University of Carthage

Higher School of Communication of Tunis

Scope of statement

BerryScan
A Robotic Approach to Strawberry Health Monitoring

Presented in the purpose of obtaining :

Cloud of things project

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0.1 Concept

0.1.1 Project Context

The agricultural sector is in a perpetual state of evolution, striving to meet the rising global food demands while ensuring sustainability and minimizing environmental impact. Strawberries, being both a popular fruit and a high-value crop, play a significant role in this equation. They are cultivated worldwide, feeding millions and contributing billions to the global economy.

However, strawberries are also particularly susceptible to various diseases that can adversely affect their yield and quality. This vulnerability stems from their delicate nature, their ground-level growth habit which makes them prone to soil-borne diseases, and their popularity which means they are cultivated in diverse climatic and soil conditions.

While traditional farming practices have served well in the past, the modern complexities brought about by larger cultivation areas, changing climate patterns, and the globalized nature of the food supply chain demand more sophisticated and proactive approaches. Early detection and intervention in disease outbreaks can save vast portions of a harvest, ensuring economic viability for farmers and consistent supply for consumers.

In this evolving landscape, technology offers promising solutions. The digital transformation wave that has been revolutionizing industries from finance to healthcare is making its mark on agriculture too. Technologies like artificial intelligence, robotics, and data analytics promise to tackle age-old challenges in novel ways. "BerryScan" emerges in this context, aiming to blend traditional agricultural knowledge with modern tech solutions. By doing so, it seeks to usher in a new era of precision farming where every plant matters and proactive interventions, powered by data-driven insights, become the norm rather than the exception.

0.1.2 Problematic

- **Manual Labor Intensity:**

  Traditional methods of disease detection largely rely on manual inspection. This involves labor-intensive efforts where farmers or agricultural experts walk through vast fields, examining plants one by one. Such methods are not only time-consuming but can also be inconsistent due to human fatigue and oversight.

- **Timeliness of Detection:**

  Early detection of diseases can often prevent their spread and reduce the need for widespread intervention. However, manual checks are sporadic and can miss the initial onset of a disease, allowing it more time to spread and potentially affect a larger portion of the yield.

- **Accuracy and Expertise:**

  Correctly identifying plant diseases requires expertise. Misidentification or the lack of recognition can lead to inappropriate treatments or missed treatment opportunities. Without the right expertise on hand at all times, farms are at risk of not addressing diseases effectively.

- **Scale and Coverage:**

  As farms expand in size, ensuring comprehensive coverage during manual checks becomes even more challenging. Larger farms can mean that certain areas are checked less frequently, leading to potential blind spots in disease detection.

- **Data-Driven Decision Making:**

  Traditional methods do not provide a systematic way to collect, store, and analyze data. This absence of data-driven insights means that farmers might miss patterns, such as specific zones in their fields that are more susceptible to certain diseases, or trends that could indicate larger environmental or soil issues.

- **Environmental Impact:**

  Inaccurate or delayed disease detection can lead to the overuse of pesticides or the use of incorrect treatments. This not only increases costs but can also have negative environmental impacts, affecting soil health, water quality, and local biodiversity.

0.1.3 Objectives

1. **Automation:** Develop a mobile robot capable of navigating strawberry fields, capturing high-definition images of plants without human intervention.

2. **Disease Detection:** Integrate a trained AI model to analyze the captured images and accurately identify signs of diseases on leaves or fruits.

3. **Data Visualization:** Design and implement an application that provides a comprehensive map of the farm, highlighting potential disease hotspots for further manual inspection or treatment.

4. **User Feedback Loop:** Allow users to confirm or refute the AI's detections, providing valuable data to refine and enhance the disease detection model over time.

5. **Scalability:** Ensure that the solution can be scaled up to accommodate larger farms or potentially be adapted for other crops in the future.

0.2 Clients

0.2.1 Strawberry Farmers and Growers

The primary beneficiaries of "BerryScan" are the farmers and growers. With the implementation of this robotic solution, they can achieve early and accurate disease detection, potentially saving significant portions of their harvest. This not only ensures a higher yield but also reduces the costs associated with disease management and crop loss.

0.2.2 Agricultural Cooperatives

These are organizations formed by farmers to collectively manage and market their produce. "BerryScan" can offer cooperatives a consistent method to ensure the quality of the strawberries they source, thereby upholding their reputation in the market.

