THE UNIVERSITY OF DANANG
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INTERNSHIP PROJECT REPORT
M1-FIRST REPORT

Outdoor Cattle Tracking Device using LoRaWAN

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1.1. Overview

a. The motivation of project

In the modern era of agriculture, optimizing livestock management is a key component of ensuring both animal welfare and farm profitability. The integration of cutting-edge technology, such as the Outdoor Cattle Tracking Device using LoRaWAN, has revolutionized the way cattle are monitored and managed in outdoor environments. This innovative device harnesses the power of low-power, long-range communication technology (LoRaWAN) to enable precise and continuous tracking of cattle as they graze, roam, and forage in expansive outdoor areas.

Cattle tracking is of paramount importance in agriculture, particularly for ranchers and livestock farmers. It offers insights into the health, location, and behavior of individual animals, ensuring their well-being and providing data that can enhance operational efficiency. The Outdoor Cattle Tracking Device represents a pioneering solution tailored to the unique needs of outdoor cattle management in various regions, including the vast pastures and open landscapes of rural areas.

b. Existing techniques solutions

There are a lot of solutions which could be purchase by any farmers. During our research, we focused on French solutions, here is some interesting links:

- https://digitanimal.fr/product/localisateur-gps-vaches/
- https://www.geovie.eu/collier-gps-vache/
- https://www.smartbow.com/fr/home.aspx

We also found something really interesting, because there is a chinese solution based on LoRaWAN technology :

- https://www.mokolora.com/fr/livestock-tracking/

1.2. Preliminary solution

a. Technical solution with block diagram

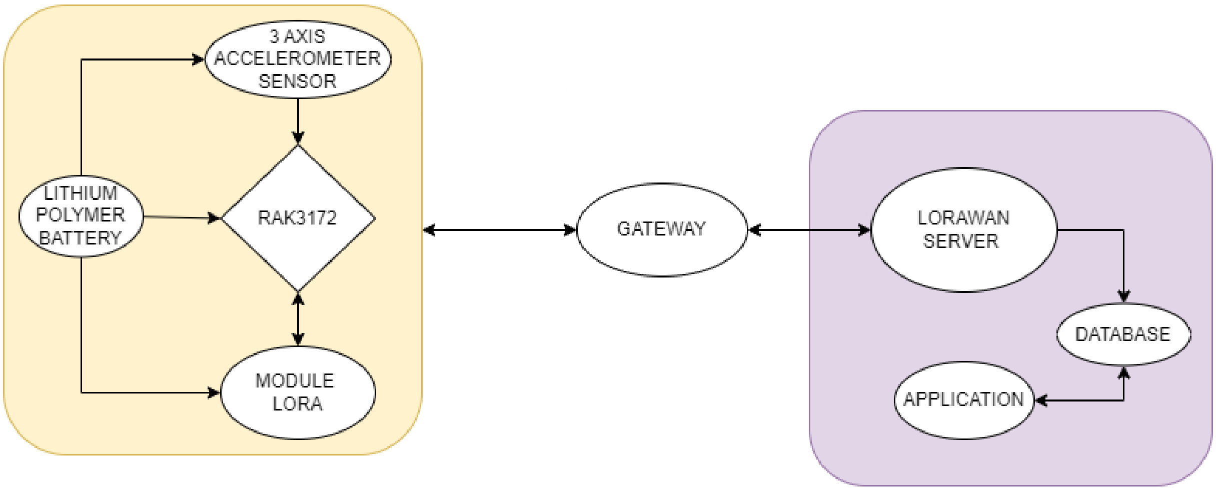


Figure 1-3 System block diagram

To describe this System block diagram, we will speak about each colored part:

- Yellow part: It's about the necklace which will be placed on the cattle. In this necklace, we will need a 3-axis accelerometer sensor which will be used to detect some abnormal behaviors from the cattle based on their movements. We will also need a battery which will be important, a central processing block and a module lora to make a connection with the gateway. For detect the position of the cattle, we will use the RSSI technology, so we don't need GPS sensor (which consume a lot of battery).
- Purple part: It's about the final steps on the application. Our lorawan server will catch all the data, and after transferring it to the application, we will compute some statistics and display it on Grafana.

As we said in the Yellow part, we will use the RSSI signal to compute the cow's localization. This technology is well-known subject because we found 2 scientific articles about it :

- https://www.researchgate.net/publication/334498208_RSSI-Based_Localization_using_LoRaWAN_Technology
- https://www.researchgate.net/publication/361466177_Improvement_of_RSSI-Based_LoRaWAN_Localization_Using_Edge-AI (Improvement of the first article)

Also, there is already some implementation in different programming languages which could be used :

