



Smart Collars for Sheep: Leveraging Machine Learning for Improved Pasture Management

ICSF 2024 - First International Conference on Sustainable and Regenerative Farming

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Valencia, 20 de November 2024



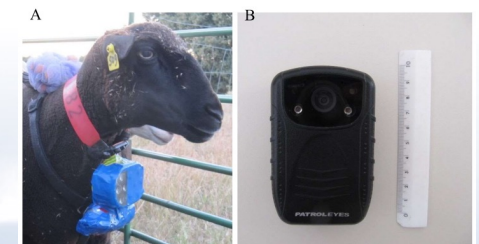
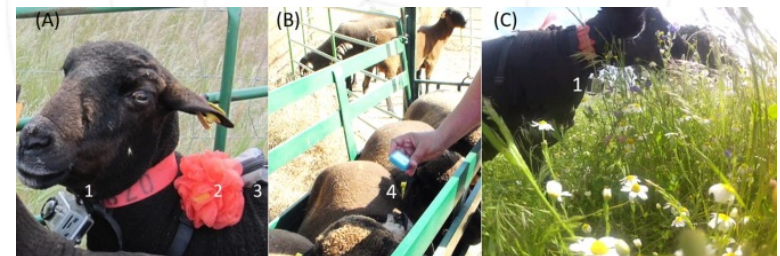
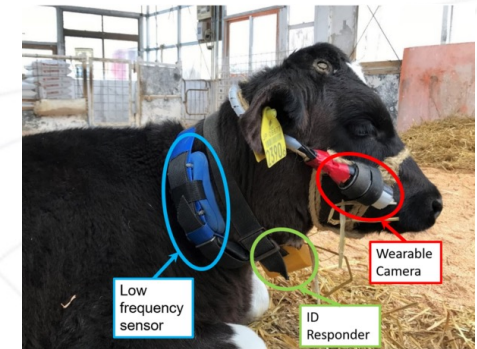
Presenter

- PhD in Informatics Engineering
 - MSc in Telecommunications
- Professor at Aveiro University
 - Computer Networks and System Administration
- Researcher at Instituto de Telecomunicações

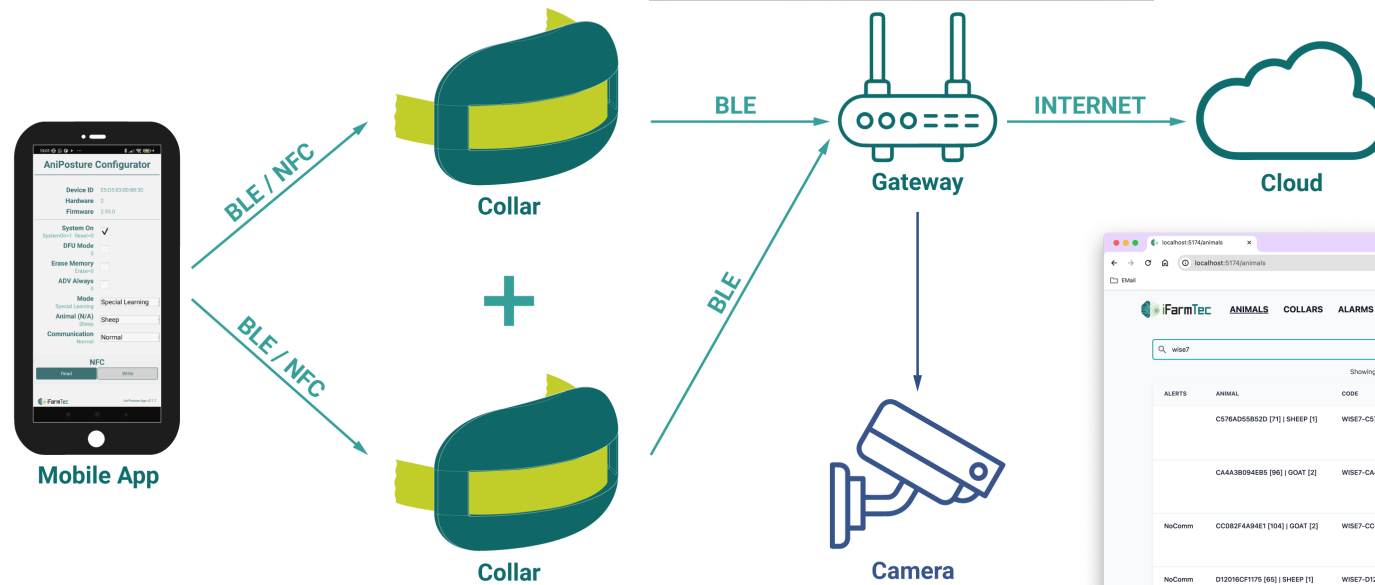


Motivation

- Floristic information
 - Allows to access meadow quality
 - Allows to evaluate the quality of animal feed
- Traditional animal feeding monitoring:
 - Manual collection of pasture images;
 - Offline analysis of pastures based on the images collected;
- Wiseware collar classifies animal behavior
 - quantity of animal feed