0.2.3 Agricultural Research Institutions

Research bodies can use the data collected by "BerryScan" to study disease patterns, explore new treatments, and develop better strawberry varieties resistant to prevalent diseases.

0.2.4 Agricultural Supply Stores

By understanding the common diseases detected in certain areas, these businesses can better stock relevant treatments, pesticides, or organic solutions catering to the local farmers' needs.

0.2.5 Governmental and Non-Governmental Agricultural Bodies

Regulatory bodies can utilize "BerryScan" data for larger agricultural landscape analyses, ensuring food security, and planning interventions if disease outbreaks are significant.

0.2.6 Tech Companies in Agribusiness

As tech integration in agriculture grows, companies that develop or market agricultural technology may find interest in partnering or integrating with solutions like "BerryScan" to offer a more comprehensive suite of services.

0.3 Functional Needs

0.3.1 Autonomous Navigation

BerryScan must be able to navigate through strawberry fields autonomously, ensuring comprehensive coverage without the need for constant human guidance. This includes avoiding obstacles, adapting to different field layouts, and ensuring minimal disruption to the plants.

0.3.2 High-Resolution Image Capturing

The robot should be equipped with cameras capable of capturing high-definition images to ensure accurate disease detection. This requires clear visuals of both the leaves and fruits of the strawberry plants.

0.3.3 Real-Time Disease Detection

Integrate an AI model trained to detect common strawberry diseases. As the robot captures images, the AI should analyze them in real-time, flagging potential disease markers immediately.

0.3.4 Data Storage and Management

All captured images, along with their corresponding analysis results, need to be stored securely. This data repository should be easily accessible for further analysis and should allow for historical trend analysis.

0.3.5 Interactive Farm Mapping

The system should generate a dynamic map of the strawberry field, plotting out areas where potential diseases have been detected. This map will serve as a quick reference for farmers to locate problem areas.

0.3.6 User Interface and Feedback Loop

Develop an intuitive user interface, preferably a mobile or web application, where farmers can view the mapped data, see individual image analyses, and provide feedback on the accuracy of detected diseases.

0.3.7 Notification System

In cases of severe or widespread disease detection, the system should have an alert mechanism to immediately notify farmers, allowing for swift intervention.

0.3.8 System Updates and Learning

Given the evolving nature of diseases and the possibility of new strains, the system should allow for periodic updates to the AI model. The feedback loop from users can serve as valuable data to continuously train and refine the AI for better accuracy.

0.3.9 Integration Capabilities

BerryScan should be designed with the foresight of potential integrations, whether it's with other farm management software, weather prediction tools, or advanced analytics platforms.

0.3.10 Environmentally Friendly Design

Given the agricultural setting, it's crucial that the robot's design and operations are environmentally friendly, ensuring minimal carbon footprint and no harm to the field's ecosystem.

0.4 Components

0.4.1 Autonomous Navigation

- **Sensors:**
  - **HC-SR04 Ultrasonic Sensor:** For obstacle detection.

FIGURE 1: HC-SR04 Ultrasonic Sensor

  - **IR Proximity Sensor:** For close-range obstacle detection.

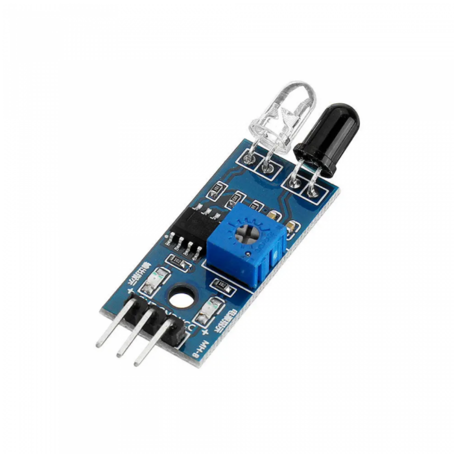

FIGURE 2: IR Proximity Sensor

- **GPS Module:**
  - **U-blox NEO-6M GPS Module:** To provide accurate location data for each image captured.

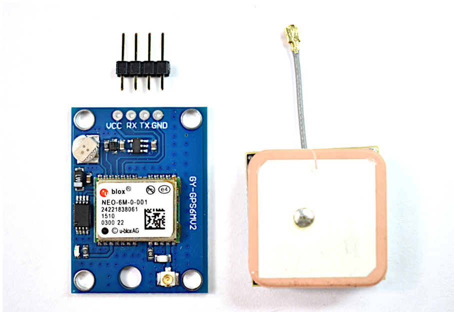

FIGURE 3: U-blox NEO-6M GPS Module

- **IMU (Inertial Measurement Unit)**
  - **MPU-6050:** Useful for stabilization and directional data.

