SOFTWARE REQUIREMENTS SPECIFICATION

Farm Bot

CENG350 Software Engineering

GROUP-1

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Revision History

Version	Date	Explanation
1	17.03.2024	Part 1 completed
2	04.04.2024	Some parts are fixed according to the feedback.

Table - 1 Revision History

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1 Introduction

1.1 Purpose of the System

The purpose of the CNC system is to create an open and accessible technology that helps people (possible farmers) about grain, farming and growing plants and crops. This efficiency is achieved by a remote farming bot that can be controlled via web application. It also aims to help education, research related to farming, as well as home use for ordinary people.

1.2 Scope

The main scope of the FarmBot is to provide reliable, fast, efficient and cheap crop growing at the same time, provided the bot is properly installed on the corresponding area. To be specific, there is no one type of FarmBot. There are various of FarmBots. Each has different features with different size and cost.

- FarmBot will maintain an automated planting, seeding, weeding, maintenance, watering, crop monitoring and crop rotation.
- There are a lot of sensors that are attached to bot. The bot has a camera, soil sensors and a watering tool for the both data and maintenance purposes.
- FarmBot collects data on various aspects of crop growth and environmental conditions, which allows users to analyze trends, identify patterns, and optimize the farming practices.
- There is a graphically designed application with a game-like interface to help users grow crops easily via an interface map.
- The system will provide a flexible behaviour. The FarmBot can be configured and customize easily. All can be done with changing the basic parameters, meaning there is no coding knowledge required.
- There will be an extensive software documentation with how-to guides, descriptions of every feature and pro-tips.

1.3 System Overview

This section provides a non-technical overview of the basic components of FarmBot.

1.3.1 System Perspective

FarmBot provides an application for configuration and customizing as well as giving the instructions to robot. When FarmBot is given an instruction via its application, it first applies the instruction and then, updates the corresponding data. The user can observe various data provided by sensors and camera to application. Finally, the user can collect the crops at the end of the growth period.

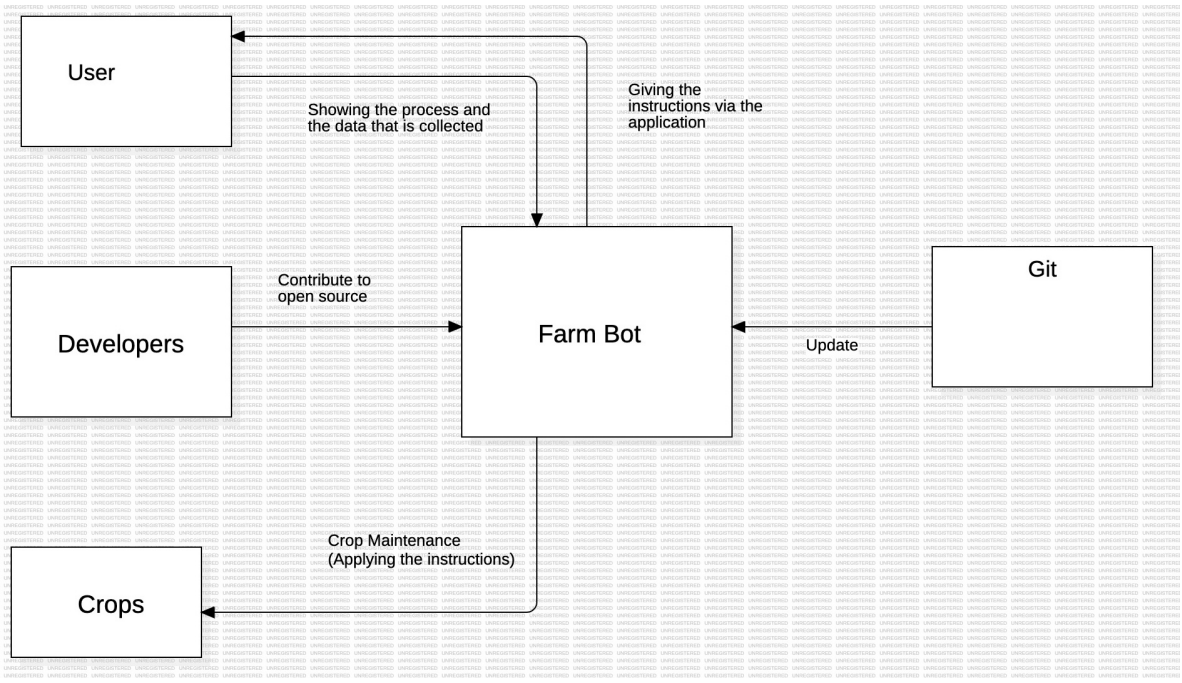

Figure 1: Context Diagram

1.3.1.1 System Interface

Interfaces are the components that help other components interact with each other, users and developers. FarmBot has various interfaces. This autonomous robot has both hardware and software components that require interaction with other components. Those are the following interfaces.

- User Interface
- Hardware Interface
- Software Interface
- Communication Interface

1.3.1.2 User Interface

The FarmBot has an application that establishes the connection between the user and the system. To see the demo of the application, you must click **here**.

Main Interface: The figure below is the main page of the FarmBot application. As can be seen, the detailed map is there with the axis coordinates to let the user identify the location. The bar above shows the current x-y coordinates, the complete percentage, the state of the machine and connection information. The user can choose where to plant, seed and water. In the toolbar, there are various of buttons to change the interface.

Note: The following photos and screenshots are from the demo of the application.

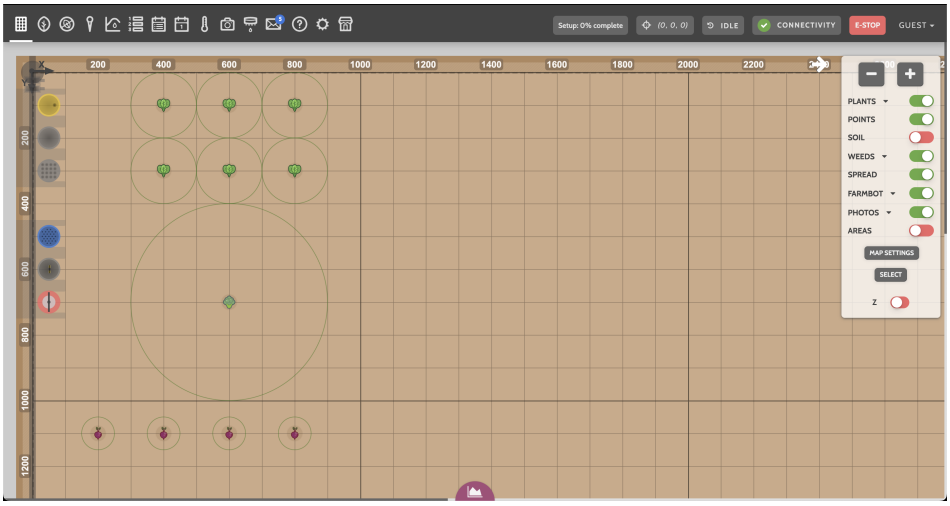

Figure 2: Main Interface

Plant Interface: There is also an interface plants. The plants can be seen in the list and each can be chosen for the detailed information.

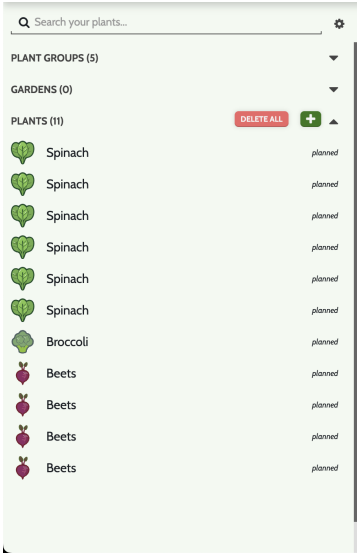

Figure 3: Plant Choosing Interface

Plant Edit Interface: There is also an interface for editing the plant chosen from the interface above. This interface contains the detailed information about the plant such as date, size, coordinates and so on.

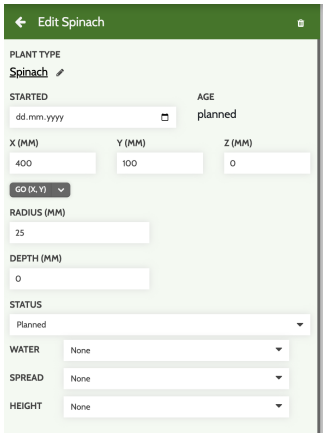

Figure 4: Plant Editing Interface

Weed Interface: There is an interface that lets user see the detailed information about the weeds. The user can observe the state of the weeds, their group and one can add weed from this interface.

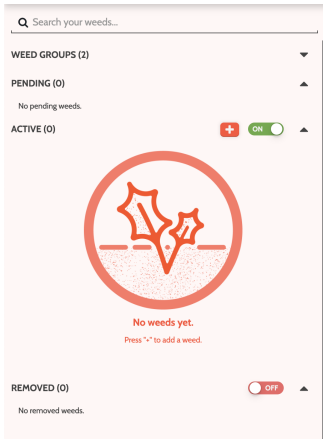

Figure 5: Weeds Interface

Point Interface: The figure below shows the interface where the user form points or group of points.