Monitoring platform



The screenshot shows the iFarmTec web interface with a table of alerts. The table has columns for ALERTS, ANIMAL, CODE, DEVICE, and BATTERY. It displays 12 of 79 animals.

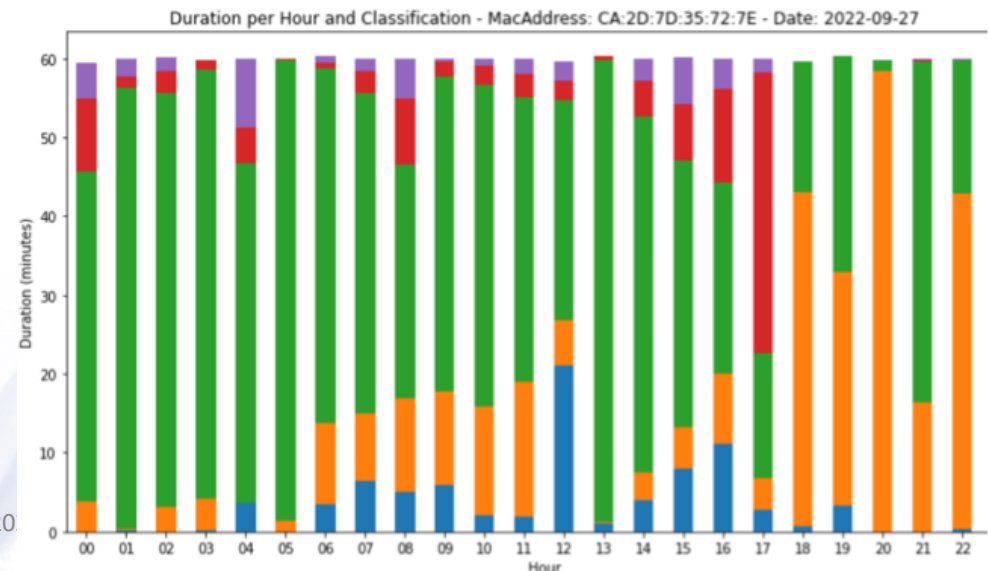
ALERTS	ANIMAL	CODE	DEVICE	BATTERY	
	C578AD55852D [71] SHEEP [1]	WISE7-C578AD55852D led verde	C578AD55852D - hw:2 fw:2.93.0 0, mem:3, mode:A, rssi: n/a 1 minute ago (2024-03-08T15:44:20.304271Z)	82	New Animal Edit Animal
	CA4A3B094E85 [98] GOAT [2]	WISE7-CA4A3B094E85	CA4A3B094E85 - hw:2 fw:2.93.0 0, mem:3, mode:A, rssi: n/a 2 few seconds ago (2024-03-08T15:45:34.843083Z)	88	Edit Animal
NoComm	CC082FA484E1 [104] GOAT [2]	WISE7-CC082FA484E1	CC082FA484E1 - hw:2 fw:2.93.0 0, mem:3, mode:A, rssi: n/a 3 hours ago (2024-03-08T12:48:47.441895Z)	39	Edit Animal
NoComm	D12016CF1175 [65] SHEEP [1]	WISE7-D12016CF1175	D12016CF1175 - hw:2 fw:2.93.0 0, mem:2, mode:A, rssi: n/a 2 days ago (2024-03-06T18:30:05.498991Z)	91	Edit Animal

