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Cow health tracker

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شكر و عرفان

قال تعالى : { وَمَنْ يَشْكُرْ فَإِنَمَا يَشْكُرْ لِنَفْسِهِ } {لقمان:12}

وقال رسوله الكريم ﷺ : " من لم يشكر الناس , لم يشكر الله عز وجل ".

نحمد الله تعالى حمدا كثيرا طيبا مباركا ملئ السموات والارض على ما أكرمنا به لإتمام هذه الرسالة التي نرجوا أن تنال رضاه

وانطلاقا من الآية الكريمة والحديث الشريف نتوجه بجزيل الشكر و عظيم الإمتنان الى أساتذتنا المشرفين رياض خنفر و طالبي محمد الأمين حفظهما الله، لتفضلهما الكريم بالإشراف علينا وإرشادنا، كما نتقدم بجزيل الشكر لأعضاء لجنة المناقشة الكرام لتفضلهم بقبول مناقشة هذا العمل المتواضع. و نود أن نعرب عن خالص شكرنا وامتناننا إلى الطبيب البيطري تواتي محمد الأمين على توجيهه ونصائحه التي ساهمت في إنجاح هذا العمل.

وفي الاخير ، ندين بالكثير لكل من ساعدنا وشارك بشكل مباشر أو غير مباشر في إنجاز هذا العمل.

Dedication

باسم الله الرحمن الرحيم

قال الله تعالى :

{يَرْفَعِ اللهُ الذِينَ آمَنُوا مِنكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ}

To the greatest woman I ever know , my mother Nadia

To the most strong man in my life ,my father Mounir

Thank you for supporting me and make what I am today , May God save and protect you.

To my brothers Adel and Aness.

To my lovely sister Nour .

To my fiance Chemsedine.

To my family Adjil and Boudissa

To all freinds i love .

Last but not leat I wanna thank me for beliving in me , I wanna thank me for doing all these hard work .

Boutheina

Abstract

This thesis describes the development of a cow health monitoring device designed to enhance dairy productivity in Algeria, where there is a growing demand for milk. To address the country's reliance on dairy imports, we collaborated with veterinarians and farmers to identify key health indicators, resulting in the creation of a device that measures body temperature and detects metal ingestion in cows. Our approach involved conducting qualitative surveys to gain insights into user needs, leading to the development of a prototype utilizing an NTC sensor for temperature measurement and a LD209A sensor for metal detection. The device is powered by solar energy and connected via Wi-Fi for real-time monitoring through a mobile application. The results show that the device effectively notifies farmers of health issues, enabling timely veterinary interventions and supporting proactive herd management. Future designs will focus on integrating additional sensors for vital signs and creating a centralized application to enhance functionality. These advancements will empower farmers and veterinarians, ultimately improving animal welfare and productivity in Algeria's dairy sector.

Resumé:

Cette thèse décrit le développement d'un dispositif de surveillance de la santé des vaches conçu pour améliorer la productivité laitière en Algérie, où la demande de lait est croissante. Pour répondre à la dépendance du pays vis-à-vis des importations de produits laitiers, nous avons collaboré avec des vétérinaires et des agriculteurs pour identifier les principaux indicateurs de santé, ce qui a abouti à la création d'un dispositif qui mesure la température corporelle et détecte l'ingestion de métaux chez les vaches. Notre approche a consisté à mener des questionnaires qualitatives pour mieux comprendre les besoins des utilisateurs, ce qui a conduit au développement d'un prototype utilisant un capteur NTC pour la mesure de la température et un capteur LD209A pour la détection des métaux. Le dispositif est alimenté par l'énergie solaire et connecté par Wi-Fi pour une surveillance en temps réel par le biais d'une application mobile. Les résultats montrent que l'appareil informe efficacement les éleveurs des problèmes de santé, ce qui permet des interventions vétérinaires opportunes et favorise une gestion proactive du troupeau. Les conceptions futures se concentreront sur l'intégration de capteurs supplémentaires pour les signes vitaux et sur la création d'une application centralisée pour améliorer la fonctionnalité. Ces avancées permettront aux agriculteurs et aux vétérinaires d'être plus autonomes et, en fin de compte, d'améliorer le bien-être des animaux et la productivité dans le secteur laitier algérien.

الـمـلـخص

تصف هذه الأطروحة تطوير جهاز لمراقبة صحة الأبقار مصمم لتعزيز إنتاجية الألبان في الجزائر، حيث يوجد طلب متزايد على الحليب. ولمعالجة اعتماد البلاد على استيراد الألبان من الخارج، تعاونّا مع الأطباء البيطريين والمزارعين لتحديد المؤشرات الصحية الرئيسية، مما أدى إلى إنشاء جهاز يقيس درجة الحرارة ويكشف عن ابتلاع الأبقار للمعادن. تضمن نهجنا إجراء دراسات استقصائية نوعية لاكتساب رؤى حول احتياجات المستخدمين، مما أدى إلى تطوير نموذج أولي يستخدم مستشعر NTC لقياس درجة الحرارة ومستشعر LD209A للكشف عن المعادن. يتم تشغيل الجهاز بالطاقة الشمسية ويتم توصيله عبر الواي فاي للمراقبة في الوقت الفعلي من خلال تطبيق للهاتف المحمول. أظهرت النتائج أن الجهاز يخطر المزارعين بفعالية بالمشكلات الصحية، مما يتيح التدخلات البيطرية في الوقت المناسب ويدعم الإدارة الاستباقية للقطيع. ستركز التصاميم المستقبلية على دمج أجهزة استشعار إضافية وإنشاء تطبيق مركزي لتعزيز الوظائف. ستعمل هذه التطورات على تمكين المزارعين والأطباء البيطريين، مما يؤدي في نهاية المطاف إلى تحسين رعاية الحيوانات والإنتاجية في قطاع الألبان في الجزائر.

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List of Abbreviations

IOT Internet Of Thing

MQTT Message Queuing Telemetry Transport

HTTP Hypertext Transfer Protocol

COAP Constrained Application Protocol

General introduction

1. Introduction

Dairy is the second most crucial food in Algeria after grains. The country is one of the world's largest consumers of dry milk powder. The Algerian government aims to improve local dairy production to reduce import dependence.

Algeria currently produces 2.5 million metric tons of milk annually, while the market needs 4.5 million tons. The government has implemented various programs to boost milk production and address this shortage. These include providing subsidies to breeders, milk collectors, and processors and support for calf birth, veterinary care, and vaccinations.

In 2022, the Ministry of Agriculture launched a new program to increase the number of dairy cows and encourage heifer nurseries. They also decided to allow imports of dairy cattle again to improve milk production and reduce milk powder imports.

In a significant development, Baladna, Qatar's largest dairy producer, has agreed to set up a massive dairy farming project in Algeria, planning to use over 250,000 dairy cows.

New technologies are being developed to improve milk production efficiency. For example, a Dutch company has created a 'cold chain' system that allows fresh milk to be transported safely long distances.

Furthermore, advanced technologies like robotics, artificial intelligence, and the Internet of Things are transforming dairy farming. Robotic milking systems, for instance, have been shown to increase milk production while reducing stress on the animals. These innovations are making the dairy industry more efficient and sustainable.

2. The challenges facing farmers and vets in traditional monitoring

Milk production remains low even though most herds are cows bred to produce milk. This is because there are no sound systems for collecting and storing information about the herds. Managing breeding is also difficult because farmers do not assess the cows' body condition well enough.

Several things could be improved in livestock breeding. These include not timing insemination well with cows in heat, not noticing when cows are in heat often enough, waiting too long to check if cows are pregnant, and not giving cows enough rest between pregnancies. Farms are not using new technologies much, which shows they are not getting enough technical help.

Vets and farmers face significant challenges in traditional monitoring. Farmers often do not want to follow vets' advice because they have other things they think are more important. Also, vets do not have enough time or information to give good advice about preventing diseases before they happen.

3. The development of monitoring embedded systems in the livestock field

Monitoring embedded systems in livestock farming uses advanced technology to improve animal management and care. These systems often use sensors and devices placed on animals or their environment to collect data about their health, behavior, and surroundings.

3.1. IoT-based livestock monitoring

Internet of Things (IoT) technology has changed how farmers watch over their animals. Using IoT gateways, sensors, and devices, farmers can gather and analyze real-time data about animal health, environmental conditions, and resource management.

These IoT systems work together to oversee various aspects of livestock farming. They give farmers a complete view of their animals' well-being and productivity, allowing them to take proactive measures and improve output.

IoT technology continuously monitors key metrics, enabling early disease detection, precise feeding and breeding strategies, and optimal environmental conditions for the animals.

4. Objective

Our device aims to make monitoring cow health easier for farmers and veterinarians. It measures temperature in real time and detects iron that cows swallow while eating. The device includes a Wi-Fi-connected application that stores daily data for each cow, making it easier for veterinarians to diagnose potential diseases in the future.

5. Motivation

Algeria's investments and our survey of veterinarians encouraged us to pursue this field. Private Sector Investment:

Foreign investors are interested in Algerian dairy production. Baladna, Qatar's largest dairy producer, plans to set up a herd of over 270,000 dairy cows on 117,000 hectares. The Almarai group has also shown interest in potential dairy operations in Algeria.

Subsidies:

The government provides over 18 billion Algerian Dinars annually to support local fresh milk production. This includes dairy cattle breeders, milk collectors, and dairy processors subsidies. Breeders also receive money for new cow births, veterinary care, and vaccinations.

Algeria is one of the top consumers of milk products, with an average of 150 liters per person per year in 2015. This is higher than the World Health Organization's standard of 90 liters. However, local production only meets 33% of demand, leading to high import costs of about 868 million dollars annually.

6. Results of a survey with veterinarians

We surveyed 8 veterinarians in Bordj Bou Arreridj on February 1, 2024. All of them agreed that our device would effectively monitor cow health and save them time and effort. They all supported measuring temperature, with 75% saying a once-daily measurement is enough. All vets agreed that cows eating minerals are a health threat. Opinions varied on the usefulness of counting how often cows eat minerals.

7. Problem

Early detection of health issues is crucial to prevent large-scale livestock loss. The faster we identify threats, the quicker we can respond and potentially save animals. Dairy farmers struggle to detect early cattle health issues, leading to lower milk production and higher veterinary costs. Traditional methods like visual checks and manual temperature taking are time-consuming and may only notice problems once they worsen.

8. Hypothesis

A real-time IoT-based cattle health monitoring system will help detect health issues earlier than traditional manual methods. The device will alert farmers to problems via a mobile app by constantly tracking body temperature and metal ingestion. This will allow veterinarians to pre-diagnose issues and advise on the proper treatment quickly.

CHAPTER 1

COW HEALTH MONITORING

1. Introduction

It is essential to monitor the health of cattle to ensure high milk production to meet the population's increasing demands and achieve sustainability. Conventional methods of disease detection based on health conditions require improvement. Digital technologies such as the Internet of Things, artificial intelligence, and cloud computing are used to tackle this issue. These technologies facilitate real-time monitoring, intelligent analytics, secure data distribution, and real-time visual experiences. Challenges in monitoring cattle health include the integration of IoT, optimization of data collection, and accurate disease detection. Addressing these challenges can improve future efforts in monitoring cattle health.[2]

Dairy cows risk encountering various health issues, including disease, worms, and bacterial infections. It is imperative to enact preventive measures and ensure proper health care for the cows to mitigate these health problems' proliferation.[3]

2. Monitoring

Monitoring is collecting, processing, aggregating, and visualizing real-time quantitative data about a system. Within the framework of an application, the data being assessed could encompass the number of requests, the number of errors, the latency of requests, the latency of database queries, and the utilization of resources. Monitoring is a set of techniques for analyzing, controlling, and monitoring actions. Monitoring helps us to ensure the reliable operation of our application.

3. Cow health monitoring

Surveillance of the actions of dairy cows holds promise in enhancing their overall well-being, health, and efficiency. As a result, employing sensors affixed to various body regions of the cows (the neck, leg, and back,etc) proves beneficial in quantifying these behaviors. Many sensors are utilized to anticipate ailments, stress levels, and other factors. Nevertheless, their effectiveness is limited by factors like size and energy consumption. [1] The earlier detection of disease enhances response to treatment and prevents disease progression.

Cattle health surveillance plays a crucial role in safeguarding the well-being of cattle. Digital technologies have garnered significant interest across various sectors, enabling real-time monitoring and prediction. Insufficient monitoring of cattle health can lead to a decline in the quality of milk production. Enhancements to traditional methods related to cattle health are necessary to address the time constraints associated with detecting illnesses based on the animals' health status. Monitoring cows' health effectively involves several steps and IoT technology. Here is a structured overview:

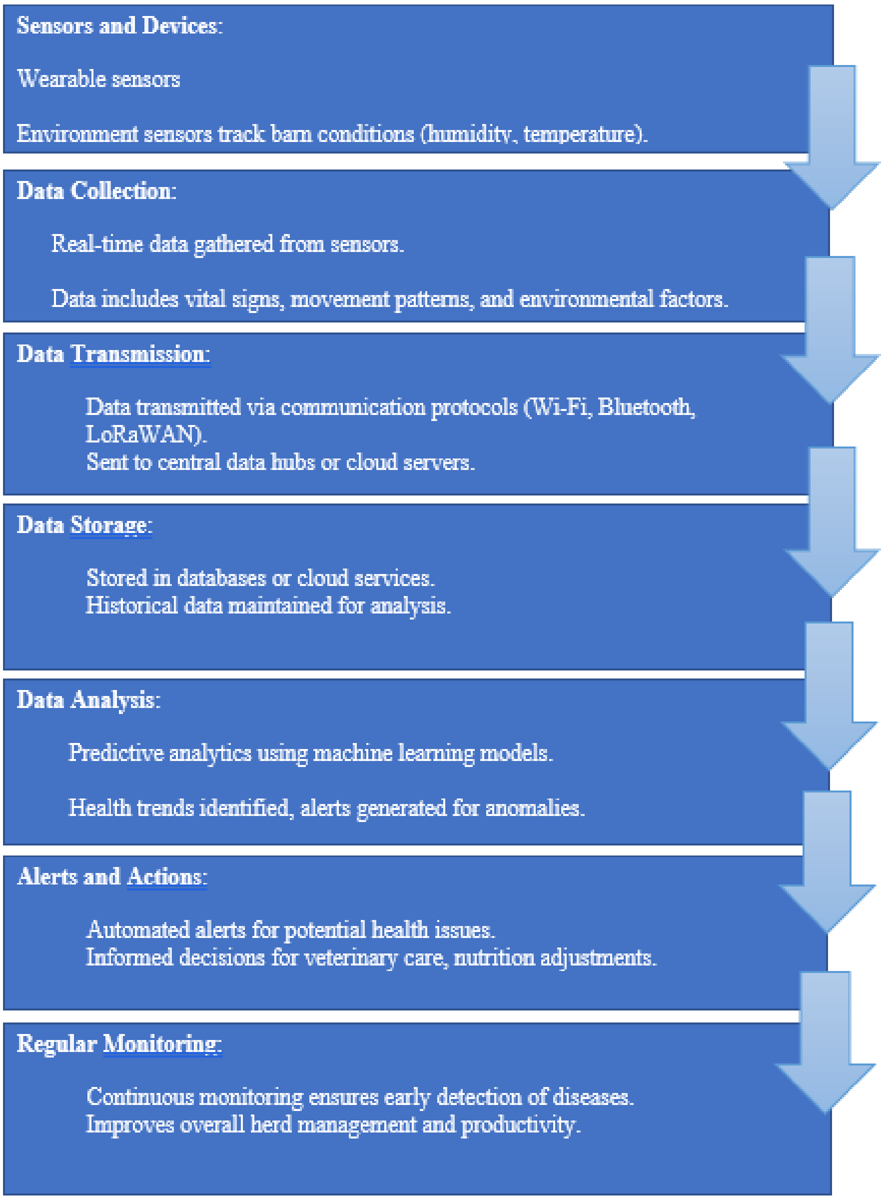

Figure I.1 : Cow health monitoring steps

4. Using of embedded system in Monitoring Cow

4.1. Embedded systems

An embedded system combines computer hardware and software designed for a specific function. Embedded systems may also function within a more extensive system. The systems can be programmable or have a fixed functionality. [8]

Embedded systems have three primary components:

4.1.1. The three main components of embedded systems

1. Hardware: Microprocessors and microcontrollers are fundamental hardware components within embedded systems. Typically, they include a central processing unit (CPU) connected to other essential computing devices, such as memory chips, power supplies, and LCDs.