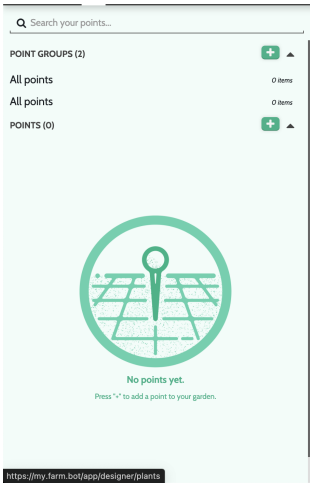

Figure 6: Point Interface

Curve Interface: The figure 7 is the interface for creating curves. Those curves can be water, spread or height curves.

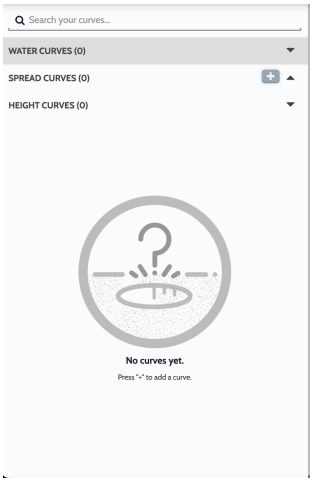

Figure 7: Curve Interface

Tool Interface: The user of the FarmBot can choose the tool that he/she wants to run. There are a lot of tools such as watering, taking photo, finding home, planting seed and so on.

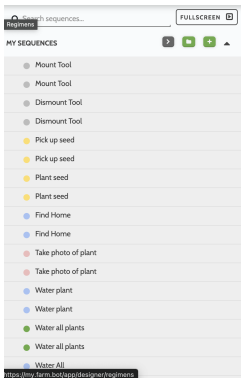

Figure 8: Tool Interface

Regimen Interface: The interface below is for a certain regimen.

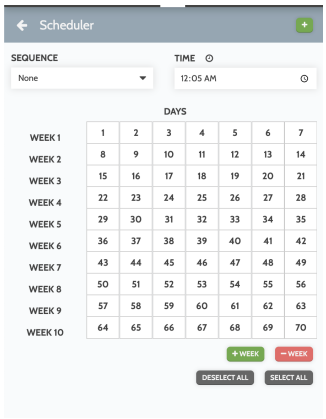

Figure 9: Regimen Interface

Scheduler/Event Interface: There is an interface for scheduling your event, which is available at figure 10.

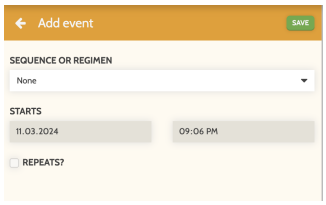

Figure 10: Event Interface

Sensor Interface:FarmBot sensors interface is the main interaction between the sensors of the robot and the user. There can bee seen the toil sensor.

Figure 11: Sensor Interface

Photo Interface: There is an interface that helps the user take photograph from the camera attached to FarmBot.

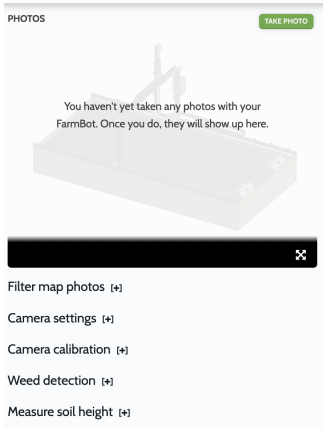

Figure 12: Taking Photograph Interface

Settings Interface: The figure 13 shows the settings interface. This is the interface of customizing and configuring the bot. The user of the system can arrange the parameters with respect to the conditions from this panel.

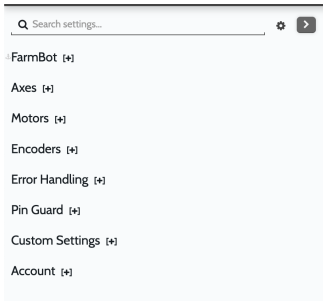

Figure 13: Settings Interface

1.3.1.3 Hardware Interface

The system is a robot. Therefore, there are a lot of sensors. The list of the hardware interface is below.

- Aluminum Extrusions, Plates and Brackets, Plastic Parts
- Farmduino (Farming + Arduino) electronics board
- Raspberry Pi 3 as the web-connected brain.
- NEMA 17 stepper motor
- The sensors such as soil sensors and camera

1.3.1.4 Software Interface

The list of the software interface is the following.

1. **Operation system**: There is a special operating system named FarmBot OS that maintains a connection and synchronize with web application.
2. **Database**: The OpenFarm database is free and open. This database service provides crop and growing information to the web app.
3. **Firmware**: A firmware flashed onto the Arduino (Farmduino) is responsible for electronics. This firmware receives G and F codes from FarmBot OS and acts according to signals.
4. **Application**: The web application can be loaded on any device.

In the next page, there is a figure (Figure-14) that shows the high level overview of the system.

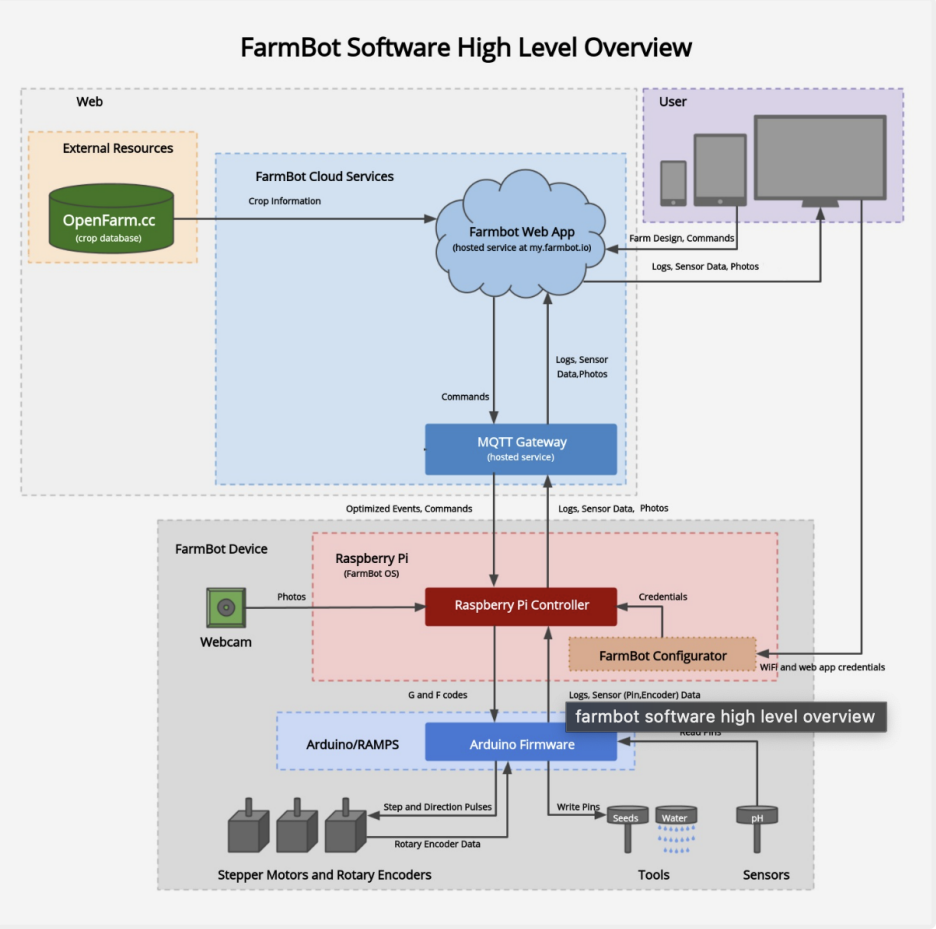

Figure 14: High Level Software Overview

1.3.1.5 Communication Interface

In order the user to communicate to the FarmBot, the Web application needs to have been preinstalled. The FarmBot Web App makes use of FarmBot Cloud Services to get the crop information. The Web App uses MQTT Gateway (hosted service) that utilizes TCP connection to convey the commands generated by the user to Raspberry Pi, and to receive the data from Raspberry Pi Controller.

1.3.1.6 Memory Constraints

The Web App requires a certain amount of RAM and GPU to be efficient. Therefore, the user must own a device that satisfies the corresponding requirements. Additionally, FarmBot is a embedded system that uses Raspberry Pi and Arduino. These devices also has limited capacity. They can handle limited amount of instructions. Also, they are capable of storing limited amount of data. So, the user should not overwhelm the memory.

1.3.1.7 Operations

User Initiated:

1. Planting crop such as spinach, beets, broccoli and so on
2. Removing weed
3. Adding point to crop area
4. Managing curves
5. Running the default instructions sequentially
6. Adding regimen
7. Scheduling events
8. Using sensors
9. Taking Photo
10. Customizing and configurating settings

Self Initiated:

1. Maintenance of the crop area
2. Arranging 3-axis gantry for automated phenotyping
3. Concurrent growth with high throughput

Researcher Initiated:

1. Acquiring plating, farming and crop data

Developer Initiated:

1. Contributing to the open source

1.3.2 System Functions

Remote View	The user has a remote view the overall crop area from the application interface.
Remote Control	With the web application, all of the plants can be examined. For instance, their x-y-z coordinates, radius, water, date and status.
Curve Arrangement	The user can choose where and when to water, and amount of water. Additionally, the width of the curve can be controlled from spread curve interface, whereas the height of the curve can be controlled from height curves interface
Sequential Control	If users have already chosen the tasks to be executed, they can arrange the sequential execution of the instructions
Setting Regimen Event Scheduling	Regimen for a specific crop, or area can be determined. There is a calendar that allows storing important events. The event can be executed when its date arrives
Soil Sensors	The current data collected from a sensor is available on the web app.
Camera	There is a camera that allows taking, filtering photos taken as well as measuring the soil height and weed detection.
Tool Management	The tools attached to FarmBot, those apart from FarmBot can be edited in detial.
Configuration And Customization	The motors, encoders, pins and even error handling can be customized and configured.