The collar



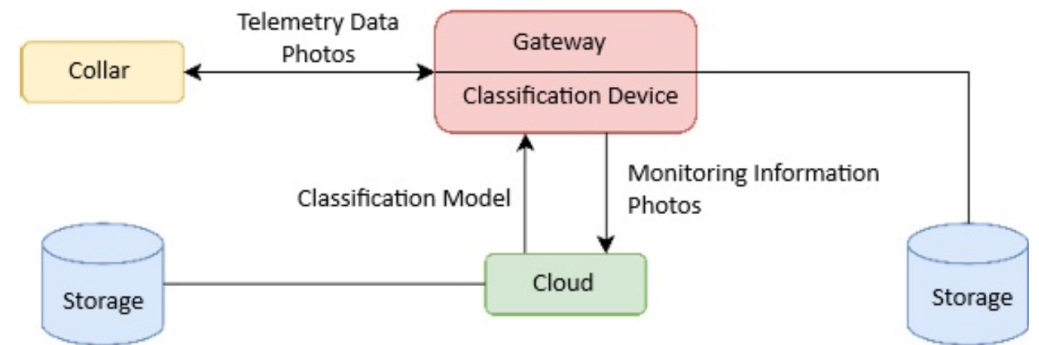
- Is a wearable sensor
 - Includes an accelerometer
 - monitors animal dynamics
- Implements an animal behavior classification:
 - Eating;
 - Ruminating;
 - Walking;
 - Standing;
 - Lying down.
- Internally stores data
 - Micro SD card
- Implements an opportunistic communication
 - NFC based communication

Timestamp	Acc_X (mg)	Acc_Y (mg)	Acc_Z (mg)	Temperature (C)	Behavior
1 709 551 104 150	-0.105	-0.031	-0.229	16.5	S
1 709 551 104 200	-0.092	-0.031	-0.220	16.5	S
1 709 551 104 250	-0.078	-0.032	-0.207	16.5	S
1 709 551 104 300	-0.081	-0.036	-0.214	16.5	S
1 709 551 104 350	-0.081	-0.031	-0.225	16.5	S



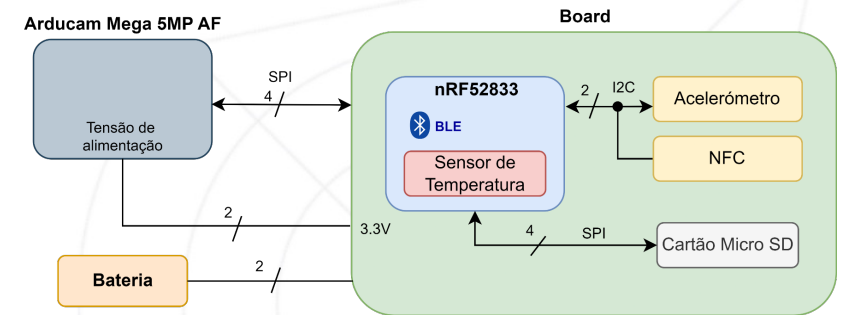
System operation

- Classification algorithm detects eating behavior:
 - Triggers camera
 - Camera stores images in internal memory
- In the barn:
 - Gateway detects collar
 - Downloads images and accelerometry data
- Gateway classifies plants in the photos
 - Identifies what animal ate
 - Uses a machine learning model
- Gateway transfers images to the cloud
 - to improve learning model



Implementation

- Arducam Mega 5MP AF
 - Auto-Focus;
 - SPI interface;
- Maximum resolution 5MP (2592x1944 pixels);
- Power supply voltage 3.3 V/ 5 V;
- Maximum current consumption: 154 mA;
- 33x33x17 mm

