UNIVERSITÀ DEGLI STUDI DELLA TUSCIA

DIPARTIMENTO PER LA INNOVAZIONE
NEI SISTEMI BIOLOGICI, AGROALIMENTARI
E FORESTALI

Nature 4.0
Inspire to invent change

DESIGN OF A FLEXIBLE, EXPANDABLE, AND CUSTOMIZABLE SENSOR NETWORK FOR MONITORING LIVESTOCK BEHAVIOUR AND WELFARE

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Introduction

Increase of animals per farm
Traceability
Early warning systems

→

Precision livestock farming
Single sensor on single spot
Incompatibility among devices

→

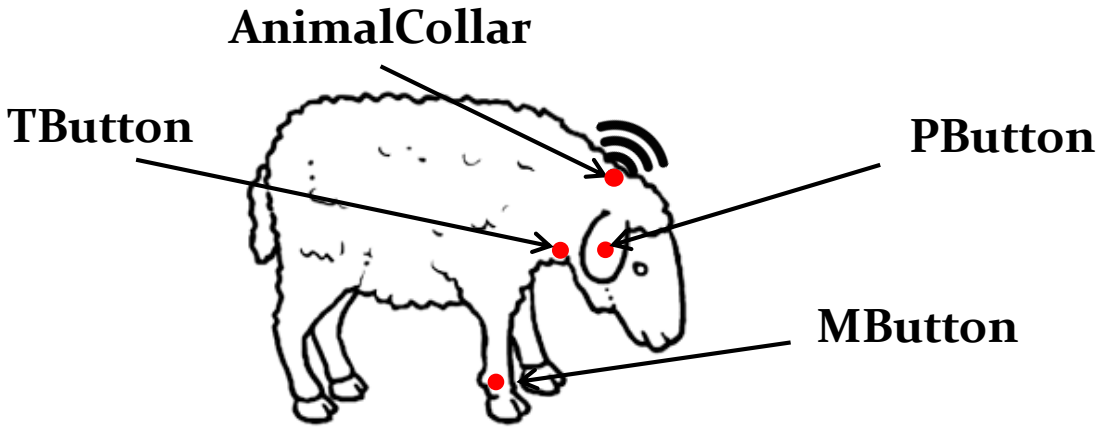
AnimalTalker

Concept

Flexible

Expandable

Customizable



AnimalButtons
- Collect information on **one particular parameter**
- **Elaborate** collected data if required
- Send the data over **BLE** (Bleetooth low energy) to the collar

Button models:
MButton: *movements* using an *accelerometer*
TButton: *skin temperature* using a *TRH sensor* and a *thermistor*
PButton: *pulse oximetry* and *IR temperature*

AnimalCollar
- **Receives** the data from the AnimalButtons
- Takes **GNSS position**, **TRH** and **accelerometric** measurements
- **Send** the data to a server using **NB-IoT/Lora** connection

Additional technologies
AnimalButtons sd version
RFID subcutaneous sensor

Design - AnimalButtons

ATtiny 3226 (Microchip Technology):

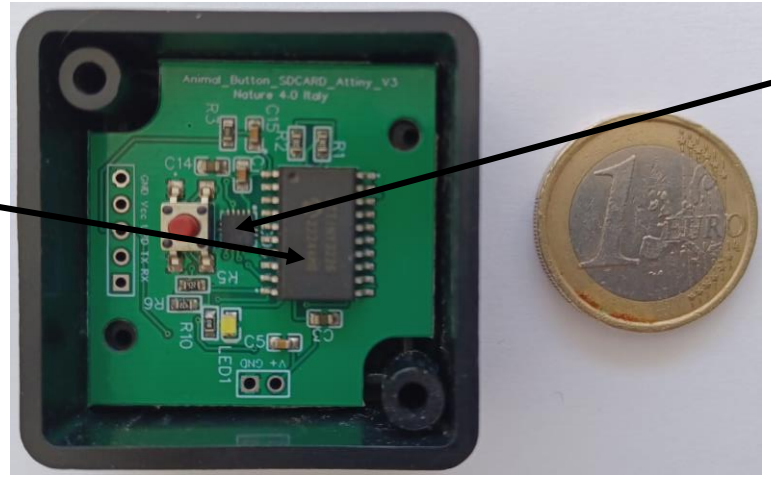
- Low power tinyAVR ® family, 20 MHz
- 3 kB of SRAM
- 256 B of EEPROM
- 3 x 3 mm form factor (20 pins)
- 1.6 mA power consumption (5 MHz), 2 µA in sleep mode