Table 1: System Functions

1.3.3 Stakeholder Characteristics

There are three groups of people as stakeholders which are users, students/lecturers and researchers.

The first group is the users. This group includes both home-use, and commercial/-trading use such as farmers. The main purpose of this group is to make use of FarmBot to produce the desired crops with certain efficiency and cost.

The second group is those who are taking an active role in education industry such as students and teachers. FarmBot can enable students to soil science, agriculture, botany, engineering by giving them experience. FarmBot has been integrated to over 500 educational instutions and their curriculum.

FarmBot shares the data it has collected with the sensors attached to it. All this data is available to Scientists and researchers. Some of the research ares are photogrammetry, food off-world and AI.

1.3.4 Limitations

A) Regulatory Requirements And Policies: The installation and operation of FarmBot systems may be subject to local zoning and land use regulations, particularly if they are installed on agricultural land or in residential areas. Compliance with these regulations may involve obtaining permits or approvals from local authorities.

B) Hardware Limitations: FarmBot system can do the task that are completed by farmers in an automated manner with its high level sensors and tools whose control is responsible for FarmBot OS, Raspberry Pi and Arduino.

C) Interfaces to Other Applications: The FarmBot project shall be compatible with sensors, microboard, hosted service and web application.

D) Parallel Operation: The system can both collect the data and operate its tasks concurrently.

E) Audit Functions: There is an audit for both plants and the system that can be sustained through the web app.

F) Control Functions: The FarmBot project is user-controlled.

G) Higher Order Language Requirements: The firmware was written in C++ and C. However, OS was coded by mostly Elixir, and Python. Finally, the Web App was mostly coded with TypeScript as well as Ruby.

H) Signal Handshake Protocols: The project communicates the user via web app. The MQTT Gateway establishes TCP connection between both sides. There is a reliable data transfer.

I) Quality Requirements: The system shall ensure that the correct physical location, amount, timing and data will be provided. Additionally, the project will be maintainable , sustainable and user friendly.

J) Criticality of the Application: If it fails, it may result in low efficiency and bad results in terms of both crops and user economy.

K) Safety and Security Considerations: The system establishes a connection to a website. Thus, there must be a secure connection to protect user confidential information from cyber attacks.

L) Physical/Mental Considerations: The power supply, cables and some electronics may harm depending on the physical conditions.

M) Limitations that are sourced from other systems: The system shall be compatible with other devices to ensure the limitations above.

1.4 Definitions

AI	Artificial Intelligence
MQTT	Message Queuing Telemetry Transport
TCP	Transmission Control Protocol
TypeScript	A strongly typed programming language that builds on JavaScript
Raspbery Pi	The name of the microboard
Arduino	Open-source electronic prototyping platform
Elixir	Dynamic function language for building scalable and maintainable applications
Ruby	Dynamic open source programming language with focus on simplicity productivity
Nema 17 Stepper	A motor that has a 1.8 degree step angle with 1.7 x 1.7 inch faceplate

Table 2: Definitions Table

2 References

[1] “Open-source CNC farming,” FarmBot, https://farm.bot/ (accessed Mar. 12, 2024).

The standarts are from:

ISO/IEC/IEEE International Standard Systems and software engineering Life cycle processes Requirements engineering.

(2018). IEEE. https://doi.org/10.1109/ieeestd.2018.8559686

3 Specific Requirements

3.1 External Interfaces

The following class diagram represents the relationship between interfaces and their functionalities. For an explanation of the interfaces, please refer to section (1.3.1.2).

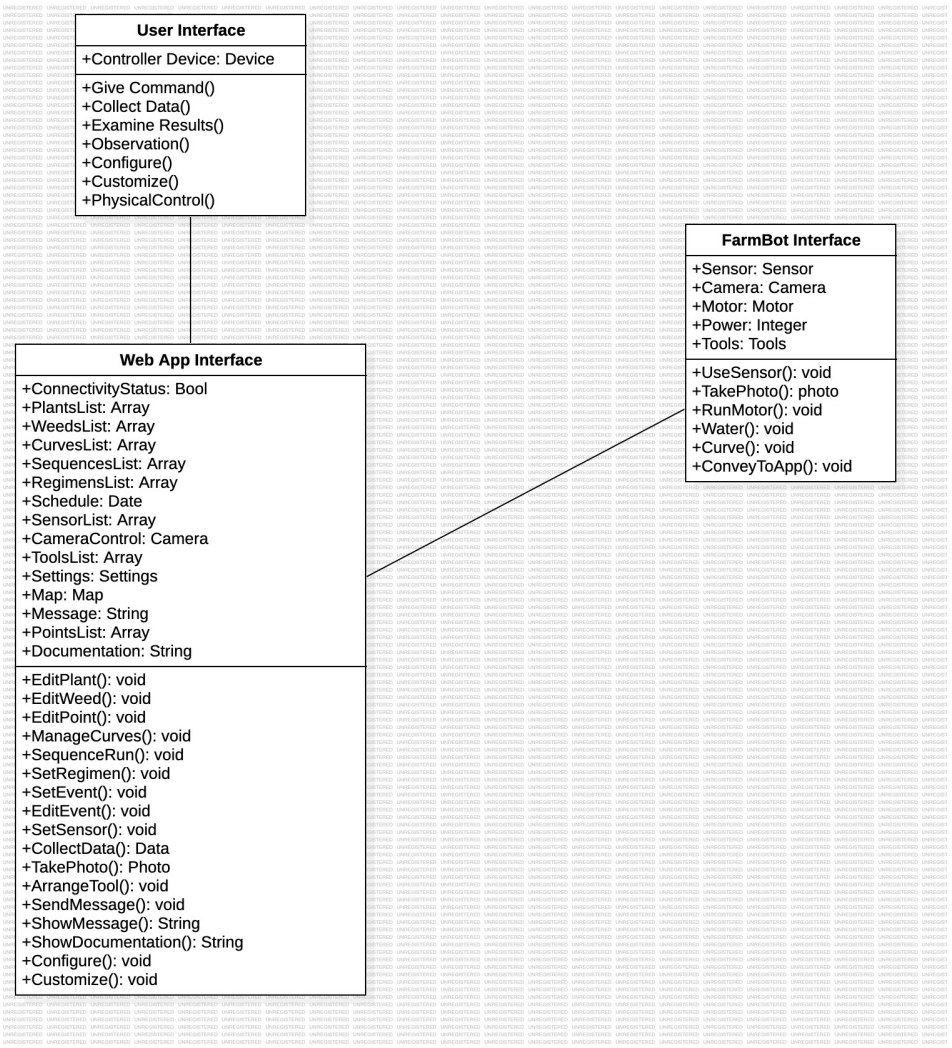

Figure 15: External Interfaces

3.2 Functions

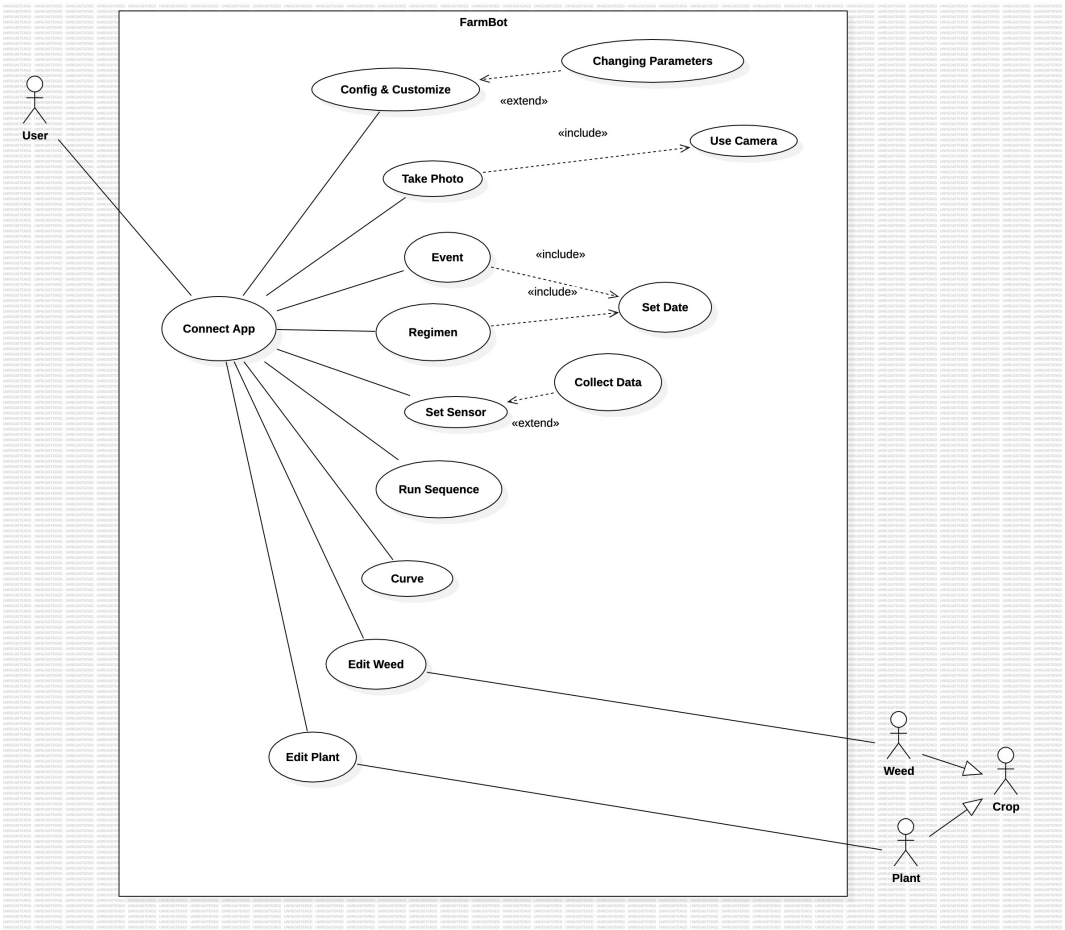

Figure 16: **Functions** Use Case Model

Use Case Name	Connect App
Actors	User
Description	User logins the system
Preconditions	Device, Internet
Data	Login Information
Stimulus	User opens the application
Normal Flow	• **Step1:** The user opens device and the app • **Step2:** The user enters login information
Alternative Flow	-
Exception Flow	Fail to Connect
Post Conditions	Being able to see the application interface

