe (High Purity Germanium) Gamma Spectroscopy for **VITAL Technology Group CO.**
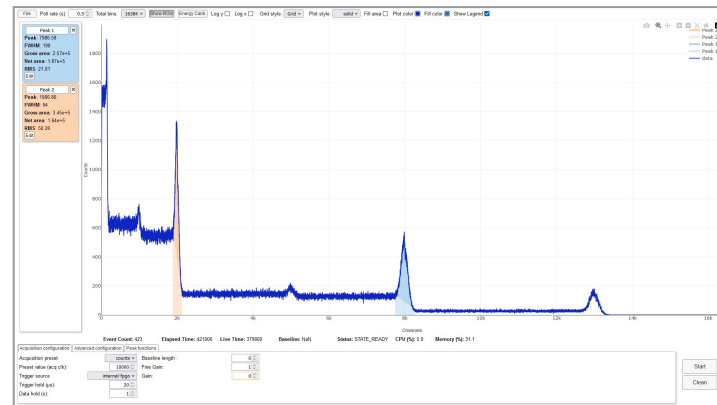 The project includes:
  - Frontend electronics (amplification, shaping and digitization of the signal);
  - Digital processing chain using a FPGA (filtering, baseline correction, peak finding, etc);
  - Web-based Graphical User Interface (GUI);
  - Finances a **scientific-technical career** (G. Pereira) + a **Master scholarship** (G. Madeira);
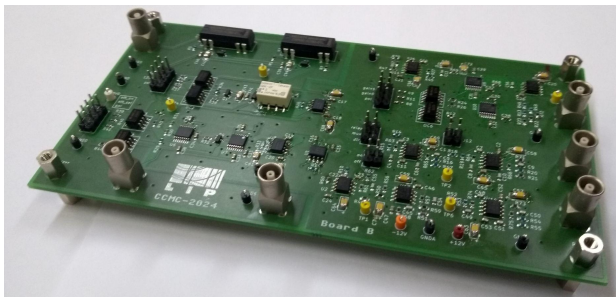
Frontend electronics test board

Signals at different steps of the digital analysis

GUI

With a lot of help from the ECO group! Thanks!

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Cloud chamber for educational purposes

As charged particles pass through the supersaturated atmosphere inside the chamber, they create a visible trail, providing a visual representation of the world of particles.

One of the advantages of this small chamber, developed in partnership with the Ciência Viva Agency, is that it uses Peltier plates to cool the alcohol to −23°, without the need for dry ice
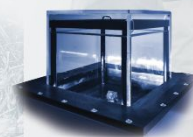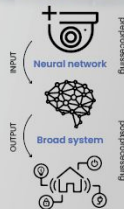
Smart HAVAC

In a partnership with Bosch Termotecnologia, CCMC has developed algorithms integrated into microcontrollers for intelligent heating, ventilation and air conditioning (HAVAC) systems.

The system uses data from a low-resolution IR camera and Machine Learning methods based on Neural Networks to measure the occupancy of a room. This intelligent approach to HAVAC control allows for energy savings and greater comfort.

Image acquisition

Neural network

Broad system

INPUT — preprocessing
OUTPUT — postprocessing

Artificial egg for non-invasive monitoring of physiological and environmental conditions in nests

The egg consists of an electronic board equipped with a microphone powered by lithium batteries. A thermohygrometer is installed in the nest itself. The system makes it possible to record the heartbeats of newly hatched birds, as well as temperature and humidity. The project is a partnership with MARE-ECOTOP that began in 2018.

The recorded signals are processed using algorithms developed at LIP and based on Hann functions, Gaussian difference and "sliding window threshold". Data analysis using Machine Learning techniques makes it possible to study the behavior of birds in their habitat - for example, to quantify the adaptation tolerance of gulls (Larus michahellis) to urban environments.

Sensors

Microcontroller

Artificial shell

(showing just 4 out of 11 pages from the portfolio)

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- Partnership with UC and ESAC in a PTDC call (12 months, 1 FTE) − LIP work focuses on using satellite and drone images to monitor invasive plants;

- Started the process of negotiating a 2nd contract with the VITAL Technology Group CO for the development of a PA for HPGe detectors;

- Master (Leonor Martins): development of ML algorithms for controlling industrial drying machines used in glass recycling. The work will be carried out in collaboration with STREAK;

- Development of heart rate monitors for gannets (Deakin, Australia);

Final remarks

- Since 2018, CCMC has demonstrated its ability to lead innovation across diverse fields.

- Continue to seek out for new funding opportunities with current/new partnerships in industry and academia.

- Continue to invest in the training of human resources and development of dissemination activities.