2. Application software: Embedded system software comprises specialized programming tools that facilitate the operation of machines. The complexity of the software may differ based on the specific devices it is intended to manage.

3. A real-time operating system (RTOS). An RTOS is a special operating system designed to respond to external events extremely quickly.[10]

4.1.2. Characteristics of Embedded Systems

Embedded systems come in different levels of complexity, but they are all tailored for specific tasks:

- Microprocessor-based or microcontroller based.
- Frequently used for Internet of Things (IoT) devices.
- Time-sensitive function execution. [10]

4.2. Cow health monitoring using embedded systems

Animal health observation methods require reliable, top-notch, and practical data for making informed decisions. Diverse technologies are employed for monitoring animal health. Combining data from multiple sources can aid in early detection and response to animal diseases and early control of outbreaks. In this section, we will see the uses of embedded systems in monitoring cow health

Embedded systems are crucial in modern livestock management, particularly in monitoring cows' health. These systems typically consist of various hardware components and sensors that collect real-time data, which is then processed and communicated for effective health monitoring.

Animal health monitoring is a critical component of livestock care. Wearable devices equipped with embedded systems gather essential information about the health status of animals. This data, provided in real-time, enables farmers to detect potential health problems promptly, leading to timely interventions and decreasing the likelihood of disease outbreaks. **[4]**

The core hardware components include microcontrollers and processing units. They serve as the central brain of the system, managing the data from various sensors. Typical sensors used in cow health monitoring. These sensors are strategically placed on the cow's body to collect vital health information continuously.

Utilizing these advancements and their integration offers advantages to farmers as they can regularly monitor dairy cattle without disrupting their natural behavior. The incorporation of these tools through computer-controlled programs, for example, can serve as valuable assets in enhancing detection rates, gaining a better understanding of the fertility level of the herd, increasing the farm's profitability, and minimizing labor. **[5]**

5. The IOT

The Internet of Things (IoT) is a network of interconnected physical devices capable of exchanging data autonomously without human involvement. This network extends beyond traditional computers and machinery, encompassing any object with a sensor and a unique identifier (UID). The fundamental objective of IoT is to develop devices that can autonomously report their status and interact with one another, as well as with users, in real-time. [10]

5.1. The Internet of Things in Health Care

The Internet of Things (IoT) reduces the reliance on conventional record-keeping methods and enhances patient safety by providing real-time notifications. [9]

5.2. Cow health monitoring using IoT

Integration with IoT platforms allows for seamless data analysis and visualization. Farmers can monitor the health status of their herd remotely through mobile applications or computer interfaces, making informed decisions promptly. Combining embedded systems and IoT ensures a proactive approach to livestock health management, improving overall farm productivity and animal welfare.

IoT devices rely on embedded systems to bridge the gap between the physical and digital realms. These systems are responsible for gathering sensor data, analyzing it, and using predetermined algorithms to make informed choices. As a result, they can react to particular events or initiate actions with tangible consequences in the real world Integrating embedded systems in IoT devices has opened up countless possibilities for enhancing various sectors such as healthcare, transportation, agriculture, industrial automation, and more. In agriculture, embedded systems assist in precision farming, enabling efficient water usage, pest control, and crop yield optimization.[6]

5.3. **Data transmission with IOT**

Data transmission using the Internet of Things (IoT) involves sending collected data from sensors and devices to a central system for analysis. This process enables real-time monitoring and analysis in various applications, including agriculture, healthcare, and smart cities.

At the core of IoT data transmission is data collection from connected devices. The gathered data is transmitted through communication protocols like MQTT, HTTP, or CoAP to a cloud server or an edge device.

Upon reaching the central system, the data undergoes processing and analysis. This real-time data analysis allows immediate insights and critical decisions, enhancing efficiency and response times. For example, real-time cow health monitoring can alert farmers to potential issues, allowing for prompt intervention.

The importance of effective data transmission in IoT cannot be overstated. It ensures the accuracy and timeliness of the information being analyzed, which is vital for maintaining operational efficiency and improving outcomes across various sectors [7]

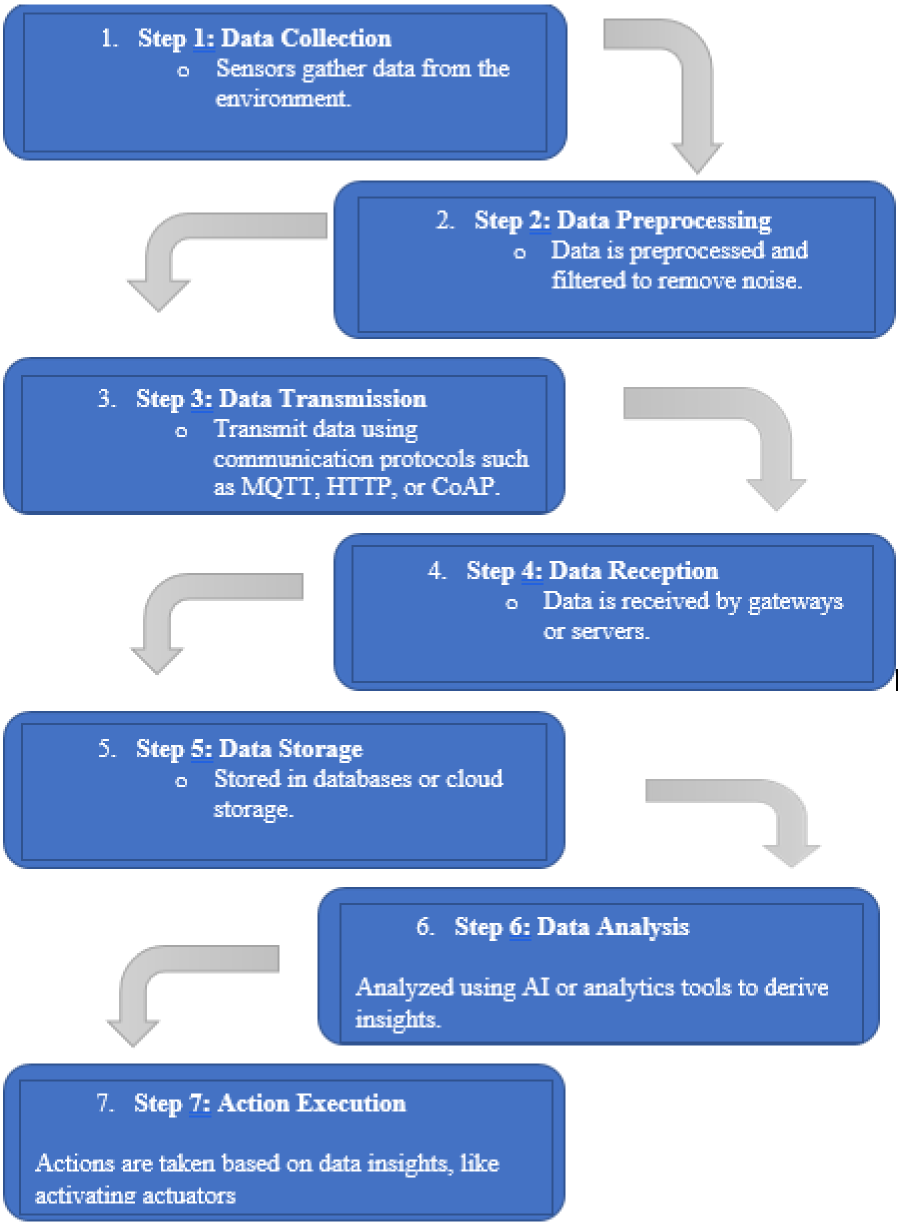

Figure I.2 : Timeline of IoT Data Transmission Steps

6. Conclusion

In conclusion, the integration of embedded systems with IoT technologies, wireless sensor networks, and cloud services presents innovative solutions for efficient livestock monitoring and management, ultimately leading to improved animal health, increased productivity, and sustainable farming practices.

CHAPTER 2

METHODOLOGY AND MATERIALS.

1. Introduction

This section provides an outline of the research methods that will be employed throughout the project. It displays the processes and procedures employed throughout the project and how the results are presented.

2. Development Research Approaches

Initially, our interest lay in the medical field, but we soon narrowed our focus to animal health. To gain insight into the challenges faced by veterinarians, particularly in Algeria, we engaged in discussions with multiple practitioners. These conversations also touched upon the mindset of Algerian agricultural workers.

To further our understanding, we conducted a survey involving approximately ten veterinarians. We inquired about their thoughts on a potential device that could connect to breeders' phones and asked for their input on the features such a device should include.

The insights gathered from these surveys and discussions ultimately led to the development of our idea. This concept emerged after multiple experimental approaches.

2.1. Experimental approach

The data to be used are cow health parameters such as body temperature and metal detection for the early detection of Reticuloperitonitis (RPT) disease in cows. Gathering this information will allow veterinarians and farmers to have a full monitoring system for their cows via their phones. The RemoteXY application will be used to collect information to offer statistical analysis.

This will help with the early detection of RPT disease. When the body temperature and metal detection parameters are abnormal, the farmer will be notified through the application.

Design and System Development Methodology

2.2. Prototyping model steps

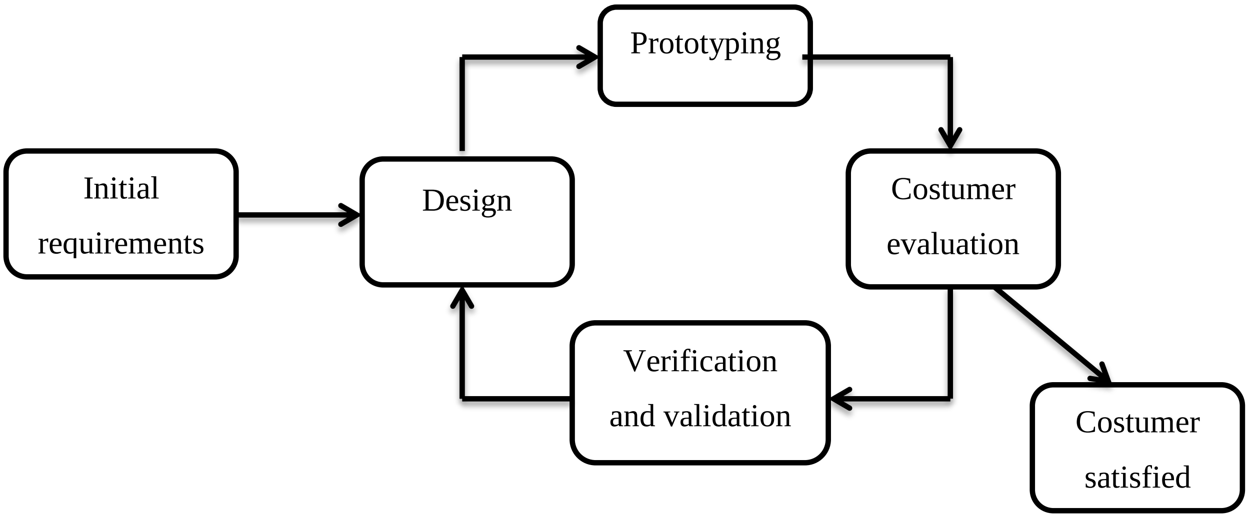

Figure II.1 : steps we follow during our study.

Figure II.1 represents the steps we did during our research and our journey of making and developing the device; while the first step was asking veterinaries and searching for breeders needs, depending on this information, we tried to propose a design that suits it well; we do a prototype to it and continue verifying and try to validate the design at the same time we show to the veterinaries so we can get his opinion and what he thinks we should add or change then getting back to verification and validation after the changes accrued till the veterinaries and the breeders are satisfied and okay with design so we can get it to the market.

3. Requirements for Hardware and Software

3.1. Hardware requirements

The following components are some of the components and the initial ones we used in our device.

3.1.1. Esp32

ESP32 is a powerful and cost-effective platform for developing IoT applications with 38 pins, as shown in Figure II.2. It provides a robust set of features and capabilities, including:

1. A dual-core processor
2. Built-in Wi-Fi and Bluetooth connectivity
3. Many general-purpose input/output (GPIO) pins
4. Low power consumption

The ESP32's higher processing power facilitates multitasking and efficient execution of complex tasks. It is designed to be energy-efficient, enabling the development of sustainable IoT applications. The chip offers sleep modes and power management features that help minimize power consumption, making it suitable for battery-powered or power-constrained projects.

The ESP32 can be connected to displays, touchscreens, or LED indicators for user interaction, providing operators or employees with an easy-to-use interface.

The ESP32 supports various development frameworks and programming languages. The most used language is C++, which can be programmed using the Arduino IDE [11].

