VAAL UNIVERSITY
OF TECHNOLOGY

Inspiring thought. Shaping talent.

Smart weed killing robot

Project submitted in fulfilment of the requirements for the Software Engineering Project

Diploma: Engineering: Electrical in the department of Computer Systems

Faculty of Engineering and Technology

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South Africa
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Declaration

I Mulalo Masia declare that this report is my own, unaided work. It is being submitted for Software Engineering to the Department of Electrical Engineering at the Vaal University of Technology, Vanderbijlpark. It has not been submitted before for any subject or evaluation to any educational institution.

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LCD - Liquid crystal display

Chapter 1: Introduction of a smart weed killing robot

1.1 Introduction and Background

Food plays an imperative role in sustaining human existence as it provides vital nutrients and minerals necessary for energy to carry out daily functions. Farmers worldwide cultivate a plethora of crops that feed billions across the planet. One challenging aspect of farming is weed management (Lida M, 2021).

Weeds refer to any plant that grows automatically in undesired locations causing competition against crops for crucial resources such as nutrients, water where they survive on sunlight making crops vulnerable to low yield rates along with compromised quality standards causing immense financial losses(Oyash N, 2011) .

Traditional methods comprising manual weeding or herbs application are labor-intensive & time-consuming leading to escalating costs besides ineffectiveness in curbing this issue proactively Therefore development & adoption of smart weed-killing machines can amplify farm productivity while also saving costs all thanks computer vision techniques crafting automation along withRobotics thus curbing the problem effectively

Figure 1: Manual weed killer (ECO Company,2018)

The purpose of a smart weed-killing robot is to alleviate difficulties with identifying widespread weeds within gardens or farmlands; thus providing an efficient automated solution without collateral damage to crops or nature via artificial intelligence optimization strategies. This innovative bot incorporates various high-end sensors such as GPS tracking systems (for location accuracy), LIDAR (depth perception technology) & vision detectors (RGB/Camera-based) for precision identification of each unwanted plant prior to initiating control mechanism optimizations intelligently.

By using machine learning algorithms coherent with recent technological advancements thus ensuring less sporadic errors during the identification stage which would greatly minimize unwanted destructions of any crops within proximity areas if wrongly identified.

This machine's unique ability of maneuvering without manual intervention provides farmers with an opportunity to focus on improving yield while cutting down the labor costs of routine herbicide application.

Subsequently, traditional methods used for weed removal from farms such as manual weeding or herbicide application are physically tiring, time-consuming, and costly. Additionally, they highly impact the environment by reducing soil and water quality in surroundings; not to mention the negative effects posed on domestic animals' welfare while intensifying development of herbicide-resistant weed species.

A smart weed-killing robot provides an eco-friendlier solution that streamlines the weed control process without any physical strain; reduces herbicide usage and save costs that can instead be applied to other productive practices throughout different fields like forestry management practices. It will also improve the viability of desired crops by increasing yields.

Lastly, this intelligent device is applicable within forestry management applications which helps eradicate all undesirable plants present alongside encouraging vital growth for preferred foliage directly from its operations using non-toxic chemicals enabling preservation of lawn aesthetics or garden landscapes minus chemicals that gradually destroy surrounding biological organisms.

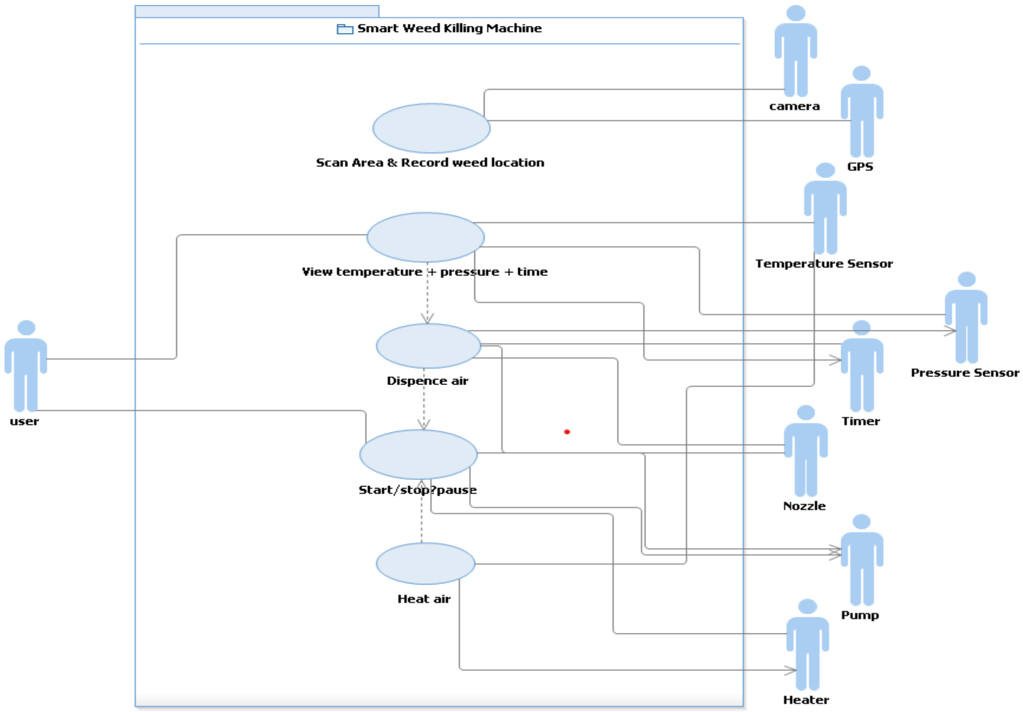
Figure 2 Smart Robotic weed killer (WeedTechics, 2022)

