# Competence Center on Monitoring and Control

# 2020–2022

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on behalf of the CCMC

Jornadas Científicas do LIP 2022 — Coimbra, Portugal

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LIP    UNIVERSIDADE DE COIMBRA

• goal: horizontal LIP infrastructure to gather the expertise in the design, implementation and operation of monitoring and control systems, accumulated by LIP groups in the context of their scientific activities

• the manufacturing of electronics and other hardware is delegated to the LIP electronics and mechanical workshops

• diversity is key to fulfil its main goal: human resources scattered among different fields of activities (from low energy and rare event searches to high energy particle physics and computing)

• sharing of knowledge (sensors, electronics, software, analysis, *etc.* . . ) among LIP members

• establish partnerships or contracts with third parties (*e.g.* other research laboratories, industry) as a means to transfer scientific know-how and solutions into the community (including training of human resources and the development of outreach instruments)

# group members

**main contributors:**



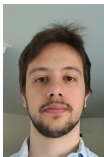Francisco Neves  Helmut Wolters  Filipe Veloso  João Silva  João Parente  Rita Barradas  José Rodrigues

**DL / MW support:**

Américo Pereira, Luís Lopes, Nuno Carolino, Orlando Cunha, Rui Alves

**interns / summer students:**

Afonso Ávila, Alexandre Nunes, Daniel Coelho, Daniel Sousa, Francisco Casalinho, Jamie Bockett, Joana Mota, João Costa, Julio Santos, Luís Melo, Luís Januário, Miguel Roldão, Rafael Molter

# dummy seagull-eggs hardware

• production of a new batch of 25 heart rate and temperature monitors for nesting birds ordered by ECOTOP - UC

• important improvements in both the hardware and firmware, allowing to extend the recording time and eliminate data acquisition dead-times

• plug and play device (windows), on-line manual, analysis application with two *classical* methods (windows/linux)

• used for real data aquisition in the field during the 2021 nesting season

# dummy seagull-eggs data analysis
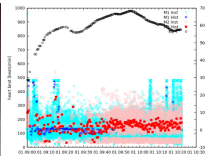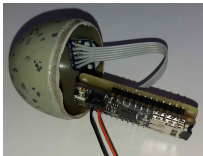
• ongoing master's thesis

• goal: development of ML tools for the caracterisation of behavioural and physiological parameters of nesting birds in their natural environment

• audio analysis with feature extraction from mel-frequency cepstrum coefficients (MFCC)

• classification (is the bird in the nest?) and regression (what is its heart rate?)
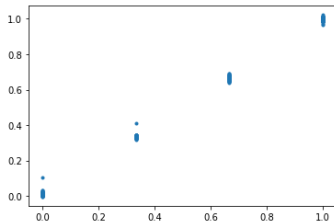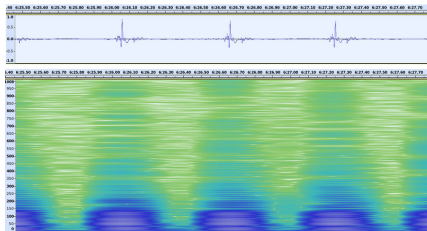
# outreach card game

• development of an interactive card game, commissioned by MARE, to be used in outreach actions, *e.g.* at elementary schools

• goal: match pairs of cards with birds and nests

• play bird sound (call/song) if correct mach or buzz sound if wrong match

• raspberry pi; nfc readers; nfc tags; audio amplifier; speaker; enclosure

• presented at the 2021 european researchers night

• can be adapted to other research fields (contact us!)

# hatchling / nestling birds monitoring?

• quick assessment, for ECOTOP - UC, if we could develop a low-cost device to measure the temperature of hatchling / nestling birds

• panasonic amg8833 thermal IR camera (8×8 pixels); Raspberry Pi Camera V2; Raspberry Pi 3B+
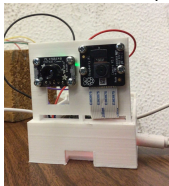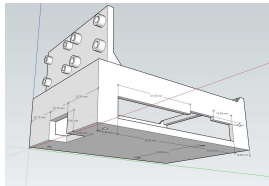
• tested with UC canary birds
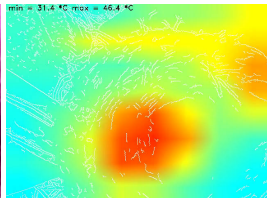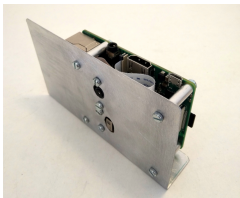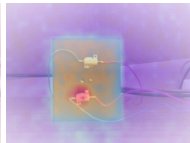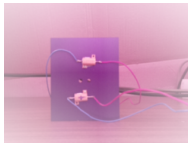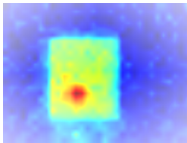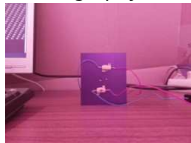


• paralax errors and not enought resolution

# non-invasive temperature monitoring

- ongoing master's thesis

- goal: development of a low-cost non-invasive temperature monitoring device with image/target recognition