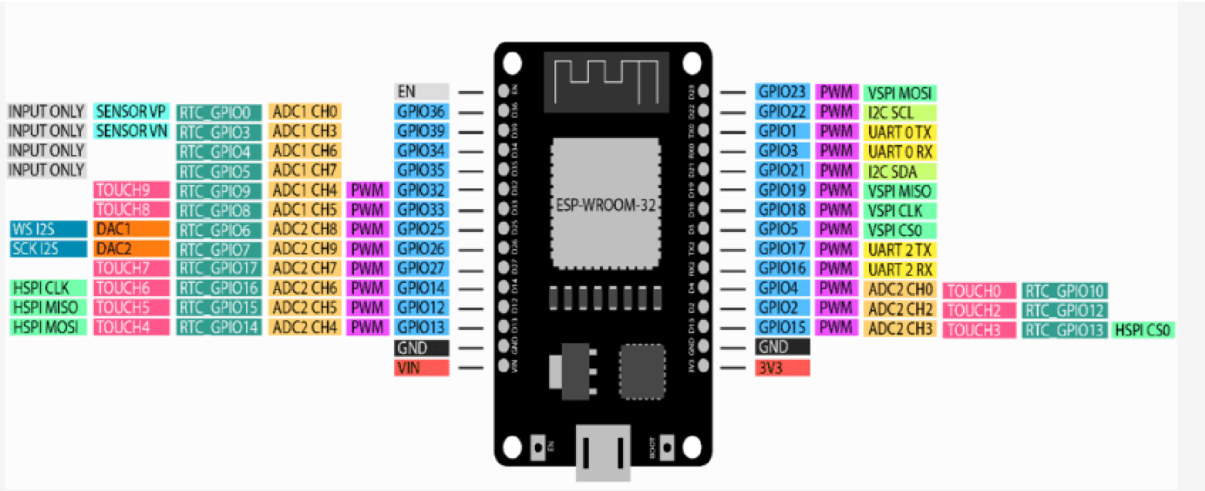

Figure II.2 : ESP32 pins. [33]

3.1.1.1 Advantages [23]

- **Robust Design:** ESP32 can function reliably in industrial environments, with an operating temperature range from –40°C to +125°C. This allows it to adapt to various external conditions.
- **Ultra-Low Power Consumption:** Engineered for mobile devices, wearable electronics, and IoT applications, ESP32 achieves ultra-low power consumption. It includes various power modes and dynamic power scaling to optimize energy use.
- **High Level of Integration:** ESP32 is highly integrated with built-in components such as antenna switches, RF balun, power amplifier, low noise receives amplifier, filters, and power management modules.

- **Hybrid Wi-Fi & Bluetooth Chip:** ESP32 can function as a complete standalone system or as a slave device to a host MCU, reducing communication stack overhead on the main application processor. It can interface with other systems to provide Wi-Fi and Bluetooth functionality through its SPI/SDIO or I2C/UART interfaces.
- **Internet of Things (IoT) [11]**

  The Internet of Things (IoT) is a network of devices, users, and services whose connectivity enables sensing, decision-making, and feedback. IoT solutions facilitate remote monitoring and operation of industrial environments, as well as the monitoring of remote, unconnected areas.

  Four essential characteristics define an IoT device:

  - **Data Collection and Transmission:** The device must be able to obtain data from its surroundings and transmit it to other devices or directly to the internet.
  - **Reactivity:** The device must react according to the current conditions.
  - **Information Reception:** The device must be able to receive information from the network.
  - **Connectivity:** IoT devices belong to a network that communicates through nodes. These devices must support connectivity with other devices on the same network.
- **Wi-Fi Communication [12, 13]**

Wi-Fi has become an essential part of our fast-paced daily lives. Thanks to Wi-Fi, we no longer need cables to connect to the internet. Wi-Fi uses radio waves to transmit information via frequencies between our device and the router. Two radio frequency bands are commonly used, depending on how much data is sent: 2.4 GHz and 5 GHz. The higher the frequency, the more data can be transmitted per second.

While many older routers operate at 54 megabits per second (Mbps), modern Wi-Fi standards allow for much higher speeds, with some capable of several gigabits per second.

The following three components are typically involved in Wi-Fi communication:

- **Ethernet (802.3) connection / Base station:** This is the main host network that provides a wired connection to the router.
- **Access point:** It accepts a wired Ethernet connection and then converts it into a wireless connection. It then extends the connection as radio waves.
- **Accessing devices:** These are the physical devices with Wi-Fi capability that we use to connect to the internet.

3.1.2. Batteries

Batteries are devices that receive, store, and release electricity on demand. They use chemistry to store energy in the form of voltage. A battery consists of two electrical terminals called the cathode and anode, separated by an electrolyte chemical. Once charged, the battery can be disconnected from the circuit to store chemical potential energy for later use as electricity.[14]

Batteries come in different shapes, sizes, and electrical capacities, designed around their intended use. They are categorized as either:

- **Primary:** Non-rechargeable, designed for one-time use.
- **Secondary (Rechargeable):** Available for repeated use.

Secondary batteries can store and conduct direct current (DC) multiple times [15].

3.1.2.1 Lithium-ion Batteries with Battery Management Systems (BMS)

Lithium-ion batteries are popular for high-demand applications due to their high energy density. However, aggressive operation can reduce cycle life and unpredictable thermal runaway reactions, diminishing the battery's functional capacity.

To address these challenges, lithium-ion battery systems incorporate a Battery Management System (BMS), as shown in Figure II. 3.

3.1.2.2 The BMS

- Controls current flow to maximize performance while maintaining safety
- Uses current, voltage, and temperature data to estimate:
  - State of Charge (SOC): Amount of charge remaining in the current cycle
  - Current total capacity state: Decreases with battery age
  - Maximum available power for both charge and discharge
- Employs a built-in predictive model for safe operation, performance optimization, and effective cell balancing.[16]

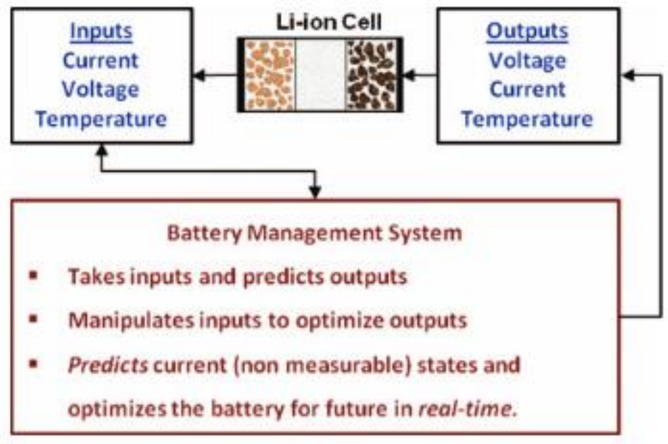

Figure II. 3 : Schematic displaying the connections between the battery and the battery management system.[16]

3.1.2.3 Li-Ion batteries Advantages

- High energy density (up to 300 WH/kg).
- High voltage.
- Low maintenance.
- No memory effect.
- low self-discharge rate.[24]

3.1.2.4 Batteries charging

Integrating batteries with solar cells enables efficient energy conversion and storage. However, safety considerations are crucial. When a battery is charged with a voltage exceeding its rated value, overvoltage can occur, potentially damaging the battery system or causing an explosion. To address this issue, the charging voltage of the solar cell and battery can be synchronized.

By setting the solar cell's charging voltage lower than the battery's overvoltage threshold, long-term safe operation can be achieved. However, this approach presents a trade-off: if the charging voltage is lower than the battery voltage, the battery cannot reach full charge. Consequently, it is essential to implement a system that accurately synchronizes voltages from both devices, allowing for safe transmission of large amounts of electrical energy. [17]

3.1.3. Solar Energy

Solar energy has gained significant attention as a renewable energy solution, offering potential for energy independence and environmental stability while becoming increasingly cost-competitive. Government support and private investments have fueled technological advances, propelling solar energy towards becoming a major energy source. [18]

The photovoltaic effect, fundamental to solar energy conversion, occurs when semiconductor materials absorb light photons and generate electric current by converting light energy into electrical energy.

Several factors influence photovoltaic cell efficiency, including light reflection and transmission on the cell surface, material resistance losses, and electrical contact quality. Generally, photovoltaic cell performance decreases as temperature rises. [19]

3.1.4. Solar and Batteries

Opting for a comprehensive solar power and energy storage system empowers users to take control of their energy future. This choice extends beyond cost savings, offering energy independence and positive environmental impact. Residential solar solutions provide long-term savings and sustainability for homes, whether the goal is to reduce energy bills or optimize electricity usage. These systems enhance the value and sustainability of residential properties, often a homeowner's most significant asset.

3.1.5. NTC

A thermistor is a type of resistor that changes its electrical resistance in response to temperature changes (Figure II.4). They're frequently used in temperature measurement and control applications.

Measuring temperature with a thermistor involves passing a known current through it and measuring the voltage drop across it. The change in resistance, and hence the voltage drop, corresponds to a specific temperature.

Thermistors offer several advantages, such as high sensitivity to temperature changes, small size, low cost, and a wide range of resistance values. [20]

Thermistor resistance and temperature is expressed in the equation:[26]

$$R = R_0 . e^{[\beta\left(\frac{1}{T}-\frac{1}{T_0}\right)]} \tag{II.1}$$

where:

R(T) = Resistance at some temperature (in ^oK);

R_o (T_o) = Resistance at an initial measurement (reference)

$T_0 = 298\ ^oK$.

β = Dissipation or thermistor material constant.[20]

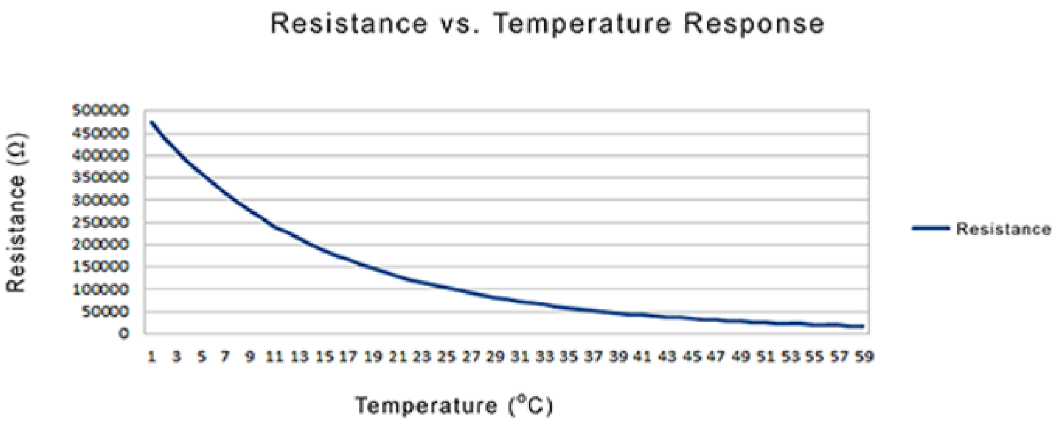

Figure II. 4 : Resistance-temperature characteristics.[31]

3.1.5.1 How It Works

NTC thermistors operate based on semiconductor material behavior. These devices use metal oxides, ceramics, or polymers with a negative temperature coefficient. As temperature increases, charge carrier movement within the material increases, causing a decrease in resistance as shown in the Figure II. 4 previously.

The resistance-temperature relationship of an NTC thermistor is highly nonlinear. This nonlinearity enables precise temperature sensing within specific ranges. NTC thermistors are characterized by two key factors:

1. Their resistance at a reference temperature, known as the "nominal resistance"
2. Their resistance-temperature curve, or "R-T curve"

These characteristics define the thermistor's behavior and performance in temperature sensing applications. [21]

3.1.5.2 Advantages

- **High Sensitivity:** NTC thermistors exhibit high sensitivity to temperature changes, making them ideal for precise temperature measurement and control in various applications.

- **Wide Temperature Range:** They function from cryogenic temperatures to several hundred degrees Celsius, allowing versatility in different environments.
- **Fast Response Time:** This enables quick and accurate temperature sensing and control in dynamic systems.
- **Compact Size:** NTC thermistors are available in small, compact sizes. [21]

3.1.6. LD209a Proximity Detector

The LD209A is a bipolar monolithic integrated circuit for use in metal detection/proximity sensing applications. As shown in Figure II.5 The IC contains two on−chip current regulators, oscillator and low−level feedback circuitry, peak detection/demodulation circuit, a comparator and two complementary output stages. [22]

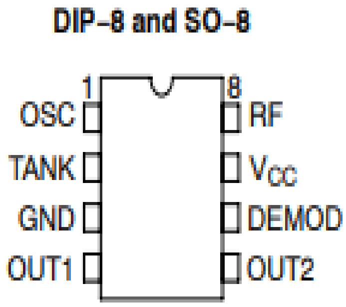

Figure II. 5 : LD209A ship. [32]

3.1.6.1 Principle of operation

The LD209A metal detector circuit operates by detecting a reduction in the Q-factor of an inductor when metal is nearby. It contains an oscillator set up by an external parallel resonant tank and a feedback resistor. As metal approaches the inductor, the voltage amplitude across the tank drops, causing the IC to switch output states.

Detection occurs through a capacitor at DEMOD, charged by an internal current source and discharged proportionally to the tank's negative bias. The DEMOD voltage is compared to an internal reference with hysteresis to prevent false triggering.

The feedback potentiometer between OSC and RF adjusts the detection distance range, with larger resistance increasing the trip-point distance. [22]

3.2. Software

3.2.1. RemoteXY

RemoteXY is a platform for creating and using mobile graphical user interfaces (GUI) to control microcontroller boards such as Arduino via smartphone or tablet. Key features include:

- An online editor for designing custom GUI interfaces.
- A mobile app that connects to boards and controls them using the GUI interface.
- On-board GUI storage, allowing mobile app connection without downloading the interface.
- Support for various connection methods: WiFi, Bluetooth, Ethernet, and USB
- Compatibility with multiple microcontroller boards including Arduino, ESP8266, and ESP32.
- Ability to control multiple devices with different GUI interfaces using a single mobile app.