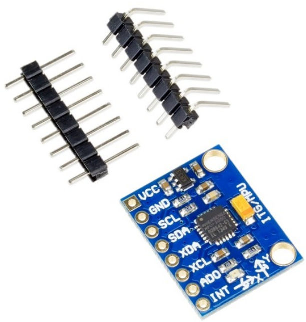

FIGURE 4: MPU-6050

- **Motor and Drive System**
  - **L293D Motor Driver:** To control simple DC motors for robot movement.

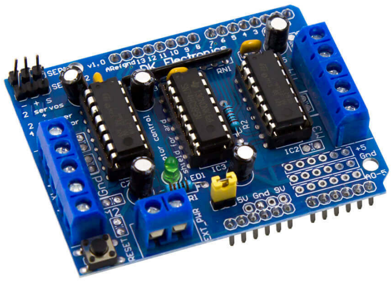

FIGURE 5: L293D Motor Driver

- **Battery:**
  - **18650 Li-Ion batteries:** Power source for the robot.

0.4.2 Image Capturing

- **Smartphone with High-Resolution Camera:** Utilized primarily for capturing images.
  - **Mounting System:** Adjustable mount tailored for phone dimensions.
- **Raspberry Pi Camera Module (optional)**
  - **Raspberry Pi Camera Module v2:** Alternative or backup to the smartphone camera.

0.4.3 Data Storage and Initial Processing

- **Raspberry Pi 5:** Coordinates the image capture, stores the temporary image data, and manages transmission.
  - **SanDisk Ultra microSD cards:** Temporary storage before transmission.

0.4.4 Data Transmission to the Cloud

- **Raspberry Pi 5 Wi-Fi Module:** Leveraging its built-in Wi-Fi capability for data transmission.

0.4.5 Integration Capabilities

- **USB ports on Raspberry Pi 5:** Useful for direct data transfer, potential software updates, or integrating additional modules.

0.5 System Architecture

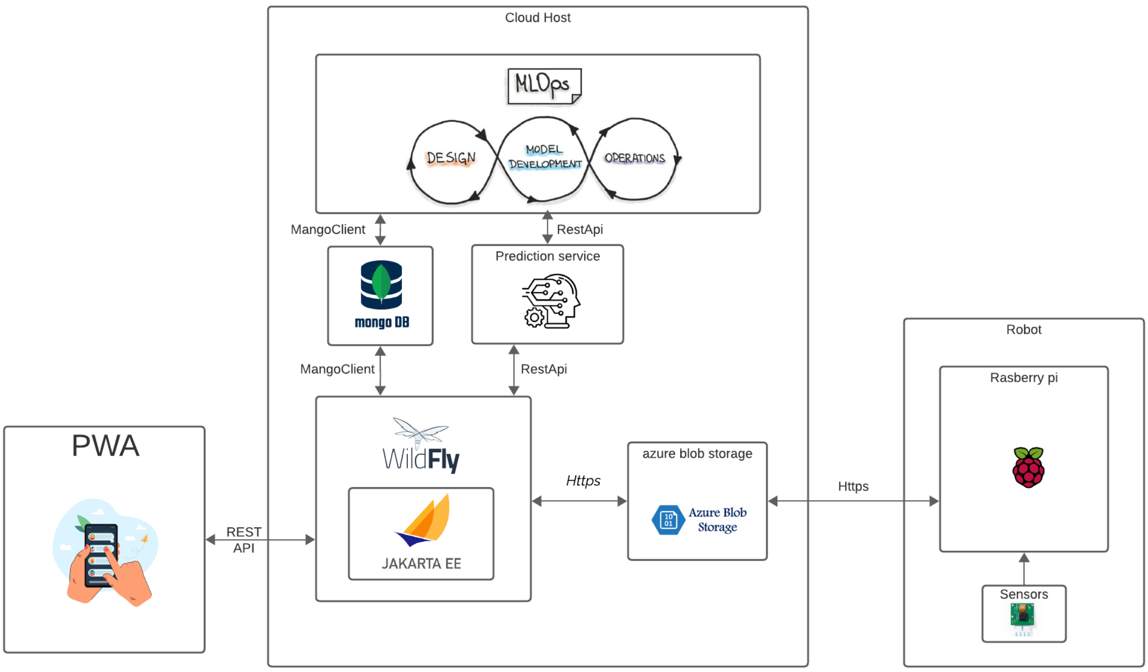

FIGURE 6: System Architecture

0.6 Deliverable

By the end of this project, these requirements must be delivered:

- **Scope of statement:** A document that defines all the elements of the project scope as well as assumptions and project requirements.
- **Design document:** A document that describes the architecture of the application the functionalities and differents components using diagrams
- **Source code:** The source code for the different parts of the project
- **Demonstration:** BerryScan prototype and simulation.