- https://pypi.org/project/rssi/

- https://github.com/ani8897/RSSI-based-Localization-using-ESP32
- https://github.com/xsimka/LoRa-Localization

b. Design process

- ❖ **Stage 1: Determine goals and requirements**
  - Clarify the goals of wearable devices, try to contact some farmers for ask them questions.
  - Set specific requirements such as:
    - Research object of the project.
    - Scope of research and implementation.
- ❖ **Stage 2: Research the technologies used in the system**
  - Overview of LoRa technology.
  - Learn about communication protocols in the system.
- ❖ **Stage 3: Research on microcontroller programming and types of sensors used in the system**
  - Learn about microcontroller programming.
  - Learn about the sensor modules used in the system and how to read values from sensors.
  - Build the IoT part of the project.
- ❖ **Stage 4: System design**
  - Design components in the system.
  - Learn how Grafana works and how we can display some data in.
  - Set up a warning system: The warning system will be trigger if a cattle is lost or steal, or also if we detect some disease with the heart rate sensor.
  - Build the "front-end" part.
- ❖ **Stage 5: Test and check**
  - Conduct performance testing of the wearable device and the associated application.
  - Ensure that the system operates stably and responds properly to the requirements.
  - Try to contact some farmers for realize real-life tests.

c. Requirements for the system

- ❖ **Requirement 1:** For wearable devices

- **3 Axis Accelerometer Gyroscope Module:**
  - Measure parameters: Measure user’s movement.
  - Accuracy: This sensor needs to measure with high accuracy.
- **Connect to LoRa gateway:**
  - Requirements: The device needs to be able to connect to the LoRa gateway over long distances, especially in mountains with natural obstacles such as water and terrain.
  - Farthest distance: Depending on environmental conditions and areas such as urban or suburban, the farthest distance can be 15km under ideal conditions.
  - **Note:** In real environments, the connection distance may be reduced due to various obstacles and environmental conditions.
- **Battery and usage time:**
  - Requirements: The battery needs to have enough capacity to maintain device operation for the expected time.
  - Usage time: Depending on the device's power consumption, the 600mAh, 3.7V Lithium Polymer Battery can provide power for a few hours to a few days, depending on usage. In this context, we want the battery provide power for few days.
  - Size and power consumption: The device needs to be compact in size, save space, and have the lowest possible energy consumption to ensure long-term operation of the device.

❖ **Requirement 2:** For LoRa

To configure LoRa devices, three important parameters are required:

- **Spreading Factor** (SF) is a factor that affects the speed and energy consumption of devices, usually ranging from 7-12. In our context, we will probably choose a high value because we want to protect our battery.
- **BW** (Bandwidth): there are three main types of bandwidths: 125kHz, 250kHz, and 500kHz - the deciding factor in the data rate and transmission distance of the devices. The larger the bandwidth, the shorter the transmission distance, so to achieve the longest transmission distance, choose the smallest bandwidth - 125kHz.

- **CR** (Coding Rate): the factor that affects the time delay when the device transmits data to the LoRa gateway and monitoring software, usually the delay can range from a few seconds to a few minutes. In our context, we can choose few minutes like 2-3 minutes.

❖ **Requirement 3:** For monitoring software

- **Compute position:**
  - Because we don’t have a GPS sensor in our necklace, we have to compute the cow’s position. To compute this position, we will use the RSSI technology.
- **Grafana integration:**
  - Need to use Grafana for display all the information for the farmer.
  - Grafana need to display information such as cattle’s health, cattle’s position etc...
- **Problem warning:**
  - Warn about dangerous situations such as lost/stolen cows.
  - Set safety thresholds for parameters such as cow’s position. When the value exceeds the safety threshold, the software needs to issue warnings and notifications directly on the application.
- **How to warn:**
  - We can ask the farmer’s phone number or email address and contact him if our software detect something.

❖ **Requirements 4:** The server

- **Goal:**
  - The server will act as an intermediary between the application and the IoT components.
- **Operating System:**
  - We will need a Linux-based server (like Ubuntu)
- **Server hardware:**
  - RAM : 4Go minimum
  - Core : 2

d. Main components needed for implementation

List all material/device need to be provided or buy to use in this project

Based on the system requirements mentioned in section C, we have decided to choose the following components to design the system:
3 Axis Accelerometer Gyroscope Module: uses GY-521 6 DOF MPU-6050 sensor.
MCU: uses LoRaWan RAK3172 module.
Battery: choose Lithium Polymer Battery 600mAh, 3.7V.
Protective case: choose a protective case that matches the design and function of the device.
Details about functions, dimensions, and power consumption... will be listed in the following table:

Components	**Devices name**	**Specifications**
MCU	**RAK3172** 	- Dimension: 15 x 15 x 3.5mm - Operating temperature: -40 degrees to 85 degrees - Supply voltage: 2.0-3.6V - Frequency range: 150MHz to 960MHz - Datasheet:[1]
Battery	**Lithium Polymer Battery 600mAh, 3.7V** 	- Dimension: 35 x 20 x 6mm - Weight: 8g - Life cycle: 1000 times - Datasheet:[2]
3 Axis Accelerometer Gyroscope Module	 **GY-521 6 DOF MPU-6050**	- Voltage used: 3~5VDC - Communication voltage: 3~5VDC - Communication standard: I2C - The value of the gyroscopes varies from: +/- 250 500 1000 2000 degrees/sec - Acceleration values are in the range of: +/- 2g, +/- 4g, +/- 8g, +/- 16g - Datasheet:[3]