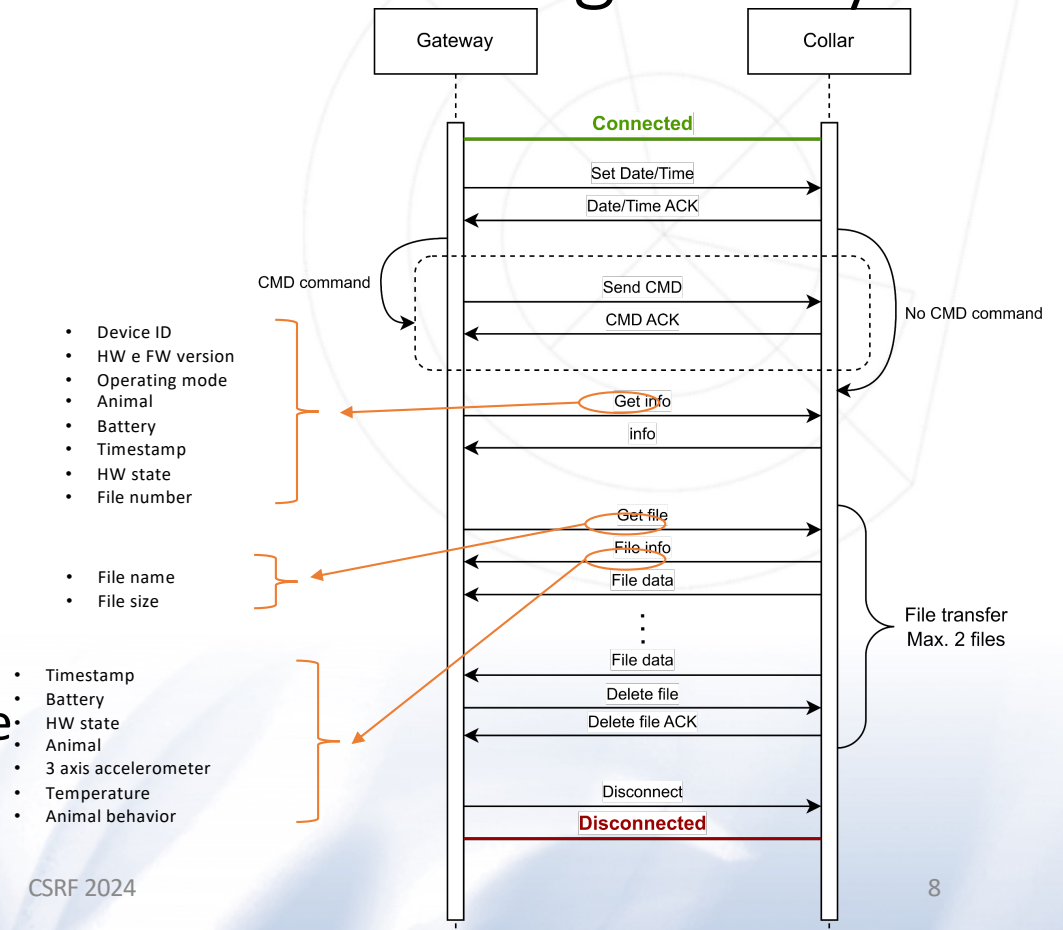


Arducam Mega 5MP AF

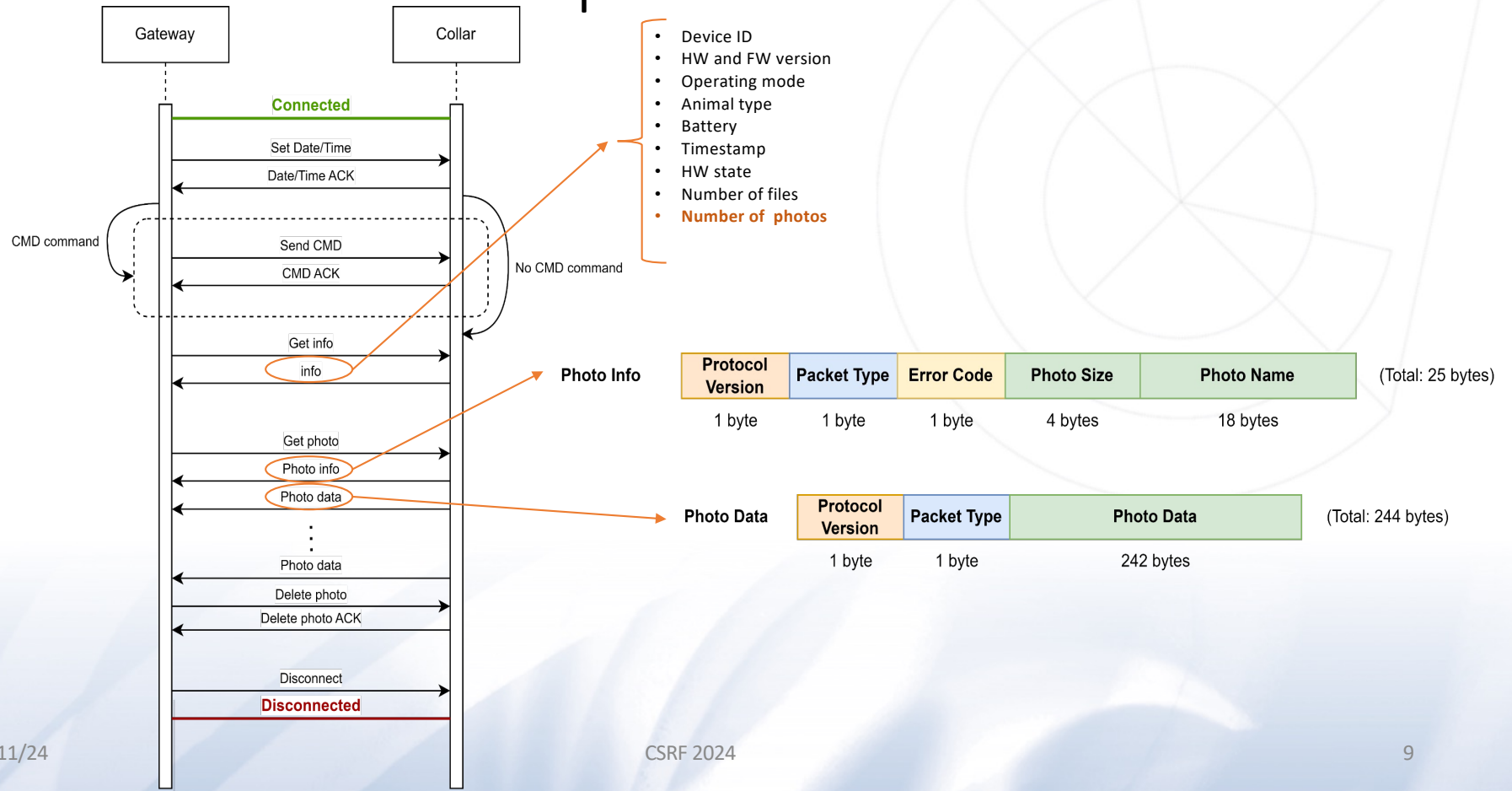


Communication between collar and gateway

- Synchronizing the date and time
- Sending a command (optional)
- Getting collar information
- Requesting a file
- Sending a command to delete the file.



Communication sequence



Resolution selection

Minimum resolution for identifying the images plants



HD (1280x720)



UXGA (1280x720)



**WQXGA2
(2592x1944)**

Image quality and file sizes

Photo 1



Total time: 5.3 sec
Size: 410 kB

Photo 8



Total time: 4.2 segundos
Size : 462 kB

Photo 18



Total time: 6.5 segundos
Size : 727 kB

Photo 20



Total time: 6.9 segundos
Size: 762 kB

- Photo 1: low lighting and with the smallest size;
- Photo 8: shortest total time because it presents a greater blur;
- Photo 18 with a total time and a size of the order of magnitude of photo 20 because it presents a good level of detail, although it does not have as much vegetation;
- Photo 20 with the longest total time and largest size since it is focused with a good level of detail.

Photo analysis of animal worn camera



size: 287.8 kB



size: : 507.9 kB



size : 392.2 kB



size: : 224.3 kB



Time to transfer photos

- Collar positioned at 3 different distances from the gateway
- As the collar moves away from the gateway, transfer times increase