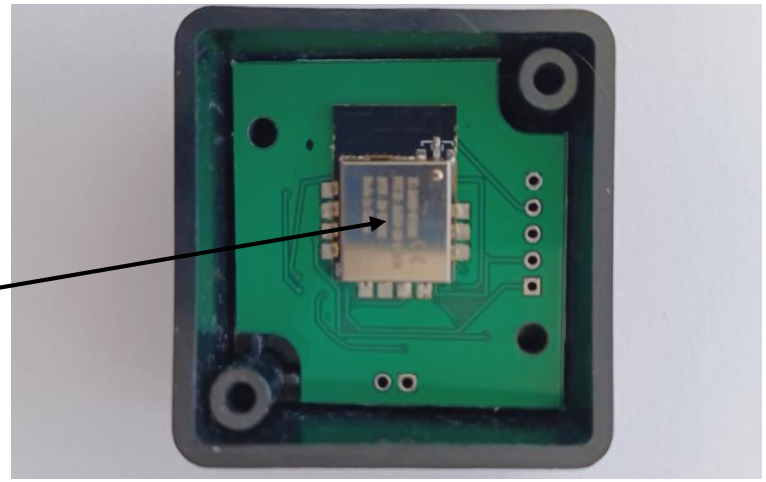
Sd version:

- Same sensors - STM32L0, Arm® 32-bit Cortex®-M0+ with MPU, 32 MHz

HM-BT4502 BLE module:

- Complete BLE 5.0 module - slave role
- UART communication
- Package length up to 240 bytes
- 3 V, 8 mA power consumption, 4 µA in low power mode
- Support 2 Mbps data transmission



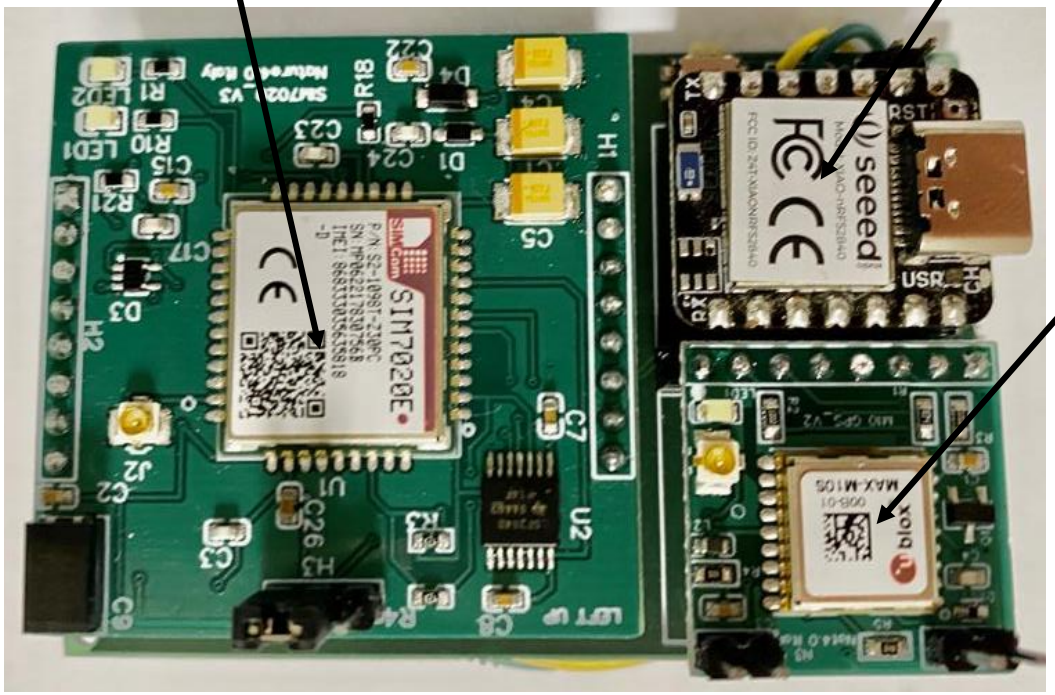


Example of sensor
(LIS3DHTR accelerometer)

Design - AnimalCollar

SIM7020 (Simcom):

- Multi-Band **NB-IoT module**
- 17.6 x 15.7 x 2.3 mm form factor
- 2.1 to 3.6 V,
  ~38 mA in transmission (10 dBm),
  5.6 mA in IDLE mode,
  down to **3.4 µA in PSM mode**



XIAO nRF52840 (Seeed Studio):

- ARM® Cortex®-M4 (Nordic nRF52840) 32 bit, 64 MHz
- 21 x 17.5 mm form factor
- Support **BLE 5.0**, NFC, ZigBee with onboard antenna
- 1 MB flash memory
- 256 kB RAM
- 16 mA power consumption,
  5 µA in deep sleep mode

MAX M10S GNSS module (U-Blox):

- Position accuracy (CEP) 1.5 m
- Time to first fix (cold start) **~30 s**
- 13 V,
  ~13 mA in acquisition,
  ~ 7 mA in tracking mode
- AssistNow feature available to **reduce TTFF**

LIS3DHTR accelerometer (STM)

SHT41 TRH sensor (Sensirion)