Protective case	**AK-NW-86**	- Components: upper case, lower case, 4 case screws - Made of UL94-HB ABS plastic with reliable and stable quality - 98*98*32mm - Datasheet:[4]

Table 1-1 Components detail

1.3. Expected results

At the end of our internship, if we manage to fully complete our internship, we will be able to provide users with:

- The necklace that can be put on cows to be able to capture information such as:

With the RSSI signals:

- Her position in real time

With the accelerometer sensor:

- How many time did she eat during the current day (based on her neck's movements)
- If she is staying on the ground since a long time? (If yes, she is probably sick)
- If she is doing randoms movements (If yes, it's a sign of distress)

- The software which allows you to display on Grafana the various information related to the user's livestock:

- Heatmap of the cattle's positions
- Warns if a cow seems to be too far from the farm (loss/theft)
- Cattle's trajectories
- Health statue of the cattle
- Database of cattle/cow's positions
- Database of cattle/cow's behaviors

1.4. Evaluation method

- **Evaluation of effectiveness:**

- We will make some tests in real life where we will put the necklace to someone and try to imitate cow’s behavior.
- If we got some time, we will try also to contact real farmers for test this program in real conditions.

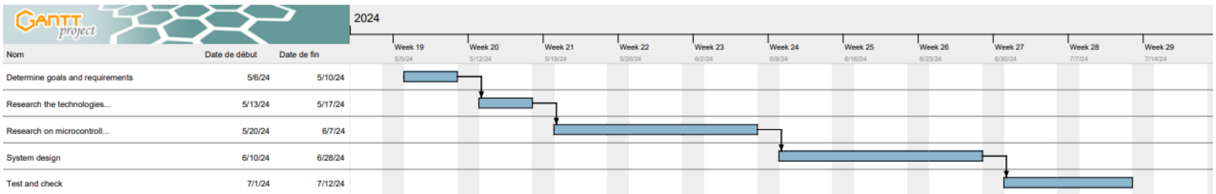
- **Cost assessment:**
  - In this evaluation, we will compute the cost of this program and we will make some tests about the battery, which is one of the most important pieces in the IoT part. We can also make an economy report about this project.
- **Accuracy and performance rating:**
  - In this part, we will try to measure the precision of the cow’s position (or fake cows in our case if we can’t test in real life).

1.5. Plan of implementation

Tasks 2

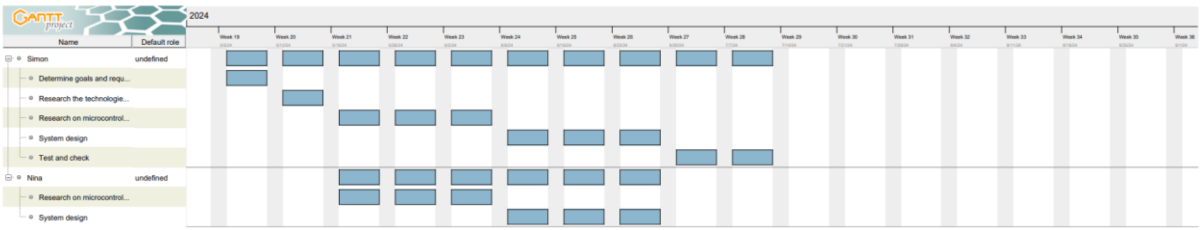
Nom	Date de début	Date de fin
Determine goals and requirements	5/6/24	5/10/24
Research the technologies used in the system	5/13/24	5/17/24
Research on microcontroller programming and types of sensors used in the system	5/20/24	6/7/24
System design	6/10/24	6/28/24
Test and check	7/1/24	7/12/24

Gantt Chart



As you can see on this Gantt Chart, there is a lot a free time during August, but this time is necessary because there will be probably some bugs or problems during the project and maybe some tasks will last longer than expected.

Resources Chart 5



Here is a link of the full document if you got some problems for read the screens : https://drive.google.com/file/d/17sEnmykqeO9y7Fe79slotv6hQ_Bjb_PB/view?usp=sh aring

Timeline		Objectives	Expected results	Confirmation from instructor
06/05 – 10/05/2024	Weeks 1	Determine goals and requirements	Submit the M1 report and get the validation from the supervisor.	
13/05 – 17/05/2024	Weeks 2	Research the technologies used in the system	Make a report for my coworker about LoraWan technology	
20/05 – 7/06/2024	Weeks 3-4-5	Research on micro controller programming and types of sensors	Achievement of a program which send good data to the gateway	
10/06 – 28/06/2024	Weeks 6-7-8	System design	Implementation of the Grafana and retrieve of the data	

01/07 – 12/07/2024	Weeks 9-10	Test and check	Make a report which can describe and prove that our software is finished.	

References

[1]. https://docs.rakwireless.com/Product-Categories/WisDuo/RAK3172-Module/Datasheet/

[2].https://www.lithium-polymer-battery.net/lp502845-600mah-3-7v-li-polymer-battery-2-22wh/

[3].https://www.hotmcu.com/gy521-mpu6050-3axis-acceleration-gyroscope-6dof-module-p-83.html

[4]. https://fr.aliexpress.com/item/1005004592997753.html