RemoteXY simplifies the process of creating and implementing custom control interfaces for microcontroller-based projects. [25]

3.2.1.1 How it works

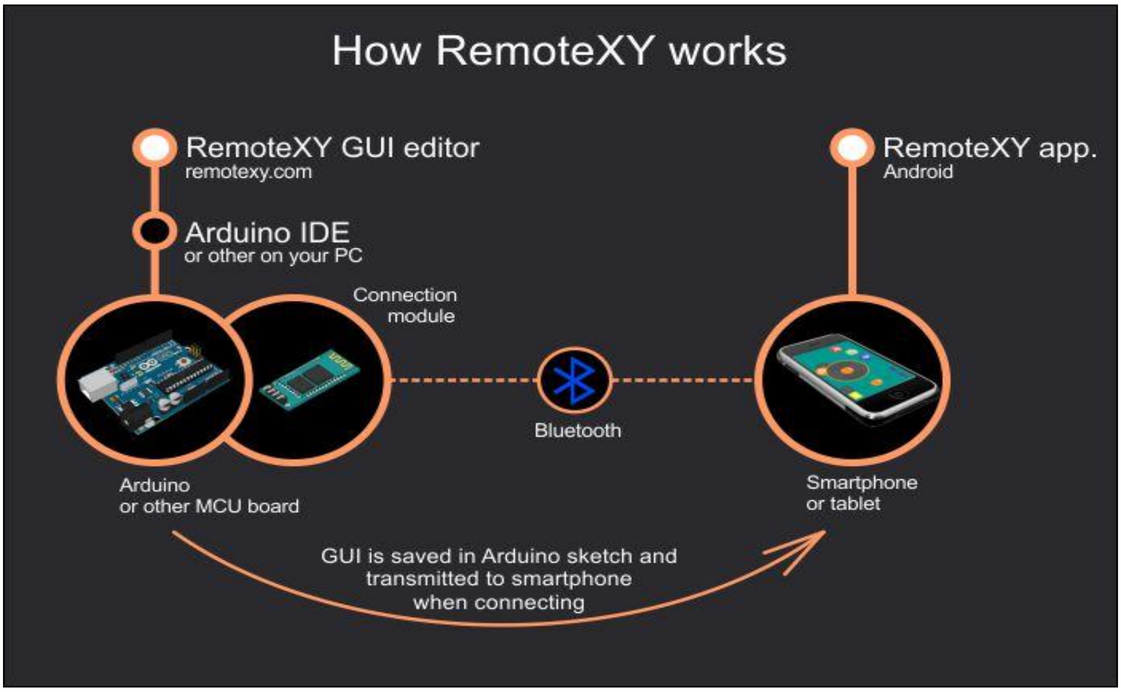

Figure II.6 : how RemoteXY works. [25]

Figure II.6 shows how the application RemoteXY application connect the smart phone with the ship using Bluetooth or WIFI or even the cloud.

4. Conclusion

In this chapter, we detailed the methodology and materials used in developing our livestock health monitoring system. We engaged in discussions with veterinarians and conducted a survey to understand the challenges in animal health monitoring, particularly in Algeria. Our experimental approach focuses on gathering crucial cow health parameters, such as body temperature and metal detection, to enable early detection of Reticuloperitonitis (RPT) disease. We discussed the hardware components of our system, including the ESP32 microcontroller and key sensors such as NTC thermistors for temperature measurement and the LD209A proximity detector for metal detection. On the software side, we're utilizing RemoteXY, a platform that enables the creation of custom mobile interfaces for controlling microcontroller boards, allowing farmers and veterinarians to easily access and monitor cow health data through their smartphones. Our aim is to create an effective, user-friendly system that addresses the real needs of livestock farmers and veterinarians, potentially revolutionizing cow health monitoring in Algeria and beyond.

CHAPTER 3

DESIGN AND ANALYSIS OF THE SYSTEM

1. Introduction

Algeria heavily relies on imported milk powder and meat due to insufficient domestic production, largely attributed to traditional cattle management practices. To address this issue, we propose a user-friendly smart wireless tracking device. This innovation aims to contribute to the development of the livestock sector and initiate efforts to mitigate the current crisis. Our project focuses on developing a prototype for monitoring cow health, specifically targeting two key parameters: temperature measurement and detection of metallic object ingestion, which can lead to traumatic reticulitis. The system comprises two primary components: hardware and software. In the following sections, we will provide a detailed description of each component. The final section will outline the system's functionalities and present results from practical experiments.

2. Block diagram of the system

The diagram in Figure III.1 illustrates the key components of the proposed system and the interconnections between its elements. The green sections represent software components, while the gray sections indicate hardware components.

The hardware part includes a power supply, ESP32 microcontroller, temperature sensor circuit, and metal detector circuit. The software part is composed of WiFi communication, a free mobile application, and Google Sheets integration.

3. System analysis

Figure III.2 represents the proposed circuit of the cow health tracker system. While this is not the final product, it serves as a functional prototype. The circuit incorporates several key components, with the ESP32 microcontroller at its core. We carefully selected the ESP32 for its accuracy, WiFi communication capabilities, and 38 available pins, which are crucial for our current needs and future developments. This choice enables us to leverage IoT technology, allowing remote cow health monitoring from anywhere in the world using a free mobile application and cloud data storage. It's worth noting that we arrived at this decision after experimenting with Arduino UNO boards and ESP-01 WiFi modules, a process that consumed significant time but yielded valuable insights.

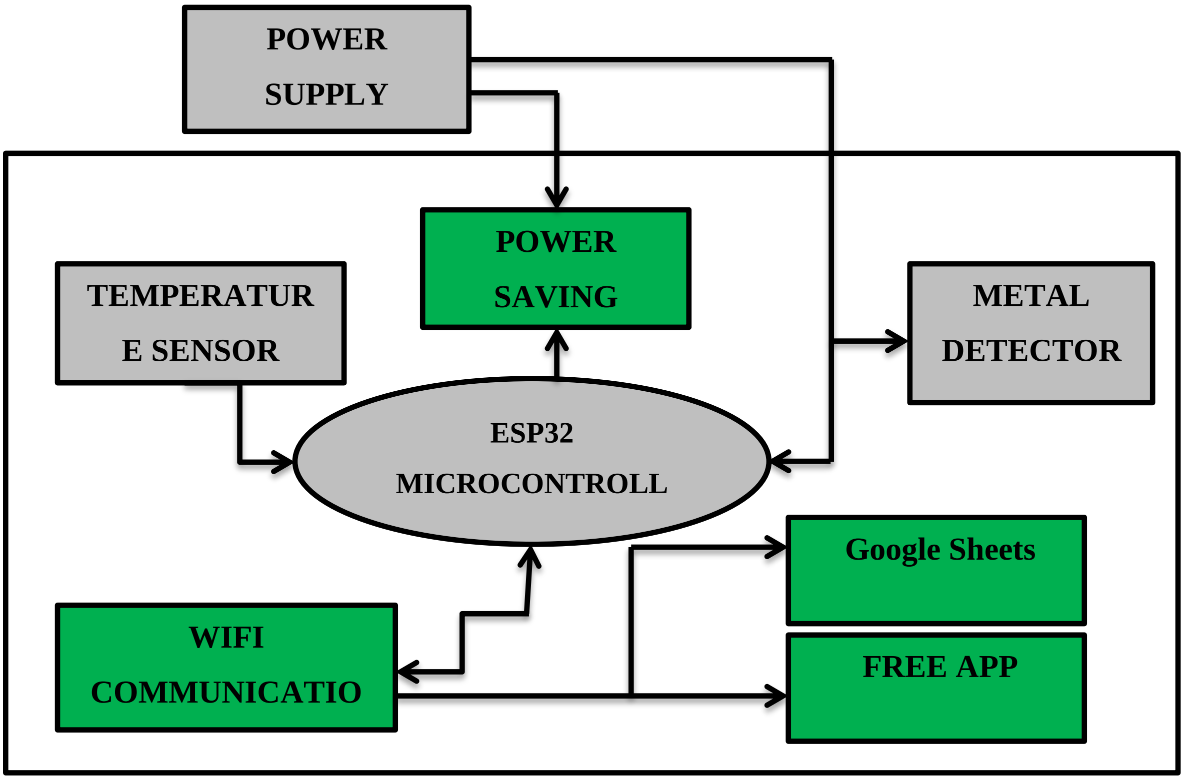

Figure III. 1 : Block diagram of cow health tracker

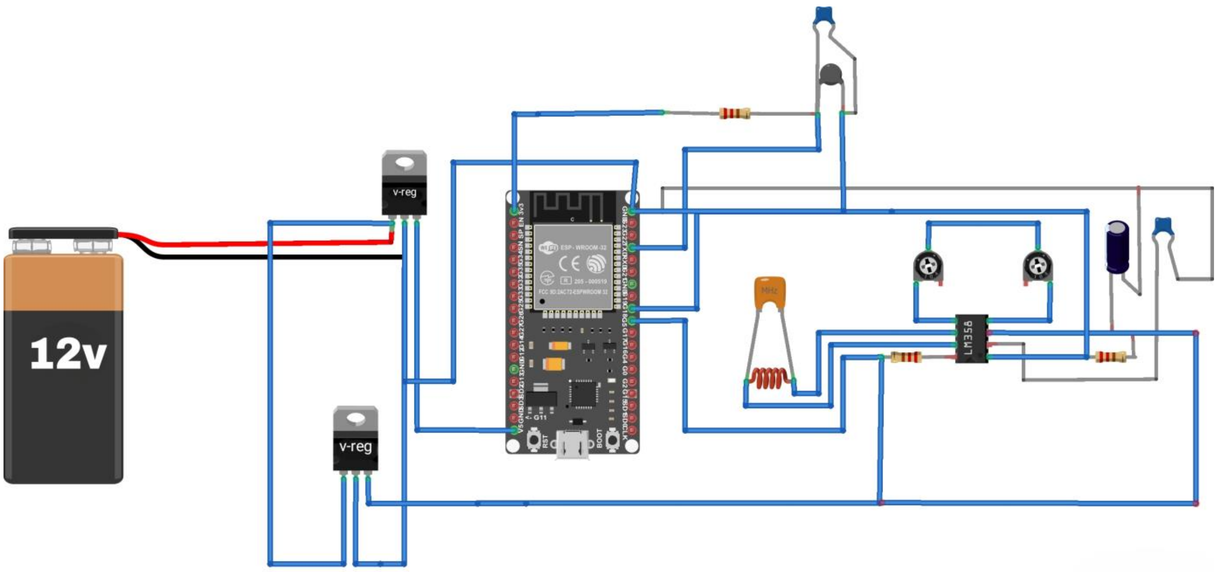

Figure III. 2 : cow health tracker system circuit

The circuit also includes an NTC thermistor sensor for measuring the cow's temperature and a bipolar integrated circuit LD209A. The LD209A contains an oscillator that, when combined with an external LC network, functions as part of the metal detection system. The system is powered by rechargeable lithium-ion (Li-ion) batteries, which are automatically charged using solar energy. To extend battery life, we've implemented a power-saving mode. Our project study consists of three main parts, as indicated in Figure 9: hardware, software, and Experimentations and implementation. Each of these sections is meticulously detailed to provide a comprehensive understanding of our work.

I. Hardware section

In this section, we describe the essential components of our proposed cow health tracking system. Our hardware design incorporates several key elements, each carefully selected to ensure optimal performance, reliability, and efficiency. The main components include:

1.1. Power supply

We've chosen rechargeable Li-ion batteries for their energy density and longevity. To ensure sustainable operation, we've implemented a self-charging mechanism using solar power.

Figure III.3 shows the used power supply circuit.

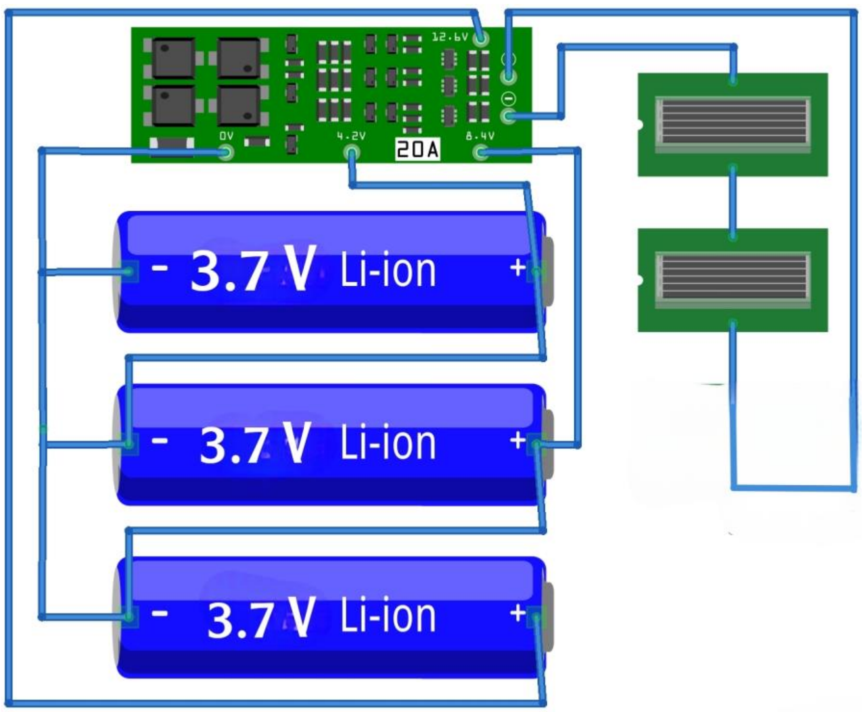

Figure III. 3 : power supply circuit

1.1.1. Dimensioning of the photovoltaic system

Table III. 1 shows the essential and important characteristics for the main components related to the power system of our device.

Table III. 1 : characteristics of the dimensioned system

Cell type	Polycrystalline
Power of cell	3W
Operating current of cell	0-125 mA
Operating voltage of cell	12 V
P_{NTC}	12s ⟶ 50mW
P_{LD209A}	200 mW
P_{ESP32}	528 mW

1.1.1.1. Determine power consumption demands

The first step in designing a photovoltaic installation is to estimate the electricity consumption. Accurately assessing the electricity needs is crucial for proper sizing. It's important to gather information on the consumption of each component used and select components with the lowest possible consumption to reduce electricity usage while maintaining a good level of comfort.

To calculate the daily energy consumption (Wh/day), multiply the power (W) of each component by the number of hours it operates per day (h/day), then sum the values obtained. The average total daily energy required, E (Wh/day), is the sum of the energy consumption of the various components that make up the system under study.

$$E_{(daily)} = E_1 + E_2 + E_3 \qquad \text{III.1}$$

Where $E_{(daily)}$ is the daily energy of the system , and E_1, E_2, E_3 are the total Watt-hours per day for each appliance used :

E_1: is the daily energy of NTC.

E_2: is the daily energy of LD209A.

E_3: is the daily energy of ESP32.

The consumption of each component can be calculated as follows:

The energy (E) in watt-hour (Wh) is equal to the power (P) in watts multiplied by the time period (t) in hours (h).

$$E = P \times t \qquad \text{III.2}$$

- **Daily energy of NTC**

Understanding the energy consumption of NTC thermistor is essential for optimizing the power efficiency of our system.