Preliminary field test

16 devices composed of an Animalcollar and a MButton were installed

1 BLE skin temperature sensors were tested

4 Animal were equipped with RFID temperature sensors in **2** different spots

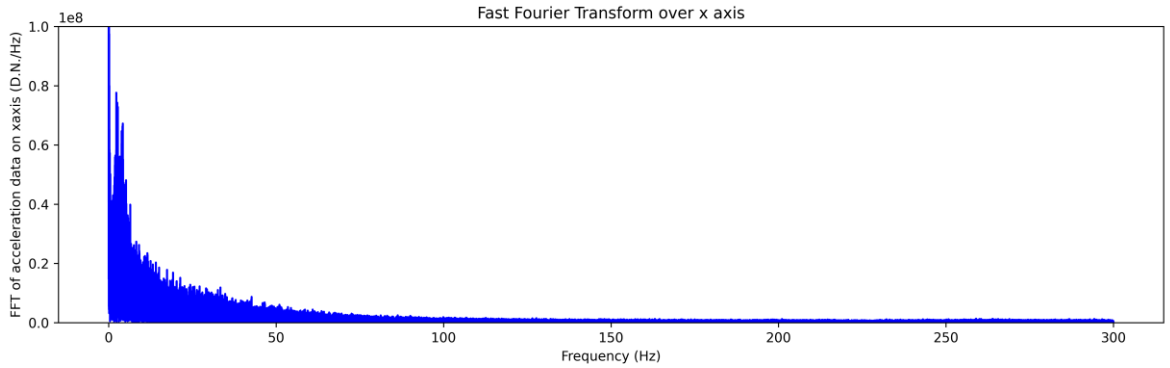
3 MButton sd version collected high frequency data for several hours

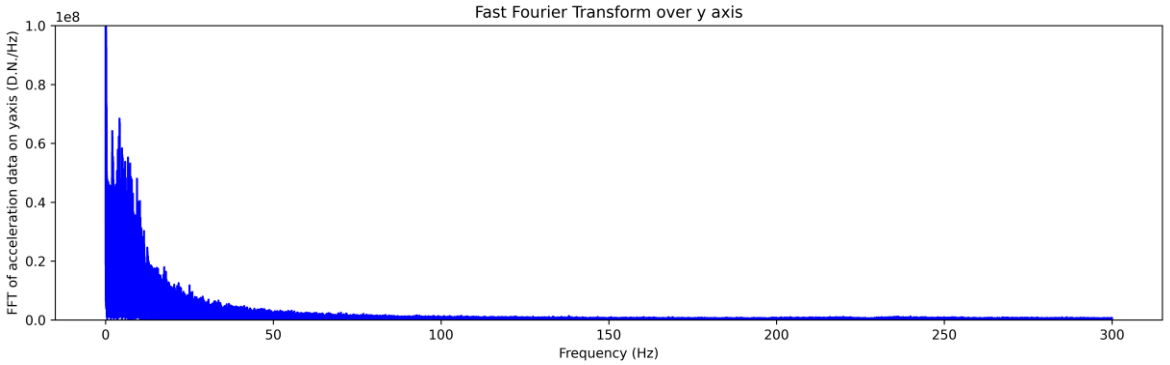
1 prototype of sd heart rate sensor was tested

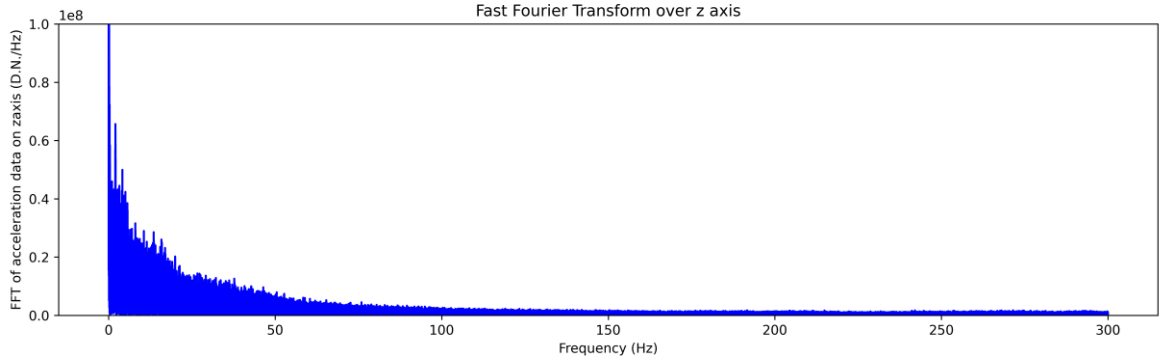
7 different parameters related to livestock wellbeing were collected,
5 using IoT technologies

PRIMA SCALA-MEDI: optimise the sustainable use and conservation of local genetic resources from Mediterranean region, focusing on adaptation to climatic conditions and consumer preferences