Table 3: **Conneting App** Use Case

Use Case Name	Config and Customize
Actors	User
Description	User can configure and customize the FarmBot as desired.
Preconditions	The Web App should work properly
Data	Encodings, Parameters, Pins
Stimulus	User clicks the settings part on the application
Normal Flow	• **Step1:** The user logins the system • **Step2:** The user changes the corresponding parameters.
Alternative Flow	-
Exception Flow	-
Post Conditions	The behaviour of the FarmBot changes

Table 4: **Config & Customize** Use Case

Use Case Name	Take Photo
Actors	User
Description	User can take photo of the current situation.
Preconditions	The Web App and the camera attached to bot should work properly
Data	Photograph
Stimulus	User clicks the taking photo interface
Normal Flow	• **Step1:** The user logins the system • **Step2:** The user opens camera option. • **Step3:** The user takes the photograph by adjusting the parameters to take the desired photographs.
Alternative Flow	-
Exception Flow	-
Post Conditions	The user can take the photograph of the current conditions of the crops

Table 5: **Take Photo** Case

Use Case Name	Event
Actors	User
Description	User can set events on the schedule to automate the system.
Preconditions	The Web App must be working properly.
Data	Date
Stimulus	User selects the data.
Normal Flow	• **Step1:** The user logins the system • **Step2:** The user chooses the event interface and selects the date. • **Step3:** The event is entered.
Alternative Flow	-
Exception Flow	Event Fails
Post Conditions	The event task is completed

Table 6: **Event** Use Case

Use Case Name	Regimen
Actors	User
Description	User can adjust the regimen of the crops.
Preconditions	The Web App and the sensors of the Farmbot must work properly. Moreover, it also needs the desired amount of resources.
Data	Sequence, Date
Stimulus	User clicks the regimen interface
Normal Flow	• **Step1:** The user logins the system • **Step2:** The user adjusts the corresponding parameters of the regimen interface.
Alternative Flow	-
Exception Flow	The application of regimen fails.
Post Conditions	The regimen is applied to the system.

Table 7: **Regimen** Case

Use Case Name	Set Sensor
Actors	User
Description	User can arrange the sensors
Preconditions	The Web App and the sensors of the FarmBot must work properly.
Data	Soil Information, Tool Verification
Stimulus	User clicks the sensor interface
Normal Flow	• **Step1:** The user logins the system . • **Step2:** The user arranges the sensors.
Alternative Flow	-
Exception Flow	The data collected from sensors and sensor tasks fail.
Post Conditions	Sensors collect data and applies the task.

Table 8: **Set Sensor** Use Case

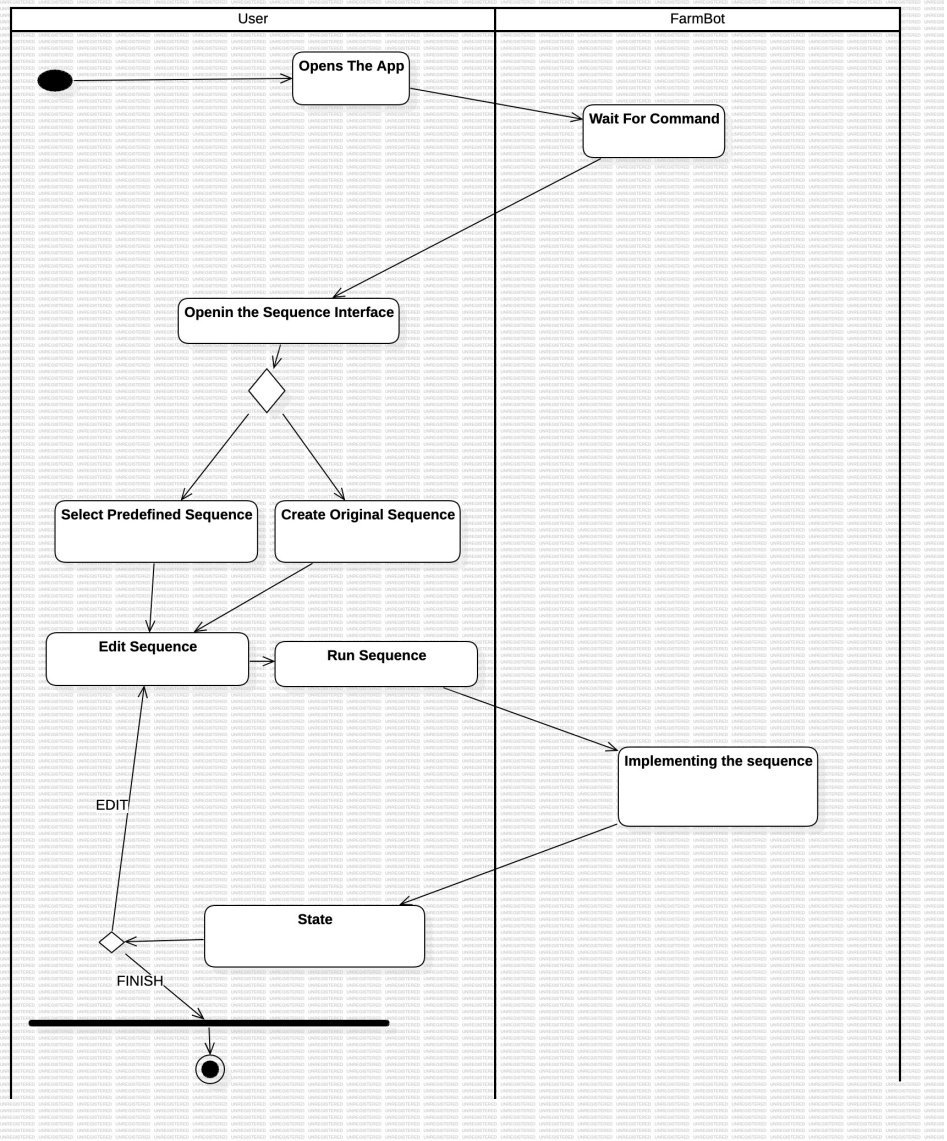

Figure 17: **Run** Sequence Case Sequence Diagram

Use Case Name	Run Sequences
Actors	User
Description	User can adjust the instruction sequence.
Preconditions	The Web App connection and robot's power must be suitable for the task.
Data	Sequence, Date, Resources
Stimulus	User clicks the regimen interface
Normal Flow	• **Step1:** The user logins the system • **Step2:** The user creates a sequence of instruction which must be completed.
Alternative Flow	-
Exception Flow	The sequence part of the application fails.
Post Conditions	The sequence of instructions is applied to the farm.