This section provides an overview of the daily energy consumption for NTC thermistor:

$$E_1 = E_{NTC} = \frac{0.05 \text{ w } \times 86400 \text{ s}}{3600 \text{ s}} = 1.2 \text{ Wh}$$

Where 0.05 is the power of NTC in watts, 86400 is number of seconds per day, and 3600 is number of seconds per hour.

The daily energy consumption of NTC thermistor is 1.2 Wh.

- **Daily energy of LD209A**

LD209A tends to consume more energy compared to NTC thermistor. This higher energy consumption is primarily due to the LD209A's more complex functionality and higher power requirements to maintain its performance. Grasping the daily energy consumption of the LD209A is essential for enhancing our system's overall power efficiency.

This section details the daily energy consumption of the LD209A:

$$E_2 = E_{LD209A} = \frac{0.2 \text{ w} \times 86400 \text{ s}}{3600 \text{ s}} = 4.8 \text{ Wh}$$

Where 0.2 is the power of LD209A in watts, 86400 is number of seconds per day, and 3600 is number of seconds per hour.

The daily energy consumption of LD209A is 4.8 Wh.

- **Daily energy of ESP32**

The ESP32 is a powerful microcontroller widely used in IOT applications due to its integrated WI-FI and Bluetooth technologies. However, it tends to consume more energy compared to simpler microcontrollers. This higher energy consumption is primarily due to the continuous operation of its WI-FI module, which requires significant power to maintain connectivity and data transmission.

This section details the daily energy consumption of the ESP32 microcontroller:

$$E_3 = E_{(esp32)} = \frac{0.528\ \text{w} \times 86400\ \text{s}}{3600\ \text{s}} = 12.672\ \text{Wh}$$

Where 0.528 is the power of ESP32 microcontroller in watts, 86400 is number of seconds per day, and 3600 is number of seconds per hour.

The daily energy consumption of ESP32 microcontroller is 12.672 Wh.

- **The total power consumption demands**

The total power consumption of our system is influenced by several key components, each contributing to the overall energy demand. The ESP32, with its integrated WI-FI technology, is one of the higher energy-consuming components due to the continuous power required for maintaining connectivity and data transmission.

Similarly, the LD209A also has significant energy demands compared to NTC thermistor.

To optimize power efficiency, we have implemented strategies such as utilizing deep sleep modes for the ESP32.

By calculating the daily energy consumption of each component, we can better understand the total energy requirements and ensure our power supply meets these demands. This comprehensive analysis helps us design a more efficient system, ultimately improving battery life and overall performance.

$$E_{(\mathbf{daily})} = 1.2 + 4.8 + 12.672 = 18.672\ \text{Wh}$$

The total daily power consumption demands from our system is:18.672Wh .

1.1.1.2. Battery sizing

To ensure uninterrupted power supply during adverse weather conditions, we have designed a storage system consisting of carefully selected rechargeable lithium batteries. This specific type was chosen for its high storage capacity relative to its small size and lightweight, making it ideal for our portable device. Additionally, these batteries are known for their long lifespan, which is crucial for our system.

We have optimized the system to achieve abattery autonomy of 2 days. This means the batteries can provide power for two days without needing a recharge, which is essential for maintaining functionality during periods of low sunlight. Furthermore, these batteries support high current charging and discharging, ensuring a stable and reliable power supply even during intermittent sunlight.

The depth of discharge D is set at 75%, meaning we can safely use up to 75% of the battery's capacity before recharging. This balance between usable capacity and battery health is critical for extending the lifespan of the batteries and ensuring efficient energy management.

In the context of solar energy systems, both battery autonomy and depth of discharge are vital parameters. Battery autonomy ensures that the system can operate independently for a specified period, reducing the risk of power outages. The depth of discharge, on the other hand, helps in determining the optimal size of the battery bank needed to meet energy demands while preserving battery health and longevity

- **Battery capacity**

  Formula (II.3) helps in determining the appropriate size of the battery needed to meet the energy demands of the system while ensuring efficient and reliable performance.

$$\mathbf{C_{(Ah)}} = \frac{\mathbf{E \times Auto}}{\mathbf{D \times V_{sys}}} \qquad \text{II.3}$$

E : total daily energy.

Auto : days of autonomy.

D: depth of discharge (%).

V_{sys}: voltage system.

$$C_{(Ah)} = \frac{18.672 \times 2}{0.75 \times 9} = 5.53 \text{ Ah}$$

$E = 18.672$: is the total daily power consumption demands.

$Auto = 2$: 2 days of battery autonomy.

$D = 75\%$: is the maximum battery discharge.

the minimum capacity required is (C_{Ah}= 5.53 Ah).

- Number of batteries needed
  - Number of serial batteries

$$N_{Bs} = \frac{V_{sys}}{V_{bat}} = \frac{9}{3.7} = 2.43 \approx 3$$

3 serial batteries of 3.7v and 5800mah needed.

- Number of parallel batteries

$$N_{Bp} = \frac{C}{C_{bat}} = \frac{5.53}{5.8} \approx 1$$

1 parallel battery of 3.7v and 5800mah needed.

1.1.1.3. PV cells sizing

Sizing photovoltaic panels is a crucial step in designing an efficient solar energy system. This process involves determining the appropriate number and size of PV panels needed to meet the energy demands of a specific application. However, in Algeria, obtaining the required PV panels can be challenging due to limited availability. So we selected a sample that has good characteristics, which is in line with our needs, and we studied according to its characteristics, although it is not currently available.

As for the prototype, we tried to manage other samples from what was available, but they didn't have the same characteristics. It's all about how long it takes until it arrives, which is not on our side as we don't have a lot of time.

- **Peak power**

The peak power of photovoltaic sensors is to be determined according to the requirements E and annual irradiation in ((kWh/m^2)/jour) it is calculated as follows:

$$P_c = \frac{E_{(daily)}}{I_{r(daily)} \times K} = \frac{18.672}{5 \times 0.65} = 5.74 \text{ watt}$$

Where :

Ir is daily irradiation in northern Algeria in ((kWh/m^2)/day) [29].

K is the PV cells efficiency.

- Total cells number

$$N_p = \frac{P_c}{P_{cell}} \approx \frac{5.74}{3} \approx 2$$

  - Serial cells number

$$N_{ps} = \frac{V_{bat}}{Vcell} = \frac{11.1}{12} \approx 1$$

  - Parallel cells number

$$N_{pp} = \frac{N_p}{N_{ps}} = \frac{2}{1} = 2$$

1.2. Temperature measurement

We have focused on temperature measurement due to its importance and commonality in most diseases. After extensive research, we determined that the NTC sensor is the best choice for the medical field.

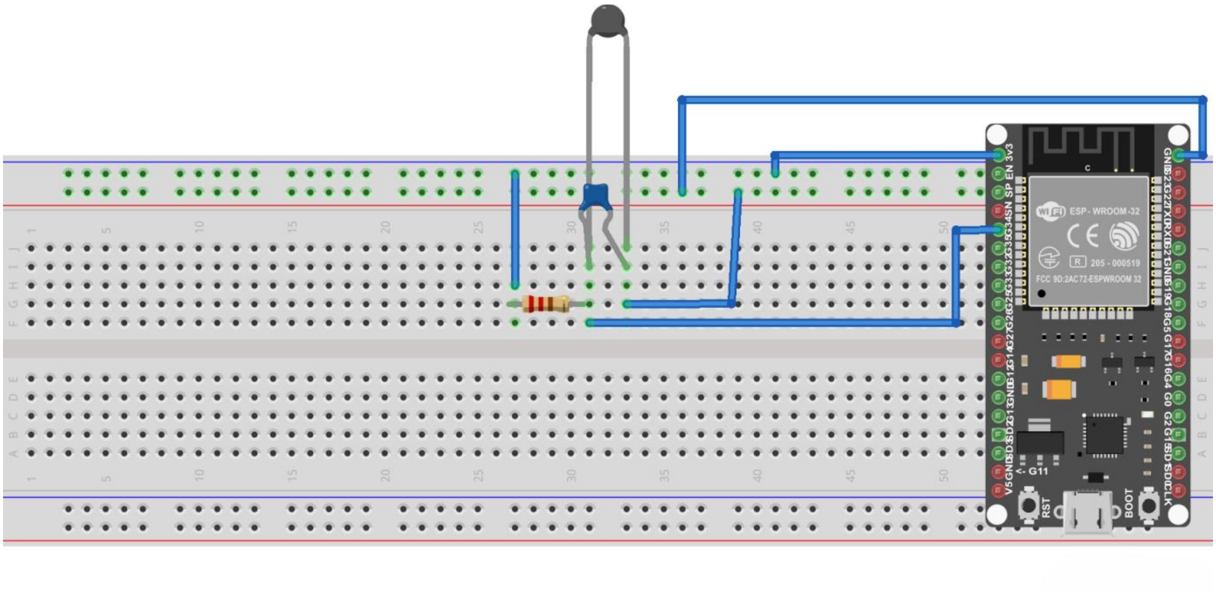

Figure III. 4 : temperature circuit design

In this prototype, we chose to measure the temperature using an NTC thermistor. This choice was made after thorough research that showed this sensor is commonly used in medical devices to measure temperature [27]. The research also confirmed the accuracy and sensitivity of this sensor to temperature changes [28], all while maintaining a very affordable price point.

The measurement results will be displayed in a free mobile application, and the temperature information of each cow will be stored in its own file as well as on a graph. This feature will be an excellent factor in helping veterinarians properly diagnose the cow's condition.

The device is programmed to measure the temperature twice a day, and if it rises, the application will provide an alarm to the owner.

1.2.1. Circuit design and wiring

The thermistor is connected to the analog input of the ESP32 microcontroller to measure its resistance, which corresponds to the temperature, via a voltage divider circuit. The thermistor is connected in series with a known resistance and in parallel with a capacitor for filtering. The known resistor is connected to the voltage source, and the NTC thermistor to the GND pin. ESP32 will provide a constant voltage to this divider and measure the voltage drop across the thermistor (Figure III.4).

1.2.2. Temperature calculation

We will use the Arduino IDE environment to program the ESP32:

- Read the analog value from the thermistor and convert it to voltage:

To measure the temperature using a thermistor, we first read an analog value from the sensor. This raw value is then converted to a voltage using the formula (III.4)

$$\text{voltage} = \text{rawValue}\,.\left(3.3/_{4095}\right) \qquad \text{III.4}$$

This conversion helps in understanding the actual voltage output from the thermistor, which can then be used to determine the temperature.

- Calculate the thermistor resistance:

To determine the resistance of a thermistor, we first need to convert the measured voltage using formula (III.5).

$$\text{resistance} = (\text{voltage}\,.\ R_{(25°C)})\,/(3.3 - \text{voltage}) \qquad \text{III.5}$$

Where

Voltage: the voltage obtained from the thermistor.

$R_{(25°C)}$: the resistance of the thermistor at 25°C.

3.3: the reference voltage of the ESP32.

This calculation helps in finding the thermistor's resistance, which can then be used to determine the temperature.

- Convert the resistance value to temperature in °C using the Steinhart-Hart equation:

$$t = [A + B\ln\left(R_{(25°C)}\right) + C(\ln\left(R_{(25°C)}\right))^3]^{-1} \qquad \text{III.6}$$

Where t is temperature, and A, B, and C are coefficients.

This equation provides a precise method to calculate the temperature from the resistance value of the thermistor.

1.3. Metal detector

Due to a common and fatal disease caused by metals, we proposed a circuit based on the LD209A proximity detector integrated circuit.

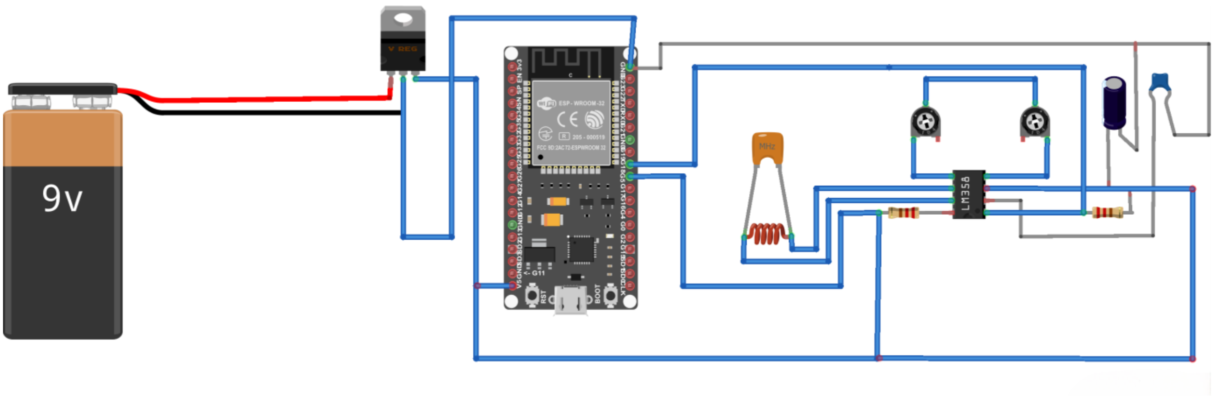

Figure III. 5 : metal detector circuit design

The LD209A contains an oscillator that works with an external resonant tank circuit (LC circuit). The oscillator generates controlled oscillations with a frequency close to the resonant frequency of the LC tank circuit. When metal is present, the oscillator amplitude decreases, causing the demodulator voltage to drop. This change triggers the comparator to change the output states, indicating metal detection.

We used potentiometers in this circuit for sensitivity adjustment. By adjusting these potentiometers, we can change the detection range and sensitivity.

1.3.1. Circuit design and wiring

- Connect the power supply voltage and GND from the power source to VCC and GND pins of LD209A.
- Connect the coil and capacitor in parallel to form the LC tank circuit, then connect them to TANK and GND pins.
- For sensitivity adjustment, connect the potentiometers to OSC and RF pins.
- Connect the OUT1 pin of the LD209A to a digital input pin on the ESP32 microcontroller. Look at Figure III.5.

1.3.2. Metal detection

We have configured the digital input pin connected to OUT1 as an input in the ESP32 microcontroller code and set the pull-up resistor configuration. When the microcontroller reads the digital input pin, it will send the information to the smartphone app using the Wi-Fi connection, indicating whether a metal has been detected or not. When metal is detected, the app will sound an audible alarm.

II. Software section

The software component of our cow health tracking system is crucial for data processing, communication, and user interaction. In this section, we'll explore the various software elements that bring our hardware to life and make the collected data accessible and actionable. Key aspects of our software design include:

2.1. RemoteXY application

RemoteXY, shown in figure III.6, is a powerful tool that makes it easy to create custom graphical interfaces for controlling various boards such as Arduino, ESP8266, ESP32, STM32, and NRF using a smartphone. It supports multiple communication protocols including Wi-Fi access point, Bluetooth, cloud server, and Ethernet. For our project, we used the ESP32 board and connected it to the cloud server.