Sd Version - MButton







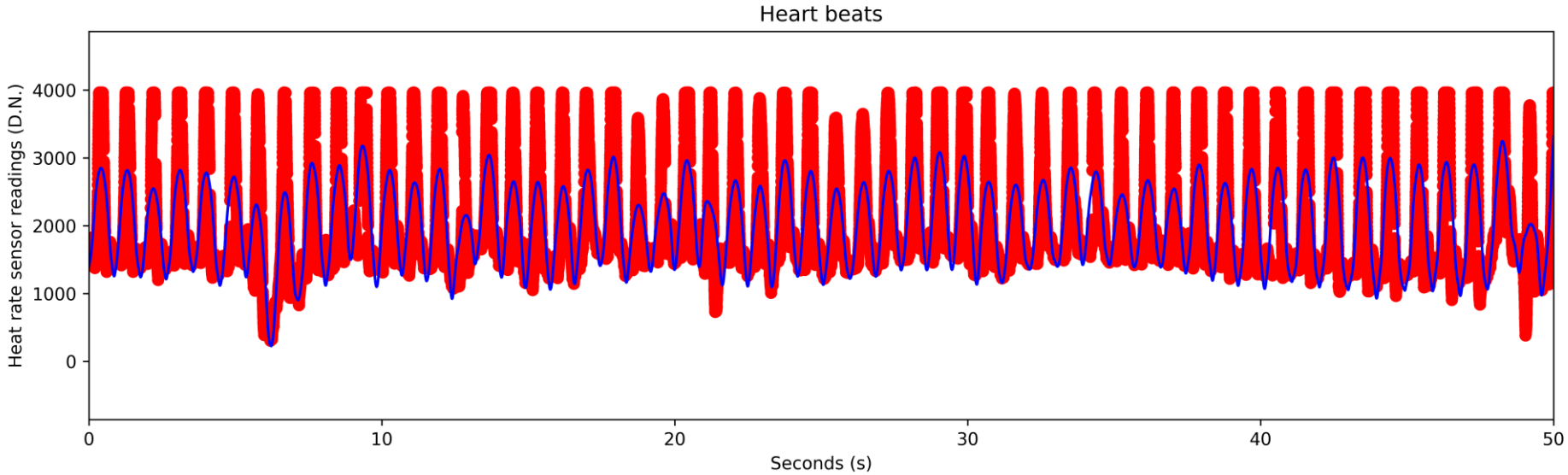
3 sheep monitored over several hours

The sensor was placed on the ankle of the sheep

600 Hz sampling frequency

The application of a Fast Fourier Transform shows that the increase of the sampling frequency above 200 Hz and below 600 Hz does not provide additional information.

Sd Version – Heart rate

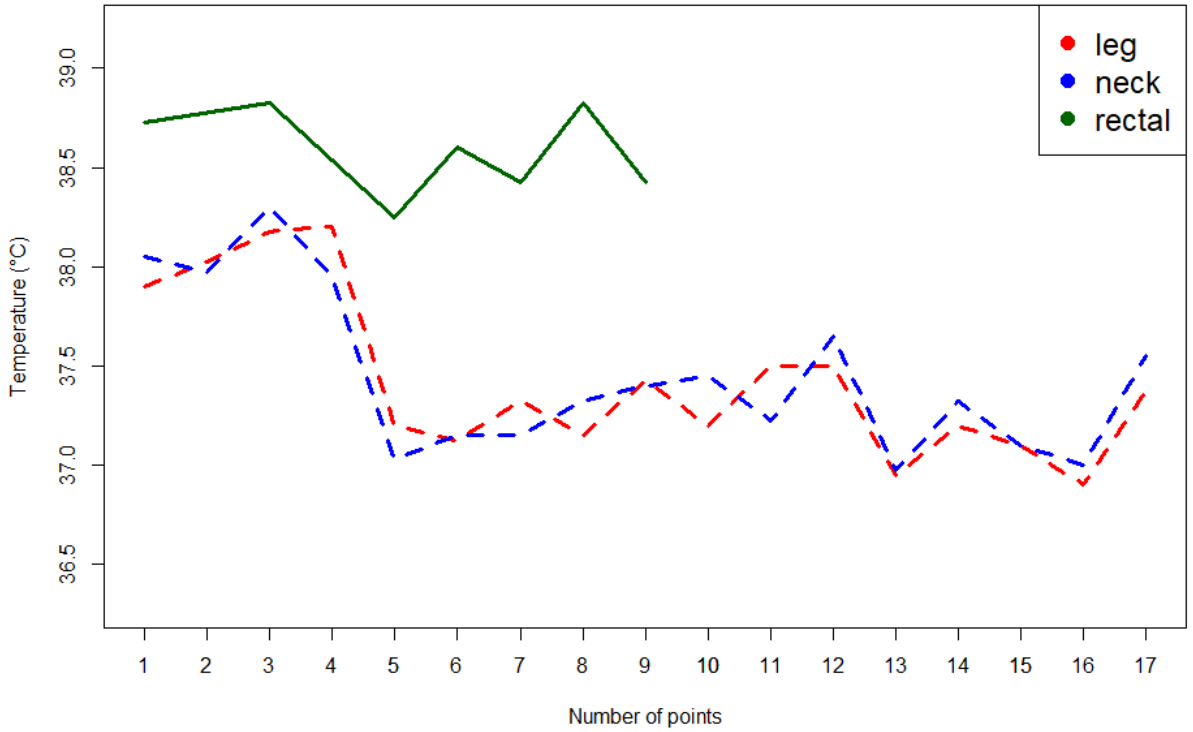


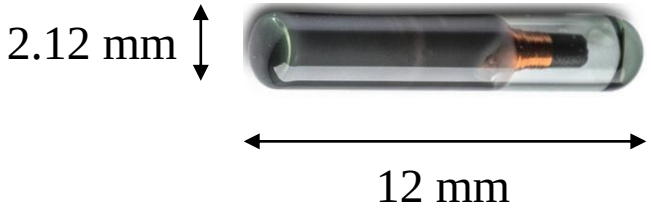
The sensor was placed on the hear of the animal – high concentration of blood vessels