Table 9: **Run** Sequences Case

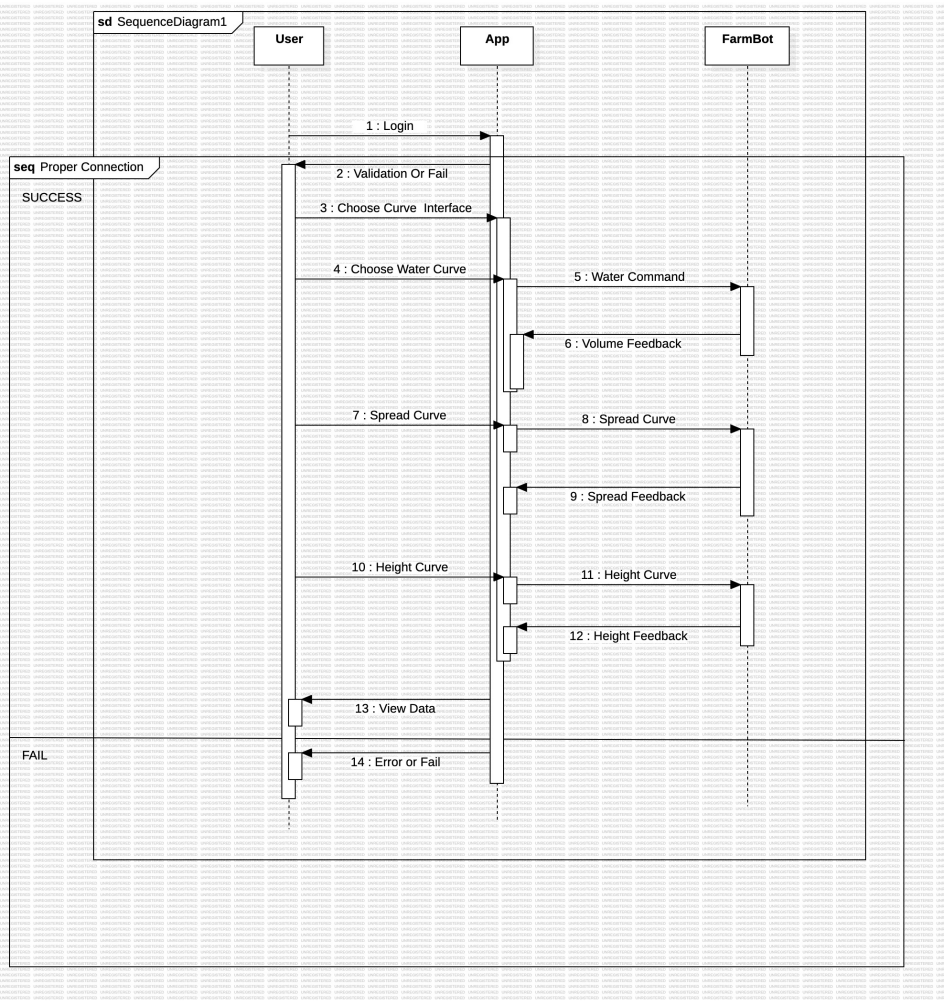

Figure 18: **Curve** Use Case Sequence Diagram

Use Case Name	Curve
Actors	User
Description	User can arrange the water, spread and height curves.
Preconditions	The Web App connection and robot's power must be suitable for the task.
Data	Coordinates, Water
Stimulus	User clicks the curve interface
Normal Flow	• **Step1:** The user logins the system • **Step2:** The user creates the desired water, spread, height curves by using the curve interface
Alternative Flow	-
Exception Flow	The desired plans for the curves cannot be completed.
Post Conditions	The desired curves are applied to the farm.

Table 10: **Curve** Case

Use Case Name	Edit Weed
Actors	User, Weed
Description	User can decide which weeds are going to be planted.
Preconditions	The Web App connection and robot's power must be suitable for the task.
Data	Coordinates, Weeds
Stimulus	User clicks the weed interface
Normal Flow	• **Step1:** The user logins the system • **Step2:** The user arranges and decides which weeds are going to be planted by using the weed interface.
Alternative Flow	-
Exception Flow	The desired weeds could not be planted.
Post Conditions	The desired weeds are planted to the correct places.

Table 11: **Edit Weed** Case

Use Case Name	Changing Parameters
Actors	User
Description	User changes the parameters for the FarmBot's function via WebApp
Preconditions	Device, Internet
Data	Parameters set by the user
Stimulus	User changes the parameters from the system
Normal Flow	• **Step1:** The user opens device and the app • **Step2:** The user enters login information • **Step3:** The user opens the FarmBot's control and changes the parameters.
Alternative Flow	-
Exception Flow	Fail to change the parameters
Post Conditions	FarmBot starts execution by adapting the newly set parameters.

Table 12: **Changing Parameters** Use Case

Use Case Name	Use Camera
Actors	User
Description	User utilizes camera to take the photo or video of the current condition of the farm.
Preconditions	Device, Internet, camera
Data	Photograph, video
Stimulus	User enters the use camera section of the WebApp.
Normal Flow	• **Step1:** The user opens device and the app • **Step2:** The user enters login information • **Step3:** The user opens camera mode of the FarmBot app. • **Step4:** The user gives take photo command to the FarmBot after adjusting some camera parameters.
Alternative Flow	-
Exception Flow	FarmBot fails to take the photo or video of the farm
Post Conditions	FarmBot takes the photo or video of the farm.

Table 13: **Use Camera** Use Case

Use Case Name	Set Date
Actors	
Description	The date is selected to arrange the event or schedule regimen.
Preconditions	A reliable connection to Web application
Data	Time period or specific date
Stimulus	User clicks the selecting date interface
Normal Flow	• **Step1:** The user chooses the reason to set the date. The reason can be an event, regimen or sequence. • **Step2:** The date selection is performed. • **Step2:** The system awaits for the time period or the specific date.
Alternative Flow	-
Exception Flow	The date or the period of time can be missed due to some system exceptions or physical conditions.
Post Conditions	The functions of the related task performed successfully.

Table 14: **Set Date** Use Case

Use Case Name	Collect Data
Actors	
Description	The FarmBot app collects the data to be shared.
Preconditions	The sensors are supposed to be functioning properly as well as the Web App connection and robot's power must be suitable for the task.
Data	All of the data regarding farming
Stimulus	User or developer choose to see the data via web App.
Normal Flow	• **Step1:** The user functions are performed • **Step2:** The data regarding those functions are collected. • **Step2:** The data is shared to stakeholders.
Alternative Flow	-
Exception Flow	The wrong data may be collected and shared.
Post Conditions	The desired sensors should be performing properly. Also, the system should be on for some period of time.

Table 15: **Collect Data** Use Case

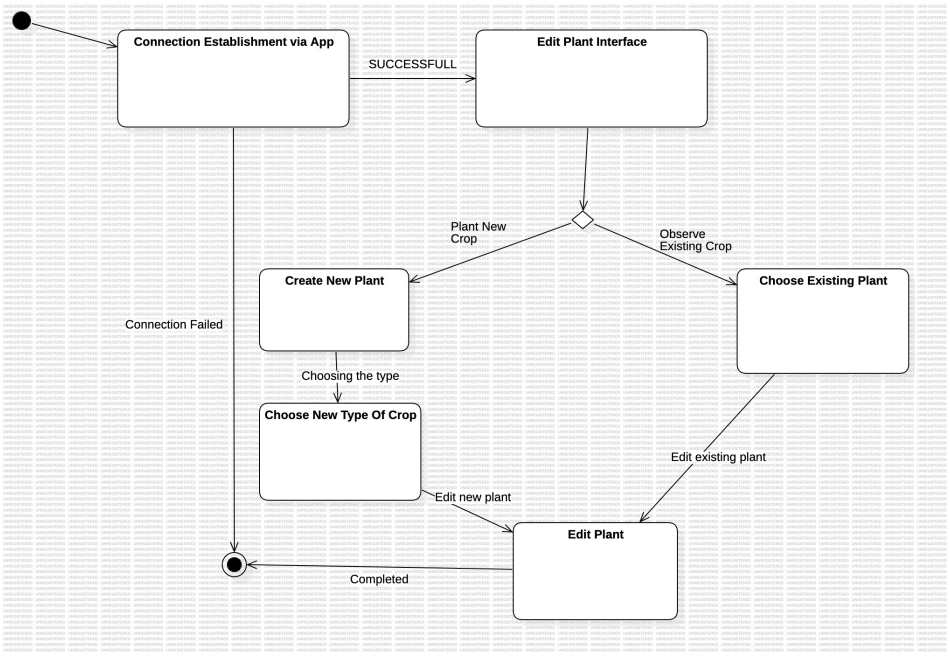

Figure 19: **Edit Plant** Case Sequence Diagram

Use Case Name	Edit Plant
Actors	User, Plant
Description	User can decide which plants are going to be planted.
Preconditions	The Web App connection and robot's power must be suitable for the task.
Data	Coordinates, Plants
Stimulus	User clicks the plants interface
Normal Flow	• **Step1:** The user logins the system • **Step2:** The user arranges and decides which plants are going to be planted by using the plant interface.
Alternative Flow	-
Exception Flow	The desired plants could not be planted.
Post Conditions	The desired plants are planted to the correct places.