We chose RemoteXY over other tools because of its user-friendly interface and comprehensive features. Its ability to quickly develop and deploy customized interfaces without requiring extensive coding expertise made it the best choice for our project.

Figure III. 6 : RemoteXY app [30]

Figure III. 7 : RemoteXY configuration

In this section, we will discuss the process of developing a graphical user interface (GUI) for our system. A well-designed GUI enhances user interaction by providing a visual representation of the system's functionalities.

We will be using the ESP32 microcontroller and the Arduino IDE to configure and program the interface, ensuring effective communication of data and alerts to the user. Creating a graphical interface in RemoteXY involves the following steps:

- Configuration settings: We have used an ESP32-based board as a microcontroller, programmed using the Arduino IDE, and connected it remotely via a cloud server as shown in Figure III.7.

```
#define REMOTEXY_MODE__WIFI_CLOUD

#include <WiFi.h>

// RemoteXY connection settings
#define REMOTEXY_WIFI_SSID "Galaxy S10+c379"
#define REMOTEXY_WIFI_PASSWORD "123456789"
#define REMOTEXY_CLOUD_SERVER "cloud.remotexy.com"
#define REMOTEXY_CLOUD_PORT 6376
#define REMOTEXY_CLOUD_TOKEN "c4c0374b[redacted]"
```

Figure III. 8 : configuration settings in Arduino IDE

To set up the configuration settings in the Arduino IDE, we need to define certain settings to enable the device to connect to the internet and communicate with the RemoteXY cloud server for remote monitoring. Here's a simple explanation of the code:

- **#define REMOTEXY_MODE__WIFI_CLOUD:**
  This directive sets the mode for RemoteXY to use WiFi for cloud communication, allowing the system to connect to the RemoteXY cloud server via WiFi.
- **#include <WiFi.h>:**
  This line includes the WiFi library, which provides the necessary functions to connect to a WiFi network using the ESP32 microcontroller.
- **#define REMOTEXY_WIFI_SSID "Galaxy S10+c379":**
  This directive defines the SSID (name) of the WiFi network to which the device will connect. In this case, the SSID is "Galaxy S10+c379".
- **#define REMOTEXY_WIFI_PASSWORD "123456789":**

This directive sets the password for the WiFi network. Here, the password is "123456789".

- **#define REMOTEXY_CLOUD_SERVER "cloud.remotexy.com":**
  This directive specifies the address of the RemoteXY cloud server. The device will connect to this server to send and receive data.
- **#define REMOTEXY_CLOUD_PORT 6376:**
  This directive defines the port number used to communicate with the RemoteXY cloud server. The port number here is 6376.
- **#define REMOTEXY_CLOUD_TOKEN "c4c0374b…":**
  This directive sets the token for authenticating the device with the RemoteXY cloud server. The token "c4c0374b" is used to identify and authorize the device.

Interface Design: we have used this application to create alarms and inform the owner about the state of temperature measurement and metal detection. For that, we chose the following elements:

1. "Text string" to print the temperature.
2. "Text string" to print the metal state.
3. "Online graph" for graphing temperatures as a curve.
4. "Sound" for audible alerts in case of high temperature or metal detection.

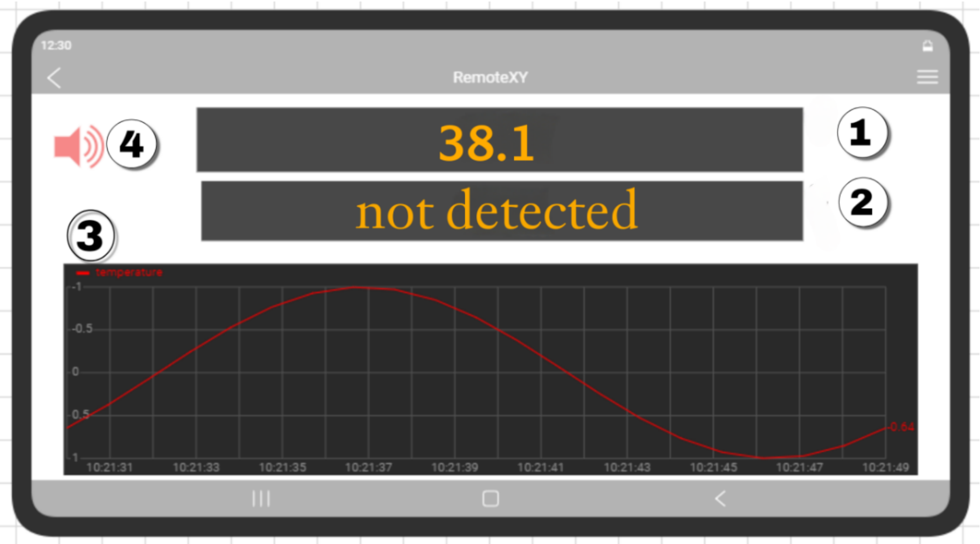

Figure III. 9 : Smartphone interface

```
float onlineGraph_01_temp;
int16_t sound_01; // =0 no sound, else ID of sound,
int16_t sound_02; // =0 no sound, else ID of sound,
char temperature[21]; // string UTF8 end zero
char metal_state[21]; // string UTF8 end zero
```

Figure III. 10 : interface design in arduino IDE

In Figure III.10, we are going to define variables to effectively organize and manage the collected data. Here is a simple explanation of this code:

- **float onlineGraph_01_temp:** Stores temperature data as a curve.
- **int16_t sound_01 and int16_t sound_02:** Represent sound levels
- **char temperature[21] and char metal_state[21]:**

  These character arrays hold UTF-8 encoded strings for temperature and metal state readings, respectively, providing a way to store and transmit the data in a readable format.

- **uint8_t connect_flag:**

This variable indicates the connection status of the system, with a value of 1 indicating a successful connection. This is important for ensuring continuous data transmission and monitoring.

2.1.1. Get source code

- Once the interface is ready, the editor will automatically generate the source code. This code will be uploaded to the ESP32 board.
- **Install the Remotexy library in Arduino IDE:**

The installation of the RemoteXY library is crucial for establishing robust communication protocols between the ESP32 development board and the RemoteXY platform. Figure III.11 illustrates the step-by-step installation procedure necessary for implementing this interface.

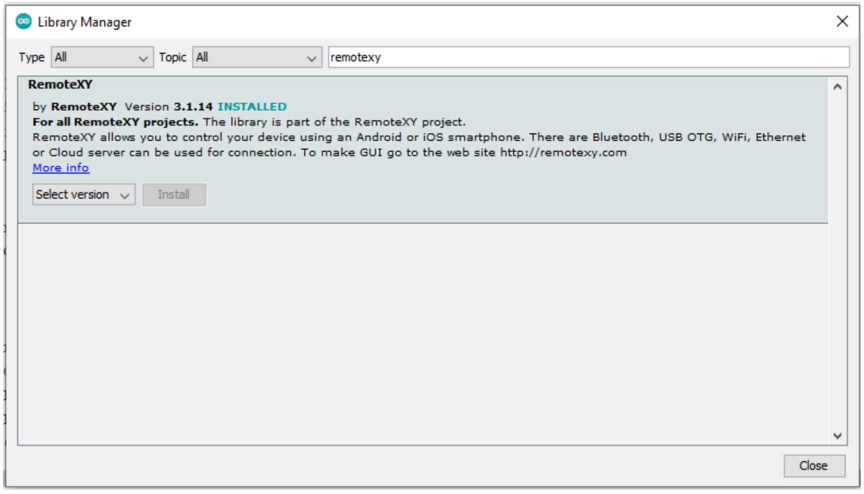

Figure III. 11 : installing remotexy library

2.1.2. Mobile app setup

After installing the RemoteXY app on smartphone, then we connect our board with the app using the token of cloud server.

2.2. Google sheets

We use Google Sheets as the central platform for storing and managing data. The system gathers real-time health data from the cows, which is then transmitted via Wi-Fi to Google Sheets.

Utilizing Google Sheets as a database to store temperature and overall health data is a practical approach for monitoring cow health. This setup allows for real-time data collection and storage, enabling early detection of health issues such as infections, heat stress, or traumatic retinitis. By maintaining accurate records of the cows' health status, farmers can make informed decisions about herd management, improving overall animal welfare and farm efficiency. Automating this process reduces manual labor and minimizes human error, ensuring reliable and consistent monitoring. This system not only enhances the health and productivity of the herd but also aids in complying with health regulations and providing valuable data for veterinary consultations.

```
      String urlFinal = "https://script.google.com/macros/s/"
      Serial.print("POST data to spreadsheet:");
      Serial.println(urlFinal);
      HTTPClient http;
      http.begin(urlFinal.c_str());
      http.setFollowRedirects(HTTPC_STRICT_FOLLOW_REDIRECTS);
      int httpCode = http.GET();
      Serial.print("HTTP Status Code: ");
      Serial.println(httpCode);
      //-----------------------------------------------------
      //getting response from google sheet
      String payload;
      if (httpCode > 0) {
          payload = http.getString();
          Serial.println("Payload: "+payload);
      }
      //-----------------------------------------------------
      http.end();
    }
```

Figure III. 12 : the code for sending data to Google Sheets

The code presented in Figure III.12 is used to send temperature and metal state data to a Google Sheets using HTTP requests. It initializes an HTTP client, sets up the connection to the Google script URL, sends a GET request, and handles the response by printing the HTTP status code and payload to the serial monitor.

2.3. Power saving

Power saving is crucial for optimizing the ESP32's power consumption. Understanding and effectively utilizing its power-saving modes can help reduce energy usage by controlling the activity of the CPU, WiFi, Bluetooth, and other peripherals. By strategically using these modes, we can significantly extend the battery life of our system, making it more efficient and sustainable.

The main power-saving modes available on the ESP32 are: Modem-sleep mode, light-sleep mode, Deep-sleep mode, and hibernation mode. In our system, we have chosen to work with Deep-sleep mode due to its compatibility with our system.

2.3.1. Deep-sleep mode

In deep-sleep mode, the CPU and most peripherals are powered down, with only the RTC and ULP (Ultra-Low Power) coprocessor remaining active. This mode is ideal for applications that need to wake up only occasionally, such as a remote sensor that transmits data once an hour. Deep-sleep mode consumes very little power, making it perfect for long-term battery-powered projects.

According to specialists, we need to measure temperature twice a day. As for the metal detector, we have chosen to use external wake-up mode, meaning it is always in deep sleep until it detects a metal. All of these factors make Deep-sleep mode the best choice for our system.

2.3.1.1. Deep sleep mode in Arduino IDE

To activate deep sleep mode on the ESP32, we need to include a few key lines of code:

- **Include the necessary library:**

  #include "esp_sleep.h"

- **Define the sleep duration:**

  #define TIME_TO_SLEEP 10 // Time in seconds

- **Set up the wake-up source:**

  esp_sleep_enable_timer_wakeup(TIME_TO_SLEEP * 1000000), this function sets the ESP32 to wake up after the specified time (in microseconds). We use this function to wake up the ESP32 twice a day for temperature measurement.

  esp_sleep_enable_ext0_wakeup((gpio_num_t)wakeupPin, LOW), this function sets up the ESP32 to wake up if the state of wakeup pin is low. We use this function to wake up the ESP32 when a metal detected.

- **Start deep sleep:**

  esp_deep_sleep_start(), this function puts the ESP32 into Deep-sleep mode.

```
COM6

rst:0x5 (DEEPSLEEP_RESET),boot:0x17 (SPI_FAST_FLASH_BOOT)
configsip: 0, SPIWP:0xee
clk_drv:0x00,q_drv:0x00,d_drv:0x00,cs0_drv:0x00,hd_drv:0x00,wp_drv:0x00
mode:DIO, clock div:1
load:0x3fff0030,len:1448
load:0x40078000,len:14844
ho 0 tail 12 room 4
load:0x40080400,len:4
load:0x40080404,len:3356
entry 0x4008059c
E (176) wifi:NAN WiFi stop
Woke up from deep sleep
Connecting to WiFi...
Connected to WiFi

Connecting to wifi: Galaxy S10+c379
.Temperature: 38.6 °C
POST data to spreadsheet:https://script.google.com/macros/s/AKfycby6kT-
HTTP Status Code: -1
going to sleep now
```

Figure III. 13 : deep sleep and wake up operation in serial monitor.

Figure III.13 illustrates the process of the ESP32 device waking up from deep sleep, connecting to wifi, measuring the temperature, and then posting this data to a Google Sheets URL. The device uses a timer to wake up after a set interval. When it wakes up, it connects to the specified WiFi network, reads the temperature, and attempts to send this data to a web server. After completing these tasks, the device logs the HTTP status code and re-enters deep sleep mode to conserve power. This cycle of deep sleep, periodic wake-ups, and temperature measurement ensures efficient power usage while maintaining regular data updates.

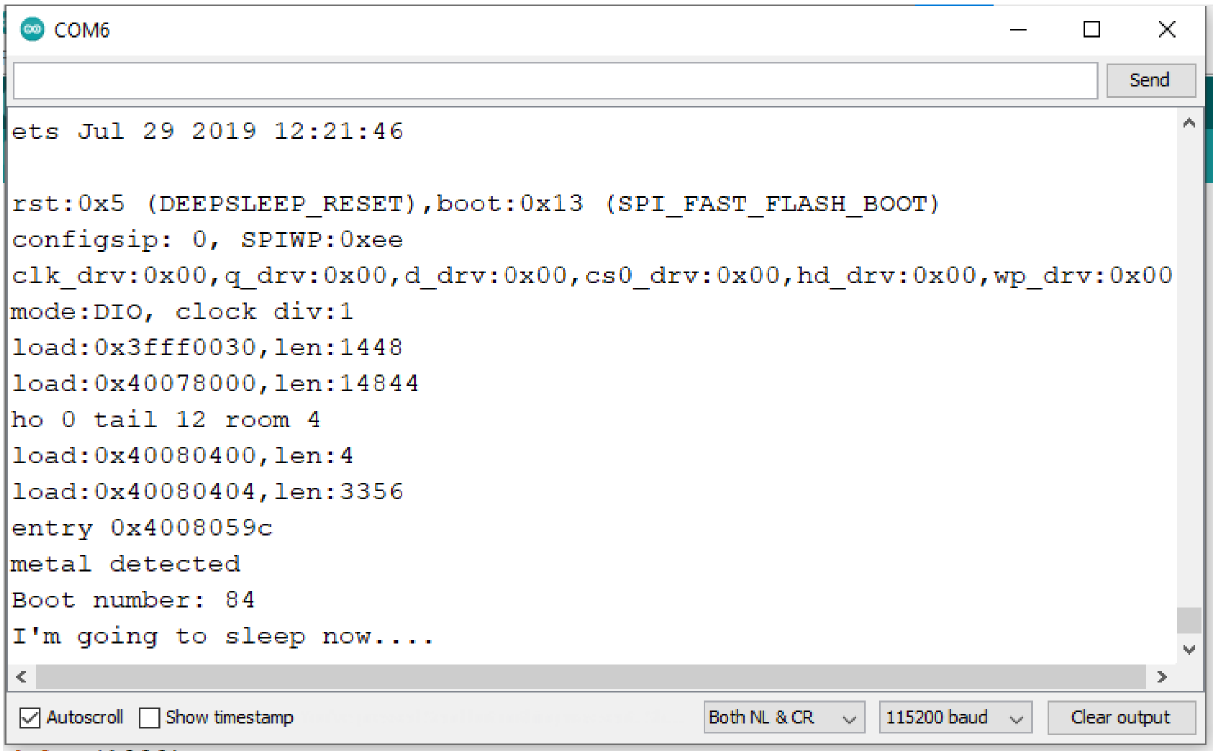

Figure III. 14 : wake up from deep sleep using external wake up.