0.7 Project Timeline

The project development will undergo different steps:

- Planning of the architecture an connecting objects.
- Handling collected data and connecting to cloud MQTT broker.
- Implementing database logic.
- Developing necessary APIs and connecting to database.
- Hosting Jakarta EE on a cloud server.
- Developing the machine learning model .
- Developing the necessary Mlops piplines
- Developing a PWA and connecting to the web server endpoint.
- Implementing necessary security mesures .
- Testing the project
- Creating a prototype and simulation.
- Organize and update the project repository with a Design Book, Full source code, Technical documentation and a Demo video.

0.8 Business Model

Having a product that perfectly aligns with the reality of the market is a complex endeavor. Consumer habits evolve, and it can be challenging to keep up with the pace of change within a company. The marketing mix, or the 4Ps, is the recipe to achieve the set objectives.

- **Product Policy :**

  Our product will be at the core of our marketing strategy.
  Brand : "BerryScan" solution that combines two hardware and software components, resulting in a hybrid application. **Product Related Services :**

  - After-Sales Service.
  - Regular updates, new features, and daily improvements.
  - Warranties extending up to 5 years.

  Features : Diversification and variety in terms of options and design.

- **Pricing Policy :**

  Price is at the core of positioning and the key element of communication. The policy followed is the skimming pricing strategy.

  Skimming Strategy:
  Companies often resort to price skimming when launching innovative products with little competition. This strategy also aims at specific customer segments with strong purchasing power. Due to the absence of direct competition in Tunisia, the price of the solution depends on the features the customer wishes to implement in their greenhouse, such as introducing fire alarms or unlocking nearby racks.

- **Commercial Discount Policy :**

  Exceptional discounts granted to customers due to quality issues or non-conformity and payment methods range from bank transfers to online payments.

- **Distribution Policy :**

  Distribution and the choice of channel determine the product's visibility and accessibility.

Distribution Channels:

- **Direct:** Our product is sold directly to customers without intermediaries. This applies to the complete software solution.
- **Short:** We source IoT equipment (sensors, electronic cards, etc.) directly and then resell to the customer.

Distribution Methods:

- Direct delivery to our customers for the software solution.
- Retail: Purchase of equipment for resale to customers.

Intermediaries:
Independent retailers and wholesalers selling IoT equipment (sensors, surveillance cameras, etc.) separately.

- **Communication Policy :**

  We offer all the public promotional techniques aimed at supporting a product.

  - **Online Advertising Measures:** Display Advertising, Videos (on YouTube, Facebook, etc.), advertising on social networks, etc.
  - **Personal Communication:** Interaction with the customer.
  - **Internet Communication:** Email marketing, newsletters, social media marketing.
  - **Sales:** Sales outreach, demonstrations, participation in trade shows and fairs.
  - **Public Relations:** Press releases, sponsorship operations, endorsements, event management.
  - **Advertising:** Display, brochures, pamphlets.

0.9 Constraints

- **Methodology of work:**
  We will work with Extreme Programming (XP) which is a software development framework agile which aims to produce better quality software, XP is the most specific of the agile frameworks regarding appropriate engineering practices for the development of software.
  The principles of the XP method are not new since they are those of agile methods. The difference and the originality lie in the fact that they are taken to the extreme. The XP method is based on:
  - Strong responsiveness to changing customer needs
  - Teamwork
  - The quality of the work provided
  - The quality of the tests carried out as soon as possible
- **Time constraint :**
  9 weeks will not be enough to complete the development of this solution with all the necessary specifications and get a stable version of the application.
- **Hidden defects :**
  A robust solution must contain unit tests to ensure the perfect functioning of the application, we can then obtain hidden defects in the developed solution if we cannot cover all possible scenarios with unit tests.
- **Lack of experience :**
  Due to the lack of experience of team members, mistakes can be made in estimating the time needed for development tasks.