Table 16: **Edit Plant** Case

3.3 Logical Database Requirements

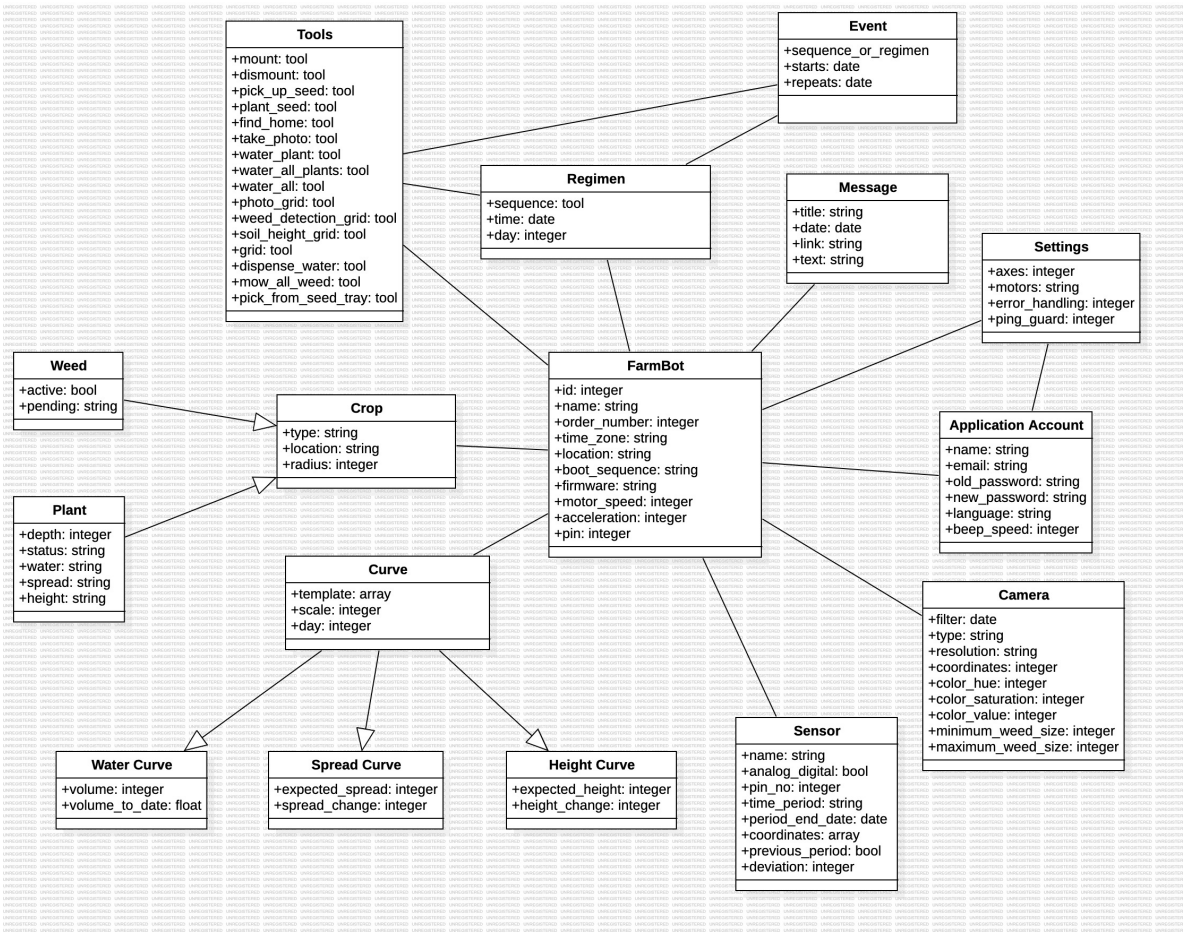

Figure 20: Logical Database Requirements Class Diagram

3.4 Design Constraints

FarmBot shall be established on top of garden. The sizes must be appropriate for the garden, and its tool must be resistant to harsh conditions.

3.5 System Attributes

1. **Reliability:**

   1.1 The FarmBot must inform the user in case of a shutdown or hitch.

   1.2 There should not be any physical harm to environment or to living things

2. **Availability:**

   2.1 After the establishing the connection between the app and the FarmBot, FarmBot must be ready to execute the user commands and sequences.

   2.2 The purchase of the FarmBot is available to most of the countries. There are partners in Europe, America and Asia.

   2.3 The aluminum extrusions, plates and brackets provide a long life time.

3. **Security:**

   3.1 FarmBot typically employs user authentication mechanisms to ensure that only authorized individuals can access and control the system.

   3.2 This is typically achieved using HTTPS (HTTP Secure), which encrypts data using SSL/TLS protocols.

   3.3 FarmBot systems can be installed within enclosures or housings to protect them from environmental factors such as rain, dust, and extreme temperatures.

   3.4 Motion sensors, proximity sensors, or other types of intrusion detection devices can be integrated into the FarmBot system to trigger alarms or alerts in case of unauthorized access or tampering.

4. **Maintainability:**

   4.1 Integration, customizing and configurations are much easy to apply without any knowledge of the advanced software and electronics.

   4.2 The recent documentation enables users to understand the new features.

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5.1 Its application can work on different mobile phones and tablets if they can satisfy the necessary requirements which is needed for application to work.

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3.6 Supporting Information

- The projects provides cheaper way of growing crops.
- Sensors use satellite or 4G/5G/LTE and are guaranteed to work anywhere.
- On average, every installed unit can save business $2466 annually. Considering the fuel, labour and vehicle maintenance costs involved in doing water runs, it is possible to save thousands of dollars per year.
- Anyone can install a FarmBot monitor within 15 minutes. All it is needed is a drill and FarmBot supplies all of the other equipment.

4 Suggestions to Improve the Existing System

- **Farming AI Configuration:** We have added AI configuration that helps user to decide certain things.
- **Pesticide Use:** There is not a tool for pesticide. Pesticide usage may be beneficial to crop growth since it protects crops from hazardous effects and other living things.
- **Voice Command:** For the sake of being user-friendly, voice recognition and voice command system would make it easy to rule the FarmBot.
- **Synchronization Between Other FarmBots:** FarmBots can be configured in a way that more than one FarmBots can operate synchronously.

4.1 System Perspective

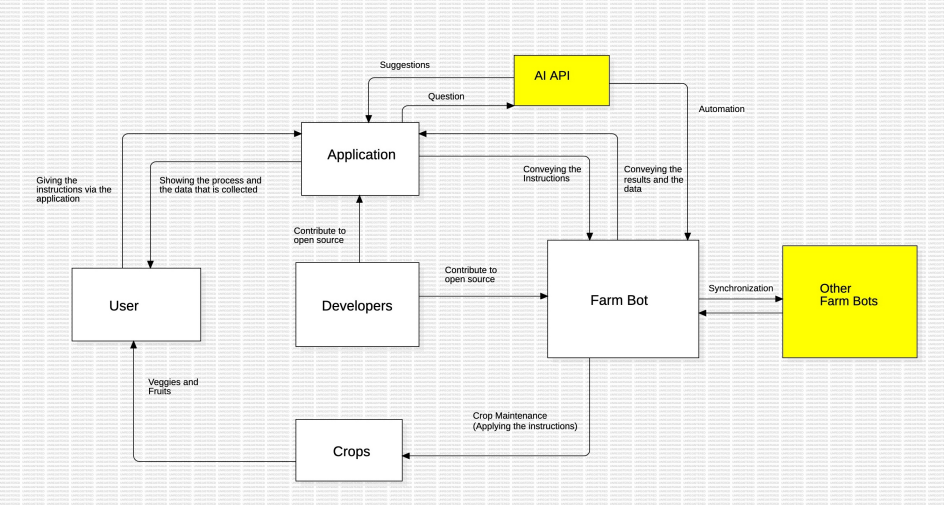

Figure 21: **Context Diagram** For Improvements

In the improved version of Farmbot, it can interact with other FarmBots on the area to fasten the process of completing the events more effectively and efficiently. Moreover, if one of the FarmBots is damaged, other FarmBots can distributes its jobs between each other so that the garden can operate without any delays. We also added AI to application so that when the users are confused or they need any help, they can directly utilize AI to get faster and better answers or suggestions. According to the users' requests, AI can also customize the FarmBot.

4.2 External Interface

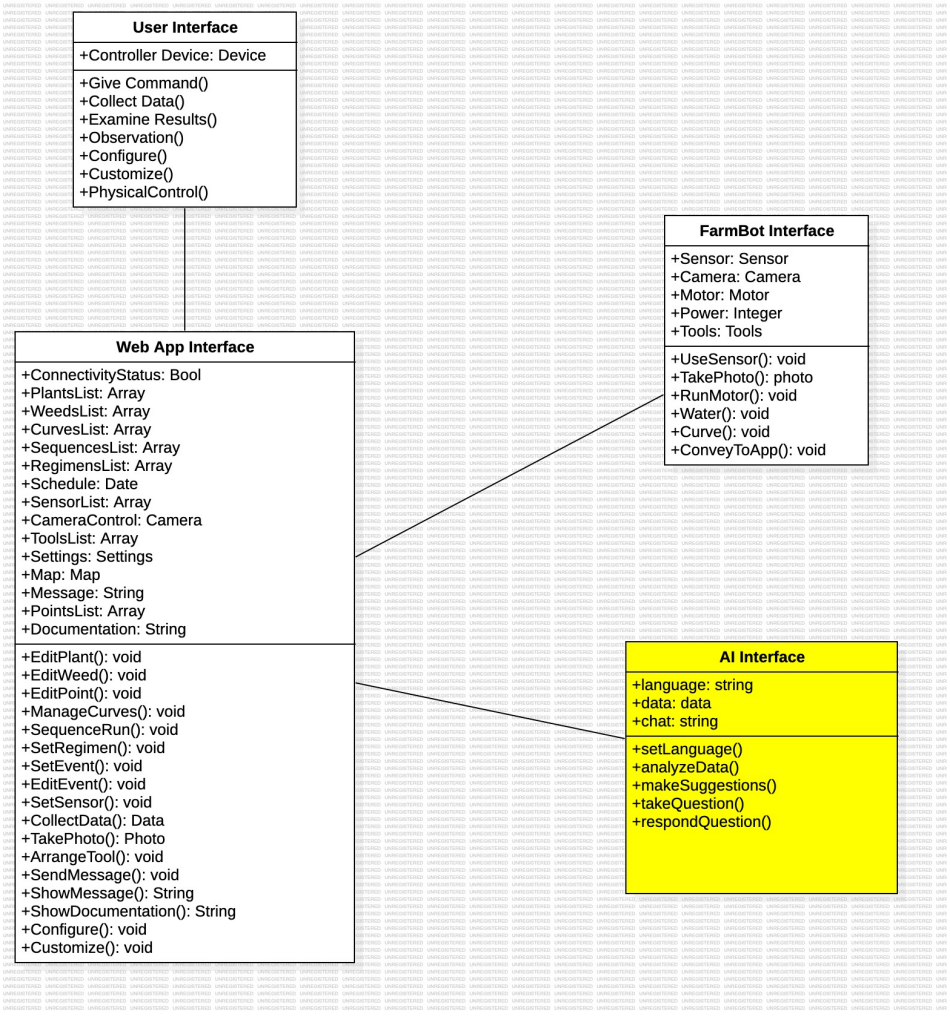

Figure 22: **External Interfaces** For Improvements

The following classs diagram represents the relationships between new application programming interfaces and their new functionalities.