The pattern is clearly visible

RFID sensor

Sample collected with a thermal camera (tc)

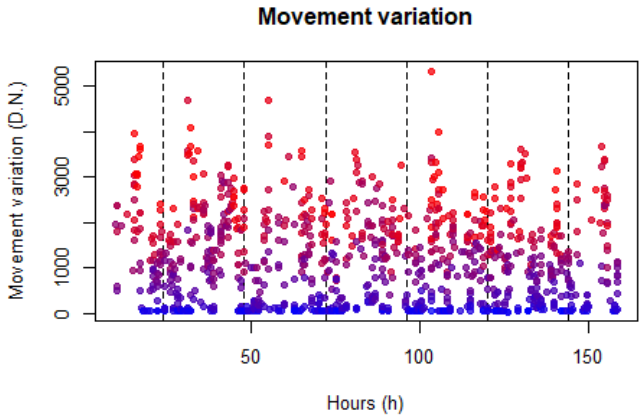


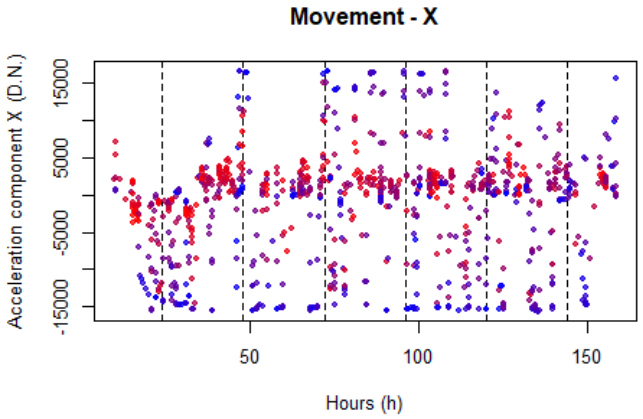


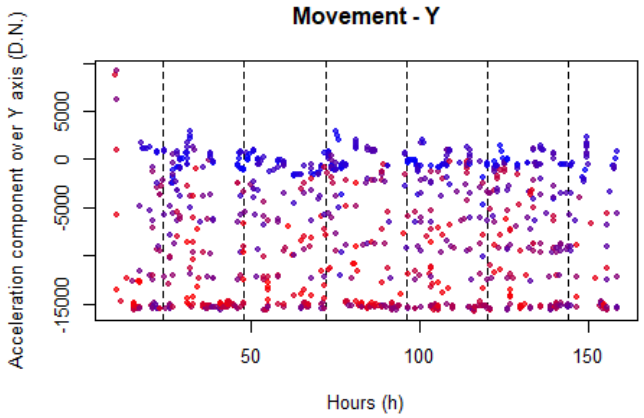
Placed in the neck and in the leg of four sheep

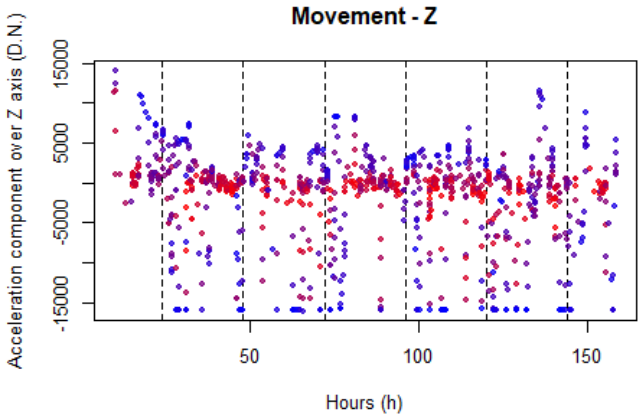
RFID sensors ~ head temperature (tc)
RFID sensors ≠ rectal, eye (tc), udder (tc)