- The presence of obstacles and metal objects between devices disrupts communication, increasing transfer times

Tamanho (kB)	5 meters	15 meters	25 meters
107.6	10s	25s	2m3s
244.8	23s	59s	4m1s
280.6	26s	1m2s	4m42s
392.2	37s	1m34s	6m47s
432.2	40s	1m35s	6m29s
534.6	49s	1m59s	6m47s
638	1m	2m33s	7m51s
761.9	1m13s	2m58s	8m44s

Concurrent transmission

- Time to transfer photos:
 - Case 1: Collar 15 meters away from the gateway
 - Case 2: Collar 15 meters away from the gateway + 4 collars
- The number of collars connected to the gateway affects the photo transfer times
 - and the **number of photos** that can be transferred.

Tamanho (kB)	1 coleira	5 coleiras
107.6	25s	1m12s
244.8	59s	2m55s
280.6	1m2s	3m45s
392.2	1m34s	4m25s
432.2	1m35s	4m58s
534.6	1m59s	5m27s
638	2m33s	7m20s
761.9	2m58s	7m52s

- 1 : \approx 30 photos/h
- 5 collars or more: \approx 11 photos /h

Conclusions

- Photos captured allow the identification of the different flower species
- Capture and storage time and the size of the photos depend on several factors
- Camera angle doesn't allow to identify what is being consumed by the animal
- Photo transfer times depend on the distance between, the number of collars connected and on the environment devices communicate
- Future work:
 - Change the angle at which the camera is placed on the collar
 - Reduce photo resolution
 - Integrate a GPS into the collar to geolocate photos

Thank you

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