Farming AI API

The users can set Farming AI API's language to have better communication. After receiving questions, it can generate the most suitable answers for the user. The Farming AI API's can also take suggestion or orders to customize and configure the FarmBot. After taking those orders, it can communicate with the FarmBot to implement them. The users can access the Farming AI API's question asking isterface; however, they will not be able to see that how it will communicate with the Farmbot and how it will generate the answers.

4.3 Functions

Figure 23: **Functions** Use Case Diagram For Improvements

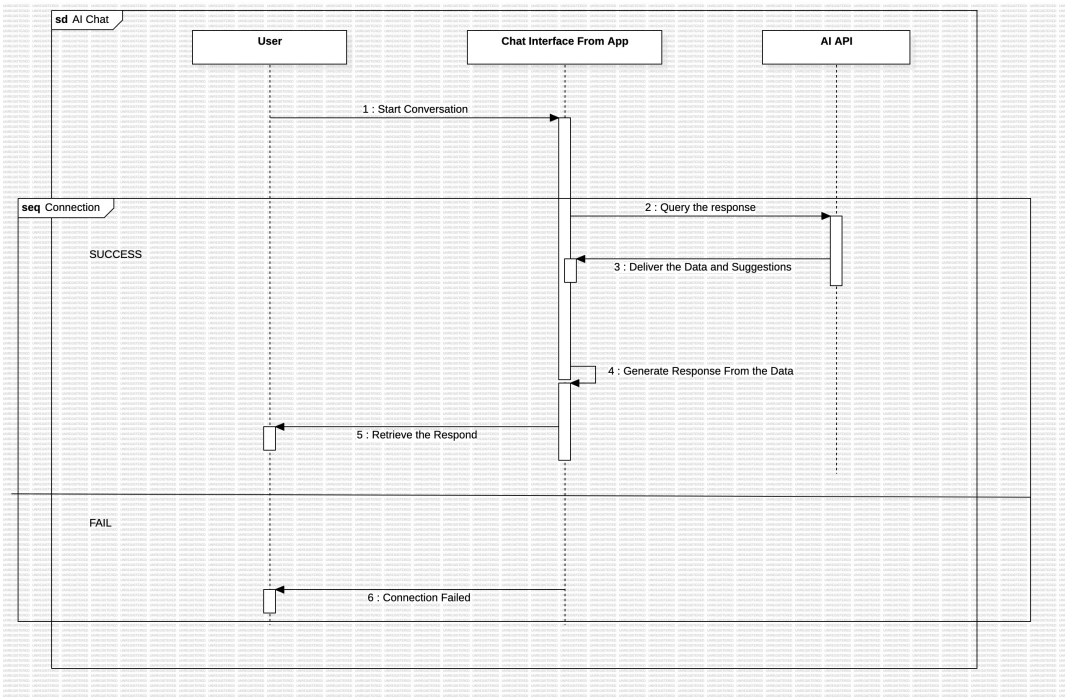

Figure 24: **AI Chat** Sequence Diagram For Improvements

Use Case Name	AI Chat
Actors	User, ChatBot, FarmBot
Description	Users can configure and customize the FarmBot by giving orders to the ChatBot. Moreover, They can take suggestions from the ChatBot by asking questions.
Preconditions	The Web App connection must be accomplished.
Data	Questions, FarmBot interface, Conditions of the Garden
Stimulus	User clicks the ChatBot interface.
Normal Flow	• **Step1:** The user logins the system • **Step2:** The user choose the ChatBot interface and ask questions or give orders.
Alternative Flow	-
Exception Flow	The ChatBot gives the error message the user about how and why the question was not answered.
Post Conditions	The ChatBot gives the suitable suggestions or implements the orders.

Table 17: **AI Chat** Case

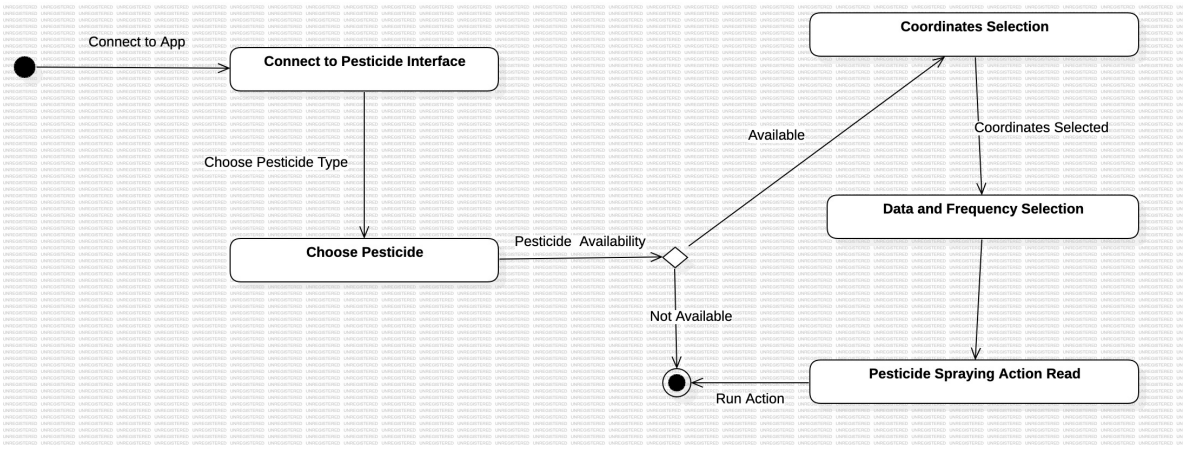

Figure 25: **Use Pesticide** State Chart Diagram For Improvements

Use Case Name	Use Pesticide
Actors	User, ChatBot, Crop
Description	Users can choose the pesticide they want to use to protect the crops from hazards or improve the growth rate of crops.
Preconditions	The Web App connection must be accomplished and there need to be sufficient to pesticides so that FarmBot can spray the pesticide to correct places.
Data	Coordinates, Pesticides
Stimulus	User clicks the pesticide interface.
Normal Flow	• **Step1:** The user logins the system • **Step2:** The user clicks the pesticide interface and choose the desired the pesticide. • **Step3:** The user chooses the spraying area. • **Step4:** The user chooses the date and frequency of the spraying activity.
Alternative Flow	-
Exception Flow	The pesticides cannot be sprayed to the desired places.
Post Conditions	The pesticides is sprayed to the desired places.