Movements









Mbutton data

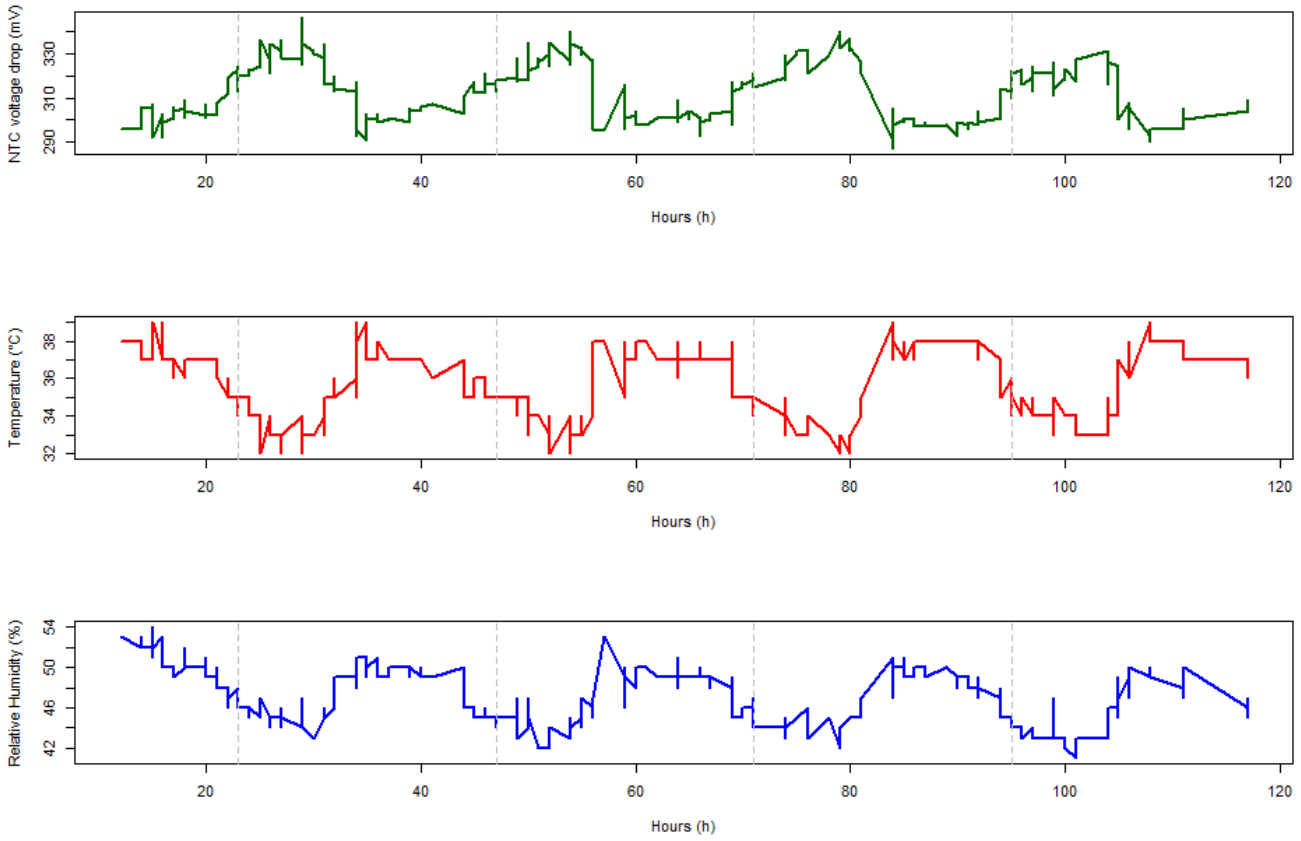
20 points per hour

Blue – lower standard deviation
Red – higher standard deviation

Standard deviation provides information on overall animal condition

Average	St.d. of St.ds.	
H	L	Overall movement is **HIGH**
H	H	Movement is **HIGH** on some directions
L	L	Movement is **LOW**
L	H	Movement is **HIGH** in 1 direction