The creation of a smart weed-killing device calls for the expertise of several disciplines including agriculture science, robotics technology, mechanical engineering, and most importantly -software engineering. The development geared towards having an efficient autonomous operation is centered on quality control systems which greatly rely on software. As such excellence is required when crafting software capable of effectively processing sensory data sets to recognize weeds while managing tools meant for their eradication.

1.2 Problem Statement

Traditional weed control methods cause harm to the environment and are not efficient, directly impacting the health of plants as well as surrounding nature. Proposed solution aims at neutralizing weed directly using hot air which is directed to the plant.

Figure 3: System's Use Case Diagram



1.3 Sub-problems

Scan area and record weed location

This sub-problem performs the work of scanning the area and identifying the weeds inthe area. As well as storing this information in the system.

View temperature and pressure and time remaining

This sub-problem allows the user to view the current temperature, pressure and timeremaining of the weed-killing robot.

Start/Stop heating

This sub-problem allows the user to start or stop the robot heating and dispensing theair.

Heat air

This sub-problem does the work of heating the air in the robot.

Dispense hot air/ Precision Spraying

This sub-problem executes the main work of this system by dispensing the hot air thatkills the weeds.

1.4 Delimitations

Environment: Unwanted weather conditions like heavy rain or snow that make up an essential part of outdoor agriculture activities could negatively affect your robotic device's performance in various ways. The machine sensors' accuracy might be unreliable alongside impaired mobility incidences caused by low visibilities associated with impacted sensors in rough weather environments.

Crop and Terrain: The ability for the bot device always optimized towards finding digs up weeds while avoiding harming crops requires it can recognize all forms of weeds rightly without causing any damages while removing them altogether from your farming landscape.

Legal and Framework: Of utmost importance is understanding how different varieties of crops behave under robotic stress situations since they could grow at varying heights relative size shapes which could impact the bot device's targeting line-of-sight vision accuracy when navigating through pathways created between crop rows alongside potential environmental hazards that exist within these fields-like obstructions such as rocks etc., uneven surfaces with loose soils worn-out surfaces bare tree roots etc.,

Maintenance and power supply issues: with your robotic device can also significantly limit its optimum performance, requiring constant attention to recharge intervals, cleaning periods or regular services required for efficient operations.

Lastly, the legal framework surrounding the use of robots in agricultural activities needs to be clearly understood, encompassing the regulations and liability concerns associated with such devices' various operational aspects, which could impact adoption rates when deploying these devices in agriculture settings.

1.5 Definitions of terms

Framework - An essential supporting structure of a building, vehicle, or object
Weed - Any plants that grow where they are unwanted.

1.6 Importance of the project

Weeds remain a significant problem within the agriculture and gardening industry due to their ability to interfere with crop growth resulting in reduced yields, thereby causing considerable losses both financially and concerning adequate food supply. Traditional means of dealing with weeds such as manual removal and herbicide application have several drawbacks such as being labor-intensive, time-consuming, expensive, and harmful towards the environment leading to issues like herbicide-resistant weeds manifesting further challenges.

A smarter alternative available nowadays lies in the invention of weed-killing robots which addresses these problems uniquely making it an efficient environmentally friendly solution. These robots function independently by using various features such as sensors that employ complex space intelligence aided by machine learning algorithms capable of identifying only weeds excluding or minimizing harm effects on both crops and surrounding environments simultaneously leading to optimal results.

Apart from incredible processing abilities that are unmatched by humans during manual removal processes; using smart weed-killing robots also reduces costs significantly through minimizing both labor-intensive activities coupled with diminished need for repeated applications due to its efficiency-based design increasing long-term productive yield output cycles.

Finally, their effectiveness extends across varied environmental conditions whilst remaining able against adverse weather challenges like heavy rain or extreme temperatures facilitating them in being used across most farming scenarios without fail.

Weed control can negatively affect both our environment's health along with producing healthy crops for consumption. Herbicides are known to lead towards soil contamination, water pollution as well as harming non targeted organisms among other issues.
Smartweed-killing robots will provide an efficient solution that reduces labour output along with limited requirements for excessive chemicals; indirectly contributing towards bettering sustainable practices within agriculture and gardening.