Table 18: **Use Pesticide** Case

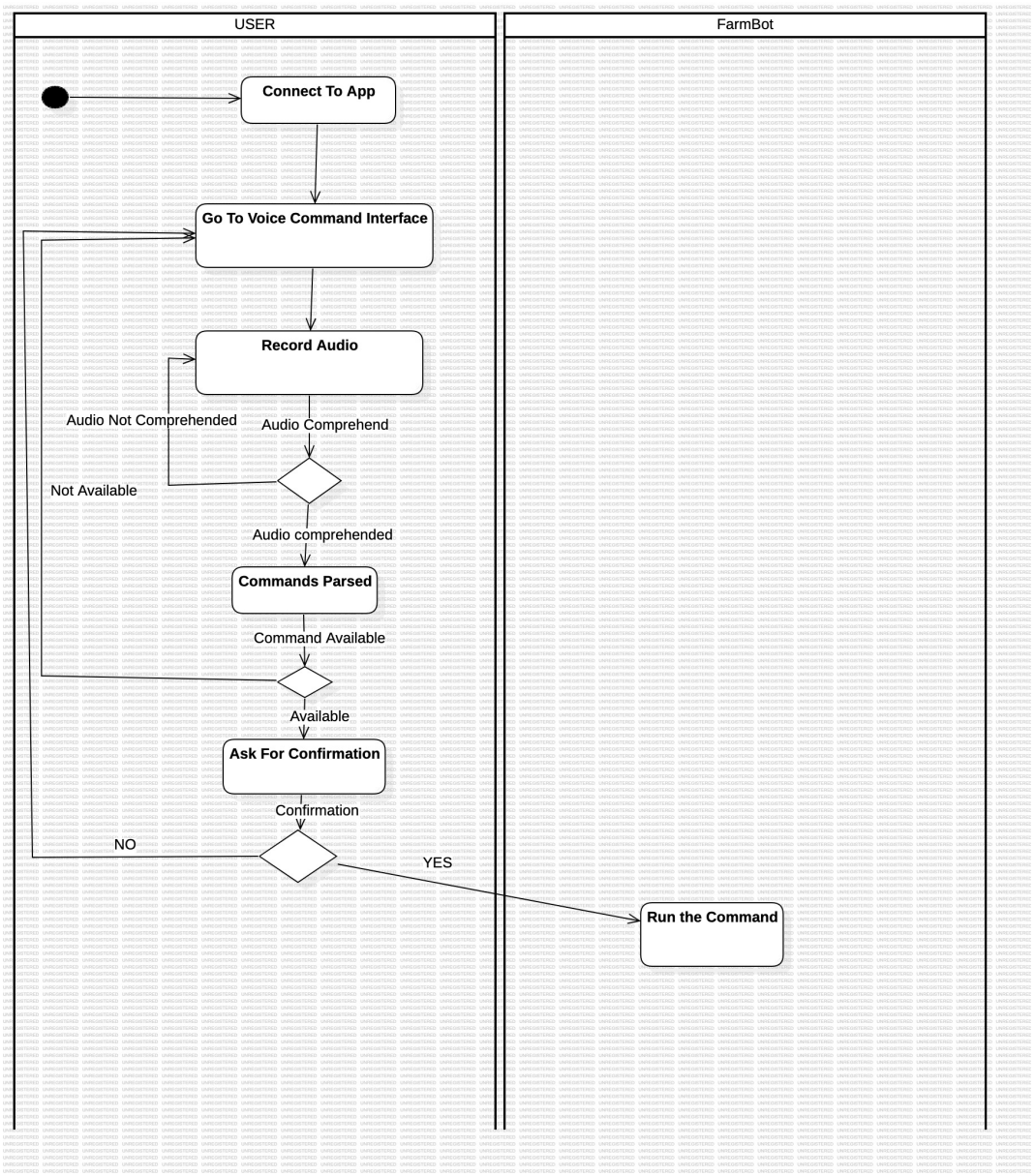

Figure 26: **Voice Command** Activity Diagram For Improvements

Use Case Name	Voice Command
Actors	User, FarmBot
Description	Users can choose the pesticide they want to use to protect the crops from hazards or improve the growth rate of crops.
Preconditions	The Web App connection must be accomplished and the voice permissions must be given.
Data	Voice
Stimulus	User clicks the voice command interface and starts to speak.
Normal Flow	• **Step1:** The user logins the system • **Step2:** The user clicks the voice command interface and then starts giving orders by speaking. • **Step3:** The FarmBot application sends a message it perceived to the user to ask for confirmation.
Alternative Flow	-
Exception Flow	The orders given by the user cannot be executed.
Post Conditions	The voice orders are taken and the FarmBot starts to implement them.

Table 19: **Voice Command** Case

Use Case Name	Synchronization and Communication Between Other FarmBots
Actors	FarmBots
Description	According to the orders by the user, sequences of tasks, and failure of some instructions, FarmBots will communicate between each other to inform each other about current activities and conditions.
Preconditions	FarmBots must have internet connection and proper sensors.
Data	Coordinates, Sequence of events, Condition of crops
Stimulus	User gives orders to the FarmBots or any of the FarmBots starts to inform others about the current conditions.
Normal Flow	• **Step1:** The user logins the system • **Step2:** The user gives orders or FarmBots want to communicate with each other. • **Step3:** Farmbots starts to communicate with each other by using sensors or the internet.
Alternative Flow	-
Exception Flow	FarmBots cannot communicate with each other and warns user about possible problems.
Post Conditions	Farmbots communicated with each other and started to executed their new orders. .

Table 20: **Synchronization and Communication Between Other FarmBots** Case

4.4 Logical Database Requirements

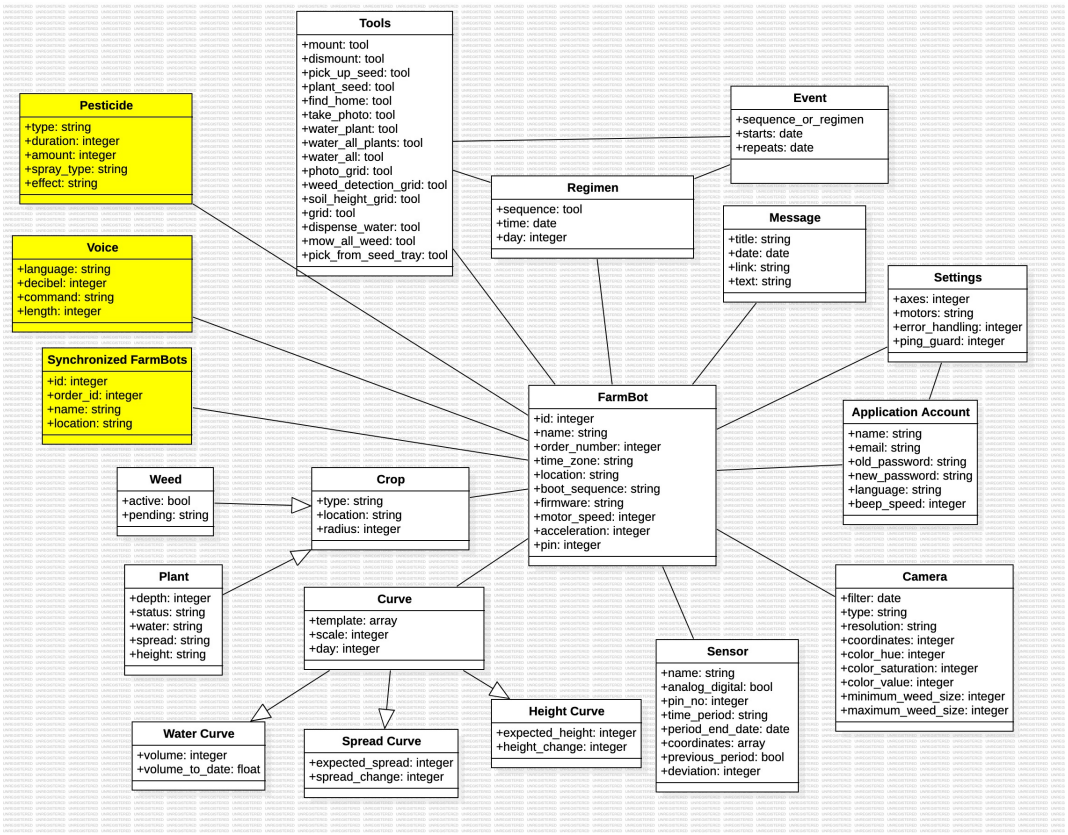

Figure 27: **Logical Database Requirements** For Improvements

In the figure above, the improvements mentioned have been added. There must be pesticide, voice and synchronized FarmBot entities for the improvements. As mentioned, there is additional pesticide tool. This tool must have the type of the pesticide, effectivity duration, amount of pesticide, spraying type and its effect stored in the database. Secondly, there is a voice entity added for the purpose of voice recognition. The voice must have a language to detect, decibel for proper recognition, related command and length. Finally, there is a list for the synchronized FarmBots. This FarmBot must store the id, order id, name and locations of the connected FarmBots because mentioned fields

are the unique identifier of a FarmBot device.

4.5 Design Constraints

- Due to voice command feature, the application needs to take the needed the permissions from the user.
- The FarmBot application needs to be done according to the privacy rules of the countries.
- The private information of the users must be kept according to the law and shall not be shared with others.
- Any information stored shall comply with the regulatory policies.

4.6 System Attributes

This section is mostly similar to the section 3.5. However, there are some **additional** items written.

1. **Reliability:**
   - 1.1 The FarmBot must inform the user in case of a shutdown or hitch.
   - 1.2 There should not be any physical harm to environment or to living things
   - 1.3 The FarmBots shall inform the user if there is an synchronization problem while working together, and if an error was aroused in any of the other FarmBots.
2. **Availability:**
   - 2.1 After the establishing the connection between the app and the FarmBot, FarmBot must be ready to execute the user commands and sequences.
   - 2.2 The purchase of the FarmBot is available to most of the countries. There are partners in Europe, America and Asia.
   - 2.3 The aluminum extrusions, plates and brackets provide a long life time.

2.4 In case of confusion or need for help, there is AI system integrated to the application for user to handle such cases.

2.5 Since several FarmBots are working together, they need to be able to access the other FarmBots' current conditions and data.

3. **Security:**

3.1 FarmBot typically employs user authentication mechanisms to ensure that only authorized individuals can access and control the system.

3.2 This is typically achieved using HTTPS (HTTP Secure), which encrypts data using SSL/TLS protocols.

3.3 FarmBot systems can be installed within enclosures or housings to protect them from environmental factors such as rain, dust, and extreme temperatures.

3.4 Motion sensors, proximity sensors, or other types of intrusion detection devices can be integrated into the FarmBot system to trigger alarms or alerts in case of unauthorized access or tampering.

3.5 The other users must not be able to access the other users voice recognition system.

3.6 Due to the new added voice recognition system, the data held by the system must be protected from harmful users and attacks.

4. **Maintainability:**

4.1 Integration, customizing and configurations are much easy to apply without any knowledge of the advanced software and electronics.

4.2 The recent documentation enables users to understand the new features.

4.3 It has huge modularity allowing for easier replacement and upgrading of individual parts.

4.4 FarmBot systems are designed to accommodate future upgrades and expansions to meet evolving user needs and technological advancements.

5. **Portability:**

   5.1 Its application can work on different mobile phones and tablets if they can satisfy the necessary requirements which is needed for the application to work.

   5.2 If the users have internet connection, they can use the application or the website whenever they want with the different devices they use.

4.7 Supporting Information

- The projects provides cheaper way of growing crops.
- Sensors use satellite or 4G/5G/LTE and are guaranteed to work anywhere.
- On average, every installed unit can save business $2466 annually. Considering the fuel, labour and vehicle maintenance costs involved in doing water runs, it is possible to save thousands of dollars per year.
- Anyone can install a FarmBot monitor within 15 minutes. All it is needed is a drill and FarmBot supplies all of the other equipment.
- **Additional to 3.6** The synchronization makes use of job division that facilities the process of crop growing.
- **Additional to 3.6** The proper pesticide provides long lasting crops.