Temperature

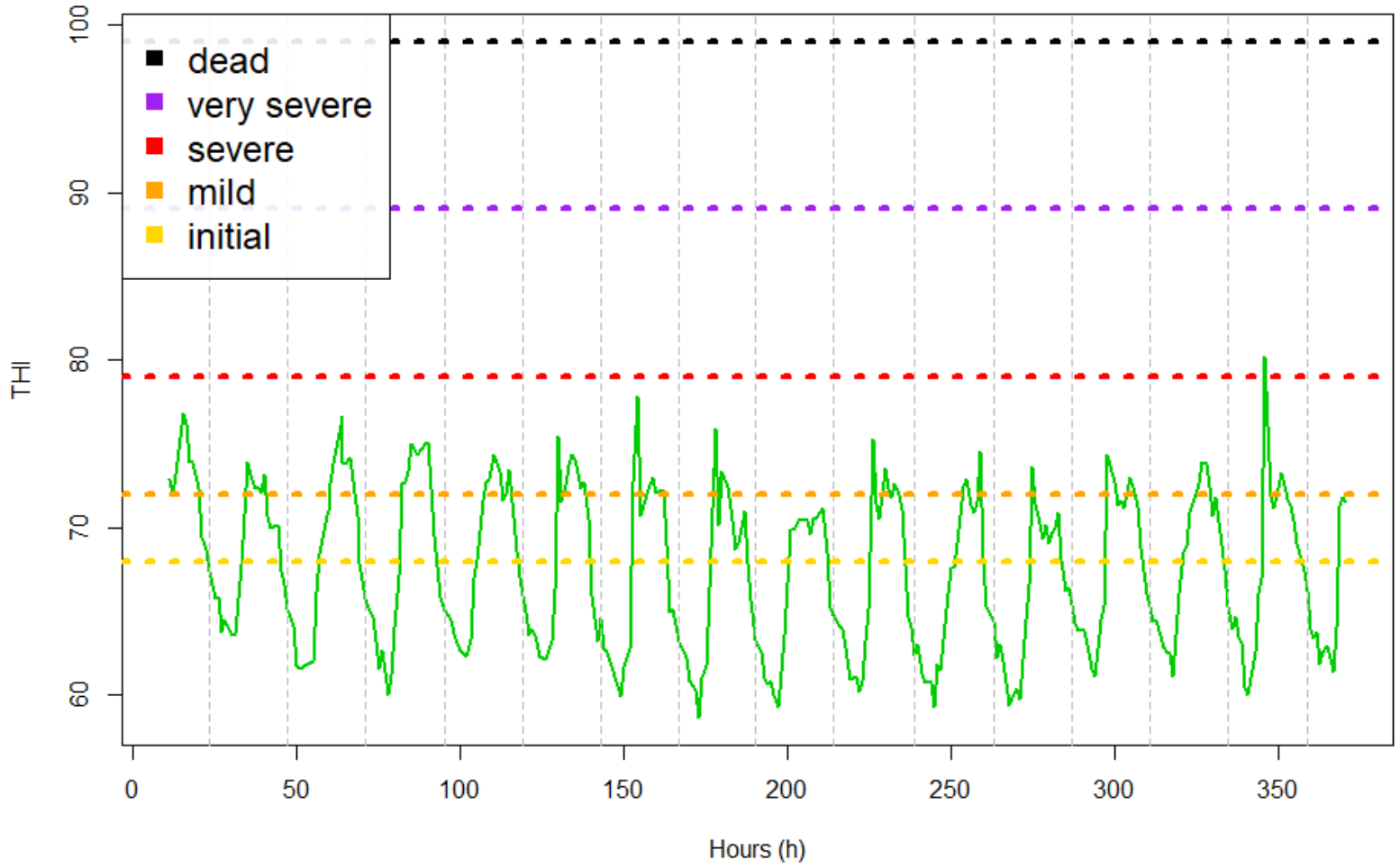


TButton data

6 points per hour

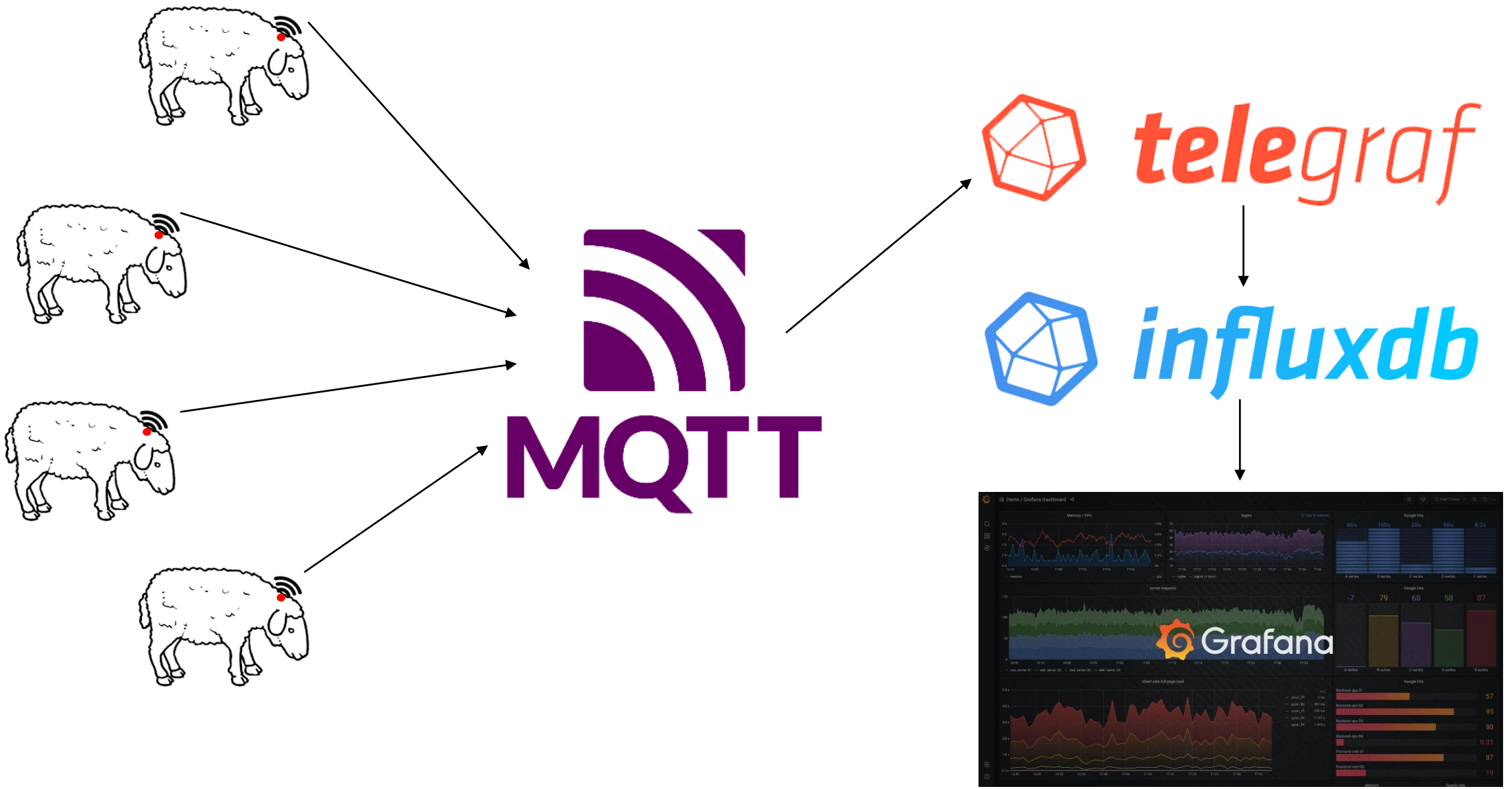
- Daily patterns can be clearly pointed out
- Strong correlation between NTC thermistor data and ambient temperature