The metal detection system implements an external wake-up mechanism to transition the ESP32 microcontroller between deep sleep and active states. As illustrated in Figure III.13, the system automatically enters deep sleep mode during periods of inactivity (absence of metal detection) and reactivates upon detecting metallic objects. This power management strategy optimizes energy consumption while maintaining operational functionality.

III. Experimentations and implementation

3.1. Temperature measurement displaying in mobile app and Google Sheets

In our system, we can monitor the cow's temperature remotely using an application and the Internet of Things feature. This allows the farmer to keep track of the health status of his cows from anywhere with internet access. As shown in Figure III.15, we display the temperature value along with a graph, highlighting the importance of comparing temperatures over time. Additionally, there is an alarm that alerts in case the temperature rises to abnormal levels.

Figure III.16 illustrates the storage of temperature data for an individual cow at carefully studied periods. This feature is crucial for both veterinarians and farmers because storing health information for each cow helps in understanding its condition and making accurate and appropriate diagnoses of its health status.

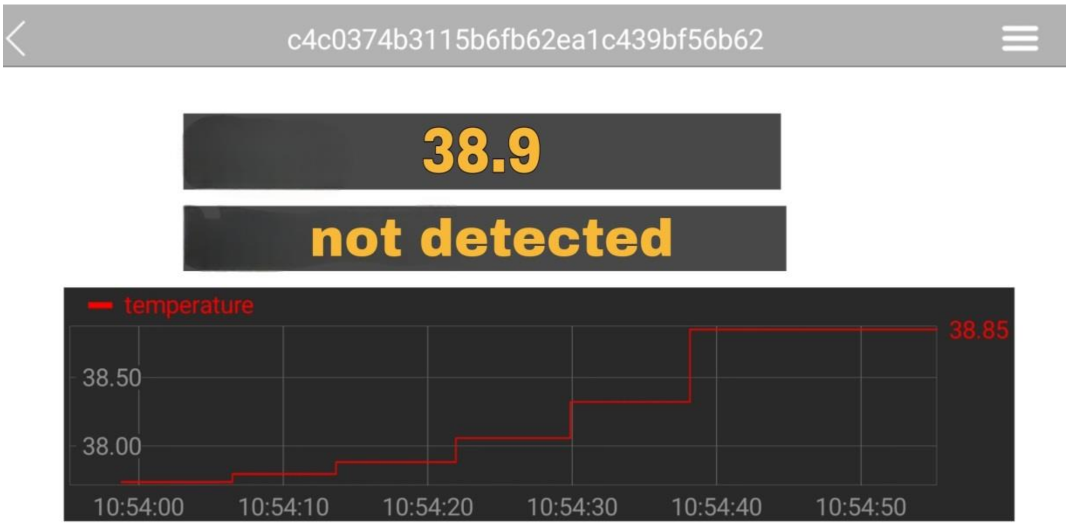

Figure III. 15 : real time monitoring using mobile app.

	A	B	C	D
1	Date	Time	temperature	metalState
2	23/07/2024	10:07:27	30.01	detected
3	23/07/2024	10:07:32	30.23	detected
4	23/07/2024	10:07:37	30.33	detected
5	23/07/2024	10:07:43	30.17	detected
6	23/07/2024	10:07:48	30.09	detected
7	23/07/2024	10:07:53	30.04	detected
8	23/07/2024	10:07:58	29.88	detected
9	23/07/2024	10:08:03	29.96	detected
10	23/07/2024	10:08:09	29.96	detected
11	23/07/2024	10:08:14	30.94	detected
12	23/07/2024	10:08:19	29.62	detected
13	23/07/2024	10:08:24	29.83	detected
14	23/07/2024	10:08:29	30.09	detected
15	23/07/2024	10:08:34	30.28	detected
16	23/07/2024	10:08:39	30.23	detected
17	23/07/2024	10:08:44	30.33	detected
18	23/07/2024	10:08:50	30.25	detected
19	23/07/2024	10:08:55	30.2	detected
20	23/07/2024	10:09:00	30.28	detected
21	23/07/2024	10:09:06	30.04	detected
22	23/07/2024	10:09:14	30.17	detected
23	23/07/2024	10:09:18	30.09	detected
24	23/07/2024	10:09:24	30.17	detected
25	23/07/2024	10:09:29	30.23	detected
26	23/07/2024	10:09:33	30.17	detected
27	23/07/2024	10:09:39	30.12	detected
28	23/07/2024	10:09:43	30.07	detected
29	23/07/2024	10:09:49	30.09	detected
30	23/07/2024	10:09:54	30.07	detected
31	23/07/2024	10:10:00	30.12	detected
32	23/07/2024	10:10:05	30.17	detected
33	23/07/2024	10:10:11	30.2	detected
34	23/07/2024	10:10:17	30.33	detected

temp_metal

Figure III. 16 : real time monitoring using Google sheets

3.2. Metal detection displaying in mobile app and Google Sheets

In Figure III.15, the real-time display of detector status on the application interface using IoT technology allows farmers to monitor their cows' well-being from anywhere. An alert system is also in place to notify in case a cow ingests a foreign object, although the alert is not visible on the interface for the sake of consistency.

Currently, due to our reliance on a pre-existing IoT tool, we are restricted in the number of cows we can monitor as we are using the free version. However, it is possible to monitor the health status of multiple cows by creating a dedicated interface for each cow and assigning it a unique token.

This is a preliminary version, and due to time constraints, we were unable to develop our own application. However, developing our own application is our top priority in the near future, and we aim to provide tracking for as many cows as possible.

In Figure III.16, we present the experiments conducted to assess the accuracy of the metal detector.

We recognize the high risk posed to the health of cows by the ingestion of metal objects, and as per expert advice, it is crucial to store detector information. Given the difficulty in removing these metals, this medical record will be invaluable and could be the deciding factor in whether to perform the removal of these metals.

3.3. Project hardware realization

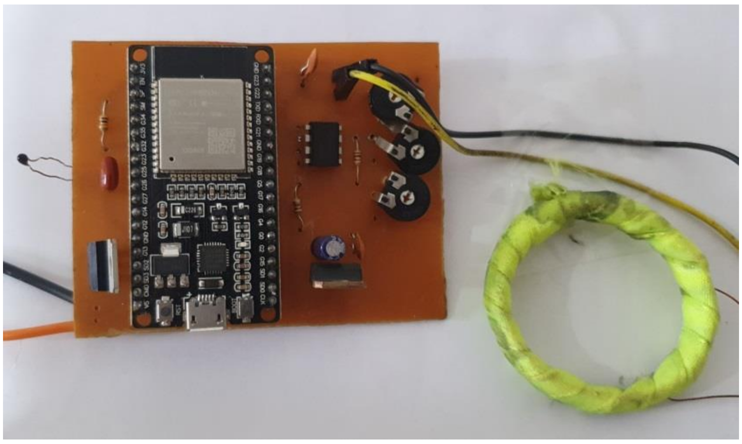

Figure III. 17 : real picture of our prototype

The Figure III.17 represents the real picture of the control part of our prototype.

3.4. Experiment of prototype

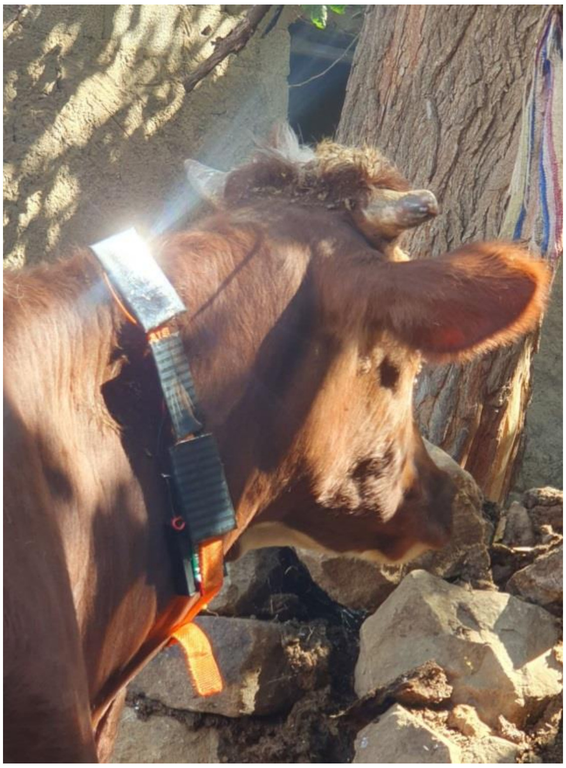

Figure III. 18 : first side of the prototype

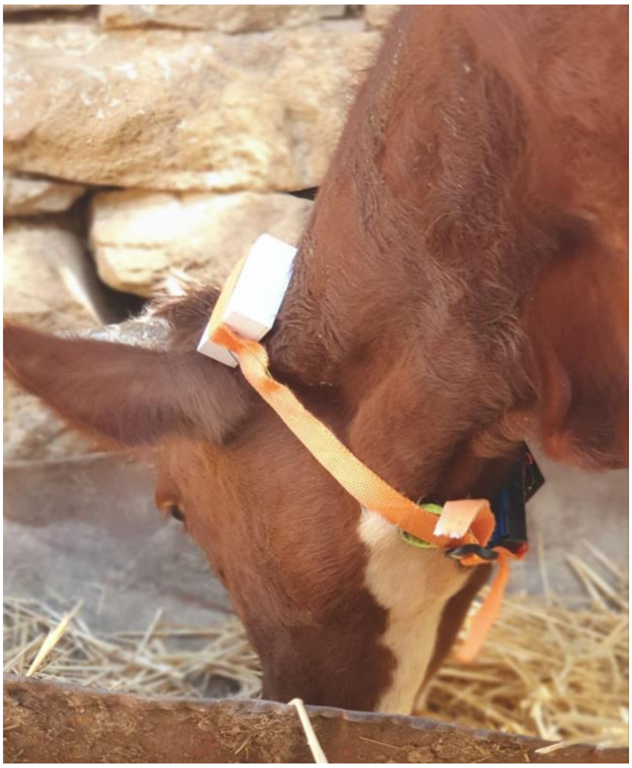

Figure III. 19 : second side of the prototype

The first part of the prototype, shown in Figure III.18, consists of the power components, including the solar panels and batteries. It's worth noting that the panels are positioned to fully capture sunlight, creating optimal conditions for charging.

Figure III.19 displays the second part of the prototype, which is the control component. Here, we can see that the temperature sensor is in direct contact with the cow's skin to ensure accurate measurement. Additionally, the coil is positioned in the cow's throat to detect the passage of any metal object.

This external design is only a preliminary concept due to the lack of necessary materials to create a more comprehensive design that prioritizes cow comfort and provides an ideal environment for the device to function effectively.

3.5. Results of experiment

Date	Time	temperature	metalState
02/10/2024	10:54:08	37.88	not
02/10/2024	10:54:15	38.06	not
02/10/2024	10:54:23	38.32	not
02/10/2024	10:54:38	38.85	not
02/10/2024	10:54:38	38.85	not
02/10/2024	10:55:05	38.85	not
02/10/2024	10:55:45	37.83	not
02/10/2024	10:56:06	37.33	not
02/10/2024	10:56:13	37.56	not
02/10/2024	10:56:23	37.8	not
02/10/2024	10:56:30	37.62	not
02/10/2024	10:56:38	38.03	not
02/10/2024	10:56:49	38.85	not
02/10/2024	10:57:01	38.85	not
02/10/2024	10:57:09	38.85	not
02/10/2024	10:57:17	38.88	not
02/10/2024	10:54:08	37.88	not
02/10/2024	10:54:15	38.06	not
02/10/2024	10:54:23	38.32	not

Figure III. 20 : Real data from the test of our device

The normal body temperature of a healthy bovine ranges from 38.1°C to 38.9°C, according to veterinary literature. As demonstrated in Figures III.15 and III.20, the measured temperatures fall within this established physiological range, though minor variations were observed. These fluctuations can be attributed to multiple factors, including the external configuration of the monitoring device.

3.6. Limitation

Throughout the process of creating this device, we have faced many challenges and limitations. We encountered problems in developing an app to connect to wifi, access temperature and metal detector data, and store information for farmers. As a workaround, we used the RemoteXY tool for wifi connectivity and created a special interface to display temperature and detector status. However, this tool lacks data storage, so we used Google Sheets for that purpose.

We aim to improve the accuracy of the metal detector, as it currently has an unstable accuracy of three centimeters under the skin. We also added a deep sleep mode to conserve power, but faced issues with wifi reconnection after deep sleep due to using the free version of RemoteXY.

In terms of equipment manufacturing and electronic components, we encountered challenges such as the unavailability of electronic components, poor quality components, lack of manufacturing facilities, and high prices.

3.7. Adding other features to the device:

The following features are proposed for future implementation to expand the device's diagnostic and monitoring capabilities:

3.7.1. Dystocia Detection System

Implementing continuous monitoring and real-time alert mechanisms for early detection of calving complications. This system aims to mitigate risks associated with difficult births by facilitating timely veterinary intervention, thereby reducing potential mortality and morbidity rates in both cows and calves.