- MLX90640 thermal IR camera (32×24); Raspberry Pi Camera V2; Raspberry Pi 4



- homography calibration:



- temperature calibration under development
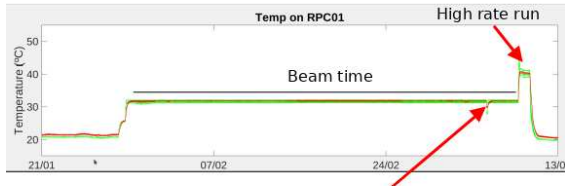- several CV and ML object detection implemented

# human detection

- ongoing master's thesis in collaboration with Bosch Termotecnologia, Aveiro

- goal: development of embedded systems for human detection using thermal imaging and machine learning to be used to control HVAC systems

- MLX90640; STM32L475
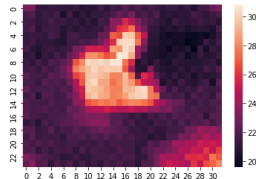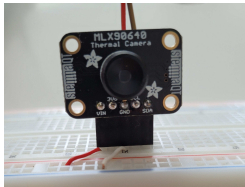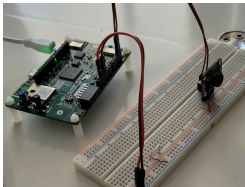


- tinyML: external ML training; inference in low performance mcu

- 3 categories implemented with LSTM + CNN (0, 1 or +2 persons)

- tinyOL: ML model fine-tuning inside the mcu (using an adaptive layer that can be re-trained online using real-time streams of data)

# end-user data-logging software-framework

- goal: developement of a user-friendly DB framework to store and retrieve sensor data

- provides complete abstration of the database

  (users do not need to care about the database structure or handle SQL commands)

- sensor parameters, validity of the collected data, temporal and geographic information

- can be interfaced with gui (*e.g.* the one developed by the LZ group)

- implementation of the temperature control software for the RPC modules installed in the HADES experiment



Heating distribution copper pipes     64 I²C temperature sensors

Heating element + pumps



Temp on RPC01

High rate run

Beam time
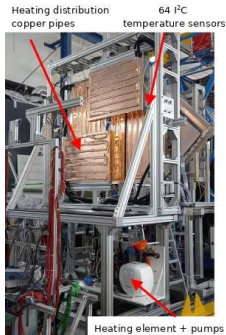
- Δtemp < 0.5 º over ~4 m²
- Just one crash of the system to be improved.
- Tip: never use mechanics relays !!!!!

210 W @ ΔT = 14º     450 W @ ΔT = 22º

# cosmic muons observation

- goal: launch an atmospheric balloon to measure muon flux vs altitude

- month-long summer internships *observação de muões cósmicos*

- two detectors (5×5×1 plastic scintillator + SiPM + arduino)

- adafruit feather + gps + atmospheric pressure sensor + thermometer + phone

- to be improved: lo-ra, gyroscope





Fluxo de muões em função da espessura do betão atravessado

$y = 0,0505e^{-0,001x}$
$R^2 = 0,9732$

Fluxo de muões (muões/segundo) — Espessura do betão (cm)
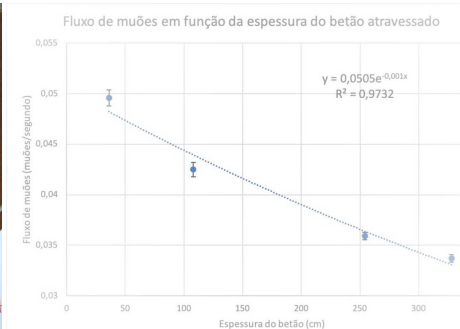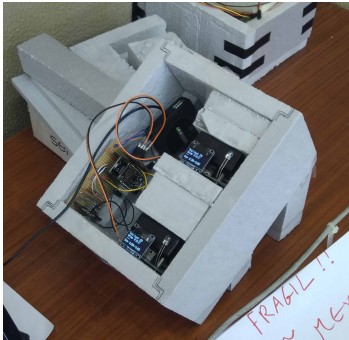
# cloud chamber

- started building an improved and autonomous version of the cloud chamber for outreach

- embed the real-time identification of particle tracks

- implement ML algorithms to characterise the identified particles

## future work / conclusions
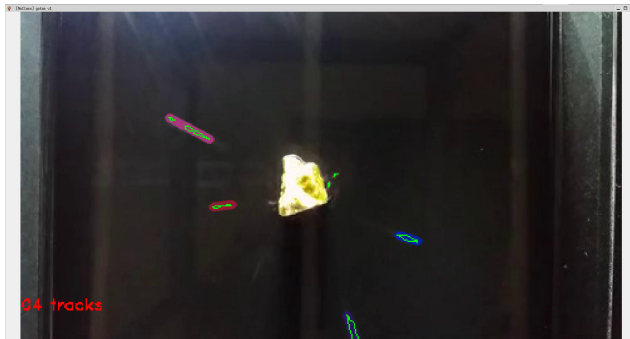
- instrumented nest boxes

- bee tracking

- smaller eggs (great tits)


- small horizontal LIP infrastructure

- growing

- contact us if you need help from us

- join us if you are an expert or like to play with sensors, iot, *etc*. . .