THI index



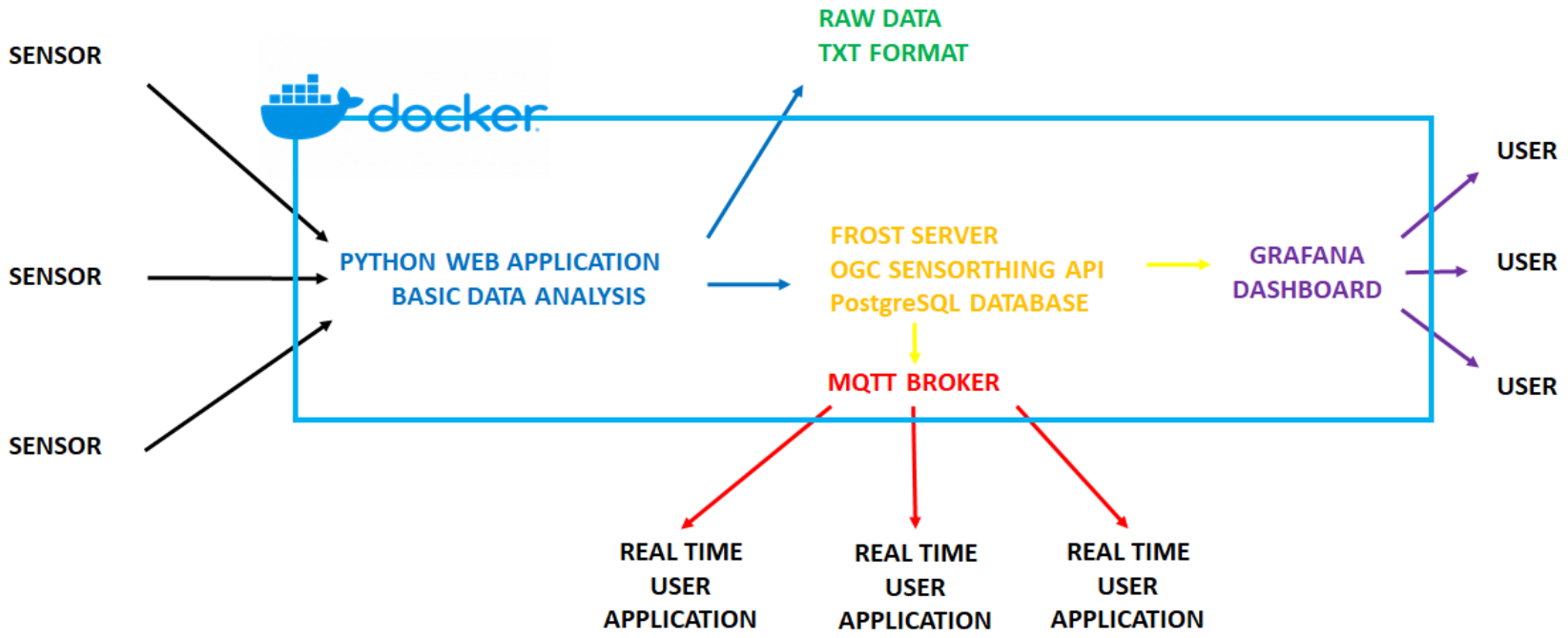
$$\mathrm{THI} = t_F - (0.55 - 0.0055*h)*(t_F - 14.5)$$

Data Chain



Ongoing developments

1. Use a camera along with sd version AnimalButtons to relate collected data with specific behaviours
2. Design an IoT reader for RFID sensors
3. Design the Pbutton after the encouraging results obtained during the preliminary test
4. Create a LoRaWan version
5. Create a stand alone version of some AnimalButtons (LoRaWan)
6. A different configuration of the data chain si under evaluation



AKNOWLEDGMENTS

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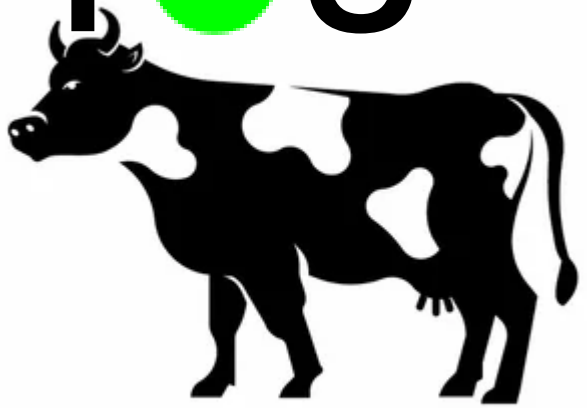
THANK YOU



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