Facilitate knowledge sharing and support the implementation of solutions across other LIP groups

Reach out if you're interested in collaborating with CCMC!
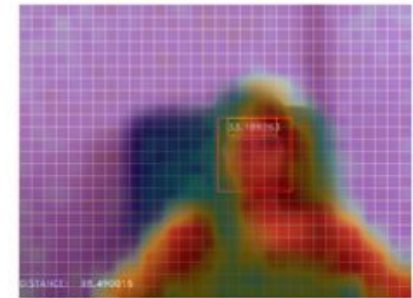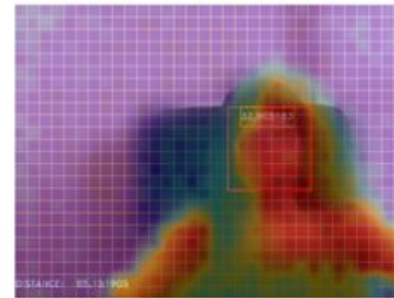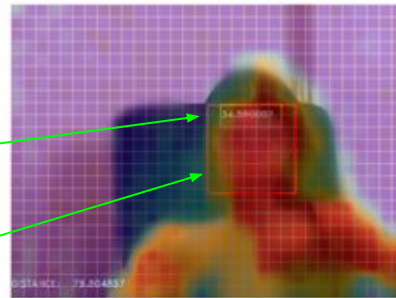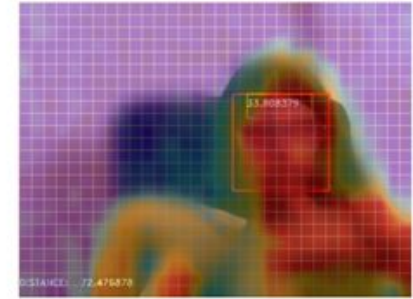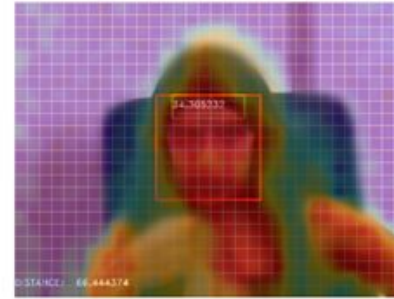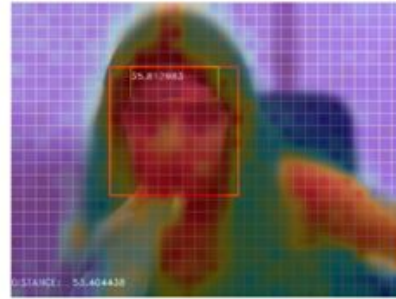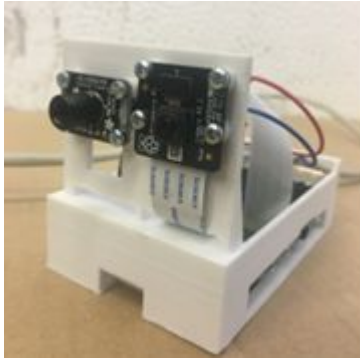
ccmc@coimbra.lip.pt

lip-talk.slack.com
@Francisco Neves
@guilherme

Thank you

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Forehead temperature measurement (distance corrected)

Face recognition

(Overlap of the images from the visible and IR cameras)

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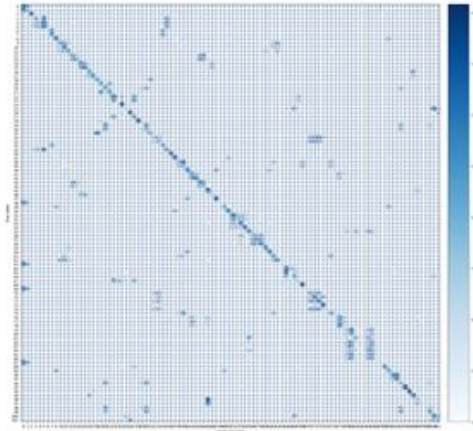- Quality of the identification to help on decision making

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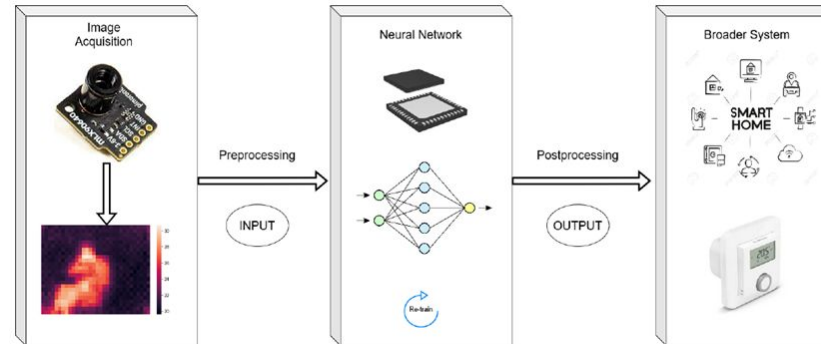
STM32L475 development board.

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