3.7.2. Behavioral Monitoring Systems

- Motion Detection: Implementation of kinematic sensors to track locomotor activity patterns, enabling early identification of behavioral anomalies indicative of health disorders.
- Positional Tracking: Integration of spatial monitoring sensors for precise localization within the facility, enhancing herd management efficiency and individual animal surveillance.
- Feed Intake Monitoring: Deployment of specialized sensors to quantify feeding duration and patterns, facilitating early detection of appetite alterations that may signal underlying health conditions.

3.7.3. Physiological Monitoring Systems

- Pulse Oximetry: Non-invasive monitoring of blood oxygen saturation (SpO_2) and pulse rate through photoplethysmography, typically applied to the auricular or caudal regions. This enables assessment of respiratory function and stress levels.
- Cardiovascular Monitoring: Integration of heart rate sensors utilizing either electrocardiographic or photoplethysmographic principles for continuous monitoring of cardiac activity. These sensors, positioned on the thoracic or appendicular regions, facilitate assessment of cardiovascular health and stress responses while enabling early detection of pathological conditions.

4. Conclusion

Despite the acceptable and reasonably satisfactory results, this device is still under development in various areas and cannot be fully relied upon at this time. As mentioned above, it needs a well thought out and appropriate external design, and it also needs to develop and improve the accuracy of both circuits and many other factors already mentioned.

Conclusion

Our project addresses the growing demand for dairy production by developing an innovative device for monitoring cow health. This solar-powered device integrates temperature measurement and metal detection capabilities, utilizing an NTC sensor and an LD209A sensor coupled with a coil. Controlled by an ESP32 module, the system features Wi-Fi connectivity, allowing real-time data monitoring through the RemoteXY mobile application and automatic data storage in Google Sheets.

The device effectively measures body temperature and detects ingested metals, promptly alerting farmers to potential health issues. Integration with Google Sheets enables comprehensive record-keeping, providing veterinarians with valuable historical data for accurate diagnoses. A deep sleep mode optimizes battery life, with the device activating upon detecting significant temperature or metal presence changes.

Throughout development, we encountered several challenges. RemoteXY app capabilities for Wi-Fi connectivity and data storage limited us. Metal detection accuracy remained inconsistent despite achieving 5cm penetration depth, and we experienced communication issues between deep sleep mode and the RemoteXY app. We also faced difficulties sourcing high-quality components and accessing suitable testing facilities.

We plan to expand the device's capabilities to include real-time monitoring of bovine dystocia, motion sensors for activity tracking and health problem detection, and position sensors for optimized herd management. We also aim to implement feed intake monitoring and vital sign measurements, including blood oxygen levels via pulse oximeters and heart rate monitoring for cardiovascular health and stress detection.

In conclusion, while we have achieved satisfactory results, the device is still under development and cannot be fully relied upon. It requires further improvements in various areas, including external design and circuit accuracy.

References

[1] A. Brahim, B. Malika, A. Rachida, L. Mustapha, D. Mehammed and L. Mourad, "Dairy cows real time behavior monitoring by energy-efficient embedded sensor," *2020 Second International Conference on Embedded & Distributed Systems (EDiS)*, Oran, Algeria, 2020, pp. 21-26, doi: 10.1109/EDiS49545.2020.9296432

[2] D. Singh, R. Singh, A. Gehlot, S. V. Akram, N. Priyadarshi, and B. Twala, “An imperative role of digitalization in monitoring cattle health for sustainability,” *Electronics*, vol. 11, no. 17, p. 2702, Aug. 2022, doi: 10.3390/electronics11172702.

[3] Tawasoll, “تربية الأبقار الحلوب,” Tawasoll. [Online]. Available: https://tawasoll.com/%d8%aa%d8%b1%d8%a8%d9%8a%d8%a9-%d8%a7%d9%84%d8%a3%d8%a8%d9%82%d8%a7%d8%b1-%d8%a7%d9%84%d8%ad%d9%84%d9%88%d8%a8/

[4] L. Harvie, “Agriculture - RunTime Recruitment,” *RunTime Recruitment*, Sep. 11, 2023. https://runtimerec.com/embedded-industries/agriculture/

[5] “Sensor technology and data monitoring in dairy cows - Disarm Project,” *Disarm Project*, May 24, 2022. https://disarmproject.eu/resources/sensor-technology-and-data-monitoring-in-dairy-cows/

[6] M. Gann and M. Gann, “What is embedded system in IoT | Robots.net,” *Robots.net*, Dec. 22, 2023. https://robots.net/tech/what-is-embedded-system-in-iot/

[7] *Unravel The Relationship Between Big Data And IoT | Blog | ByteHouse*. (n.d.). https://bytehouse.cloud/blog/relationship-bigdata-and-iot

[8] Gillis, A. S., & Lutkevich, B. (2024, August 13). *What is an embedded system?* IoT Agenda. https://www.techtarget.com/iotagenda/definition/embedded-system

[9] Schulze, J. (2024, March 29). *What Is the Internet of Things (IoT)? With Examples*. Coursera. https://www.coursera.org/articles/internet-of-things

[10] Staff, C. (2023, November 29). *What Are Embedded Systems (+ How to Work with Them)*. Coursera. https://www.coursera.org/articles/embedded-systems

[11] Y. Zhang et al., "Design and Implementation of a Smart Home Energy Management
System Based on IoT and Machine Learning," *Sensors*, vol. 23, no. 15, p. 6739, 2023.

Available: https://www.mdpi.com/14248220/23/15/6739?type=check_update&version =2.
[12] K. Lohnes, "How Does Wi-Fi Work?," *Encyclopedia Britannica*. Available: https://www.britannica.com/story/how-does-wi-fi-work
[13] J. Sharma, "Wi-Fi: Types, Working, and Applications," *Shiksha*. Available: https://www.shiksha.com/online-courses/articles/wifi-types-working-and applications/.
[14] "DOE Explains...Batteries," *Energy.gov*. Available: https://www.energy.gov/science/doe-explainsbatteries/
[15] Mouser Electronics, "Rechargeable Batteries: A Better Solution,". Available: https://hr.mouser.com/applications/rechargable-batteries-better/.
[16] P. W. C. Northrop et al., "Efficient Simulation and Reformulation of Lithium-Ion Battery Models for Enabling Electric Transportation," *Journal of the Electrochemical Society*, vol. 161, no. 8, pp. E3149–E3157, doi: 10.1149/2.018408jes.
[17] J. Kim *et al.*, "Integrated Energy Conversion and Storage Device for Stable Fast Charging Power Systems," *ECS Journal of Solid State Science and Technology*, vol. 9, no. 12, p. 125003, doi: 10.1149/2162-8777/abcc49.
[18] "SOLAR ENERGY – " *Photonics*. Available: https://photonics.creol.ucf.edu/solar-energy/
[19] Discover The Greentech, "The photovoltaic effect: the heart of modern solar energy - Découvrez la Greentech," *Découvrez La Greentech*. Available: https://www.discoverthegreentech.com/en/renewable-energies/solarpower/photovoltaic/effect/
[20] Automation Community, "*Thermistor Questions and Answers*,". Available: https://automationcommunity.com/thermistor-questions-and-answers/.
[21] "Essential Guide to NTC Thermistors: Everything You Must Know," *Ufine Battery [Official]*. Available: https://www.ufinebattery.com/blog/about-ntc-thermistors-what-you-need-to-know/
[22] ON Semiconductor, "CS209A-D Datasheet,". Available: https://www.mouser.com/catalog/specsheets/on%20semiconductor_cs209a-d.pdf.
[23] "ESP32 Wi-Fi & Bluetooth SoC | Espressif Systems." Available: https://www.espressif.com/en/products/socs/esp32

[24] University of Washington Clean Energy Institute, "Lithium-Ion Battery,". Available: https://www.cei.washington.edu/research/energy-storage/lithium-ion-battery/.

[25] “How it works.” Available: https://remotexy.com/en/help/

[26] Naval Sea Systems Command, "Thermistors,". Available: https://www.navsea.navy.mil/Portals/103/Documents/NSWC_Crane/SD-18/PDFs/Products/Archive/Thermistors/Thermistors.pdf.

[27] A. Hardian *et al.*, “Cu-Mn Co-doped NiFe2O4 based thick ceramic film as negative temperature coefficient thermistors,” *IOP Conference Series. Earth and Environmental Science*, vol. 882, no. 1, p. 012017

[28] J. T. Tao, J. M. Maitirouzi, H. Luo, T. Guo, P. Wang, and H. Ren, “Design of a multi-channel high precision wearable temperature collection system based on negative temperature coefficient thermistor,” *Wearable Technology*, vol. 3, no. 2, p. 25

[29] A. Mefti, “Estimation et Cartographie de la Composante Globale du Rayonnement Solaire,” *Estimation Et Cartographie De La Composante Globale Du Rayonnement Solaire*, Jan. 1999, [Online]. Available: http://www.cder.dz/download/jnv2_16.pdf

[30] RemoteXY, "RemoteXY: Create Your Graphical Interface for Board Control,". Available: https://remotexy.com/.

[31]S. D. Crane, *Thermistors*, Navsea. Available: **https://www.navsea.navy.mil/Portals/103/Documents/NSWC_Crane/SD-18/PDFs/Products/Archive/Thermistors/Thermistors.pdf.**

[32]Dando, *Manual 932320136205654*. Datasheets. Available: **https://download.datasheets.com/pdfs/2014/6/14/14/45/35/508/dando_/manual/932320136205654.pdf.**

[33] LME Editorial Staff, “ESP32 Pinout Reference,” *Last Minute Engineers*. https://lastminuteengineers.com/esp32-pinout-reference/

Annexe

A sample of the questionnaires we conducted for our device:

نموذج استبيان حول جهاز Cow Health Tracker

الجهاز الإلكتروني المتصل بالإنترنت الذي يجري تطويره حاليًا يهدف إلى مراقبة حالة الأبقار في الوقت الحقيقي عن طريق متابعة بعض المقادير. في نسخته الأولية، يدمج عاملان يعتبرهما الخبراء مهمان (درجة الحرارة البقرة وابتلاعها للمعادن عن طريق الخطأ).

يهدف الاستطلاع التالي إلى جمع آراء الخبراء بهدف تحسين الجهاز.

- أولا : قياس درجة حرارة البقرة و في حالة وجود أي ارتياب يرسل الجهاز إنذارا بذلك إلى الفلاح عن طريق التطبيق
- ثانيا : إلتقاط المعادن التي تبتلعها البقرة بالخطأ مع العلف وتخزين عدد المرات في التطبيق

1) ما رأيك بفكرة الجهاز ؟ مفيدة ☒ غير مفيدة ☐

2) بصفتك طبيب بيطري هل ترى أن لهذا الجهاز دور فعال في متابعة صحة البقرة ؟ نعم ☒ لا ☐

3) كطبيب بيطري هل تظن أن هذا الجهاز يقدم لك المساعدة أو يوفر عليك الوقت و الجهد ؟ نعم ☒ لا ☐

4) هل ترى أن قياس درجة الحرارة من الأمور المهمة وأنه خيار صائب ؟ نعم ☒ لا ☐

5) كيف يجب أن يكون قياس درجة الحرارة حسب خبرتك ؟

i) يجب أن تقاس درجة الحرارة في كل لحظة ☒

ii) يجب أن تقاس درجة الحرارة كل ساعتين ☒

iii) يجب أن تقاس درجة الحرارة مرة في اليوم ☐

iv) اقتراح آخر

....

6) هل أكل البقر للمعادن يشكل خطرا عن حياتها ؟ نعم ☒ لا ☐

7) هل برأيك :

- حساب عدد المرات التي أكلت فيها البقرة المعادن يقدم إضافة ☐
- يجب تحديد الكمية بشكل دقيق والخيار الأول غير مفيد إطلاقا ☒

8) ماذا يمكنك أن تقترح كإضافة لهذا الجهاز ؟

قياس دقات القلب

قياس وتيرة تنفسية

9) ما هي المشاكل الشائعة عند البقر التي يمكننا إيجاد حل تقني لها بالنسبة لك ؟

قياس نسبة الكالسيوم عند الأبقار الحوامل

....

نموذج استبيان حول جهاز Cow Health Tracker

الجهاز الإلكتروني المتصل بالإنترنت الذي يجري تطويره حاليًا يهدف إلى مراقبة حالة الأبقار في الوقت الحقيقي عن طريق متابعة بعض المقادير. في نسخته الأولية، يدمج عاملان يعتبرهما الخبراء مهمان (درجة الحرارة البقرة وابتلاعها للمعادن عن طريق الخطأ).

يهدف الاستطلاع التالي إلى جمع آراء الخبراء بهدف تحسين الجهاز.

- أولا : قياس درجة حرارة البقرة و في حالة وجود أي ارتياب يرسل الجهاز إنذارا بذلك إلى الفلاح عن طريق التطبيق
- ثانيا : إلتقاط المعادن التي تبتلعها البقرة بالخطأ مع العلف وتخزين عدد المرات في التطبيق

1) ما رأيك بفكرة الجهاز ؟ مفيدة ☒ غير مفيدة ☐
2) بصفتك طبيب بيطري هل ترى أن لهذا الجهاز دور فعال في متابعة صحة البقرة ؟ نعم ☒ لا ☐
3) كطبيب بيطري هل تظن أن هذا الجهاز يقدم لك المساعدة أو يوفر عليك الوقت و الجهد ؟ نعم ☒ لا ☐
4) هل ترى أن قياس درجة الحرارة من الأمور المهمة وأنه خيار صائب ؟ نعم ☒ لا ☐
5) كيف يجب أن يكون قياس درجة الحرارة حسب خبرتك ؟
   i) يجب أن تقاس درجة الحرارة في كل لحظة ☐
   ii) يجب أن تقاس درجة الحرارة كل ساعتين ☐
   iii) يجب أن تقاس درجة الحرارة مرة في اليوم ☒
   iv) اقتراح آخر

Fait courbe theorique

6) هل أكل البقر للمعادن يشكل خطرا عن حياتها ؟ نعم ☒ لا ☐
7) هل برأيك :
   - حساب عدد المرات التي أكلت فيها البقرة المعادن يقدم إضافة ☒
   - يجب تحديد الكمية بشكل دقيق والخيار الأول غير مفيد إطلاقا ☐
8) ماذا يمكنك أن تقترح كإضافة لهذا الجهاز ؟

....

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9) ما هي المشاكل الشائعة عند البقر التي يمكننا إيجاد حل تقني لها بالنسبة لك ؟

Chaleur, Dystocie, Fréquence respiratoir, cardiaque (N.....)

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   ..../......................................

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   d Frequence Res + Cardiaque + Mise en [illegible] (Echographie)

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   Les indigestions

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   ....[illegible]..

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fréquence respiratoire و [illegible]

....

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Les chaleurs..........

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