1.7 Overview of the project and system to be developed

For this project, chapter 1 serves as an introduction into the weed killing robot. This introduction includes background, purpose as well as the functionalities of the system which will be demonstrated by the use case diagram. In chapter 2 the project details the requirements model of the robot.

This requirements model will take a deep dive into each use case named in chapter 1 and each use case’s flow of events,in the form of activity diagrams and use case specifications. Chapter 3 serves as the requirements and analysis model for the weed killing robots. Each use case will be studied in depth, outlining its use case realisations and then further breaking it down into analysis classes and diagrams, such as class, sequence and state diagrams. Chapter 4 will conclude the project detailing how the problems discussed in chapter 1 were solved as well as recommend enhancements for the system and areas for further study.

1.8 Summary

The creation of a smart weed-killing robot requires hardware development where essential physical components like sensors, actuators, motors are fabricated. Then software development takes place where control algorithms & machine learning models are integrated into such hardware-based system which ultimately creates fully functional machinery.

Subsequently, an integral step involves testing & validating the efficiency & effectiveness of the system under various conditions including different terrains, crops & weeds for assessment using metrics like accuracy & precision in weed control while also considering other significant aspects like its impact on crop yield/quality or environmental sustainability that may arise during operation.

Skill required includes expertise in robotics engineering alongside an understanding of modern agricultural practices complemented by adept learning abilities when working with machines. This project's complexity does not detract from its potential value regarding agriculture practices due to its potential benefits facilitating more sustainable farming methods by increasing overall productivity.

Chapter 2: Requirements model

2.1 Introduction

In this chapter the View Temperature and Pressure sub-problem for the Smart Weed- Killing Robot will be elaborated on. The requirements, object-oriented analysis and design models will be provided.

2.2 Re-statement of use case

Scan area and record weed location

This sub-problem performs the work of scanning the area and identifying the weeds inthe area. As well as storing this information in the system.

View temperature and pressure and time remaining

This sub-problem allows the user to view the current temperature, pressure and time remaining of the weed-killing robot.

Start/Stop heating

This sub-problem allows the user to start or stop the robot heating and dispensing theair.

Heat air

This sub-problem does the work of heating the air in the robot.

Dispense hot air/ Precision Spraying

This sub-problem executes the main work of this system by dispensing the hot air thatkills the weeds.

2.3 Literature review

Scan Area & record weed location

The scan area and record location problem revolve around efficiently scanning and locating records within large datasets. This problem arises in numerous applications, such as database management systems, and scientific data analysis. The ability to perform these operations swiftly and accurately significantly impacts the overall performance and effectiveness of these systems.

In computer vision, determining the optimal scan area is critical for object detection, tracking, and recognition tasks. Researchers have proposed various algorithms to estimate the scan area based on the characteristics of the scene or the specific objects of interest. These methods aim to reduce computational complexity.

There are many robots that can scan and record locations. For example, Boston Dynamics' Spot is an agile mobile robot that navigates the terrain with unprecedented mobility, allowing you to automate routine inspection tasks and data capture safely, accurately, and frequently MIT researchers have developed a fully-integrated robotic arm that fuses visual data from a camera and radio frequency (RF) information from an antenna to find and retrieve the object, even when they are buried under a pile and fully out of view.

View temperature and pressure

The ability to monitor and visualise temperature, pressure, and time remaining is essential in numerous applications. Accurate and real-time Information about these variables enables effective control, optimization,and safety in various domains.

Technologies and Approaches:

Sensor-based Systems:
Researchers have developed novel sensor technologies, such as smart textiles with integrated sensors, wireless sensor networks, and Internet of Things (IoT) platforms to enhance data collection and visualisation.

Data Visualization Techniques:
Effective data visualisation plays a crucial role in presenting temperature, pressure, and time remaining information. Various techniques, such as graphs, charts, and heat maps, have been employed to represent these variables visually. Additionally, advancements in augmented reality (AR) and virtual reality (VR) technologies have enabled immersive visualisations, allowing users to interact with and gain insights from the data.

Start/Stop heating

Heating plays a crucial role in maintaining optimal functionality and performance of robots, especially in challenging environments or during prolonged operation.

In the literature review, various approaches to start and stop heating in robot designs can be explored. This includes investigating different heating technologies such as electric heaters, resistive heating elements, or even advanced methods like phase change materials. Additionally, research on the control algorithms and sensors used to regulate the heating process in robots can provide valuable insights. The review may also highlight the considerations for energy efficiency, safety measures, and the impact of heating on the overall performance and lifespan of the robot. By analysing existing literature on the subject, researchers can gain a comprehensive understanding of the current state-of-the-art techniques and identify potential areas for improvement in the implementation of start/stop heating systems in robot designs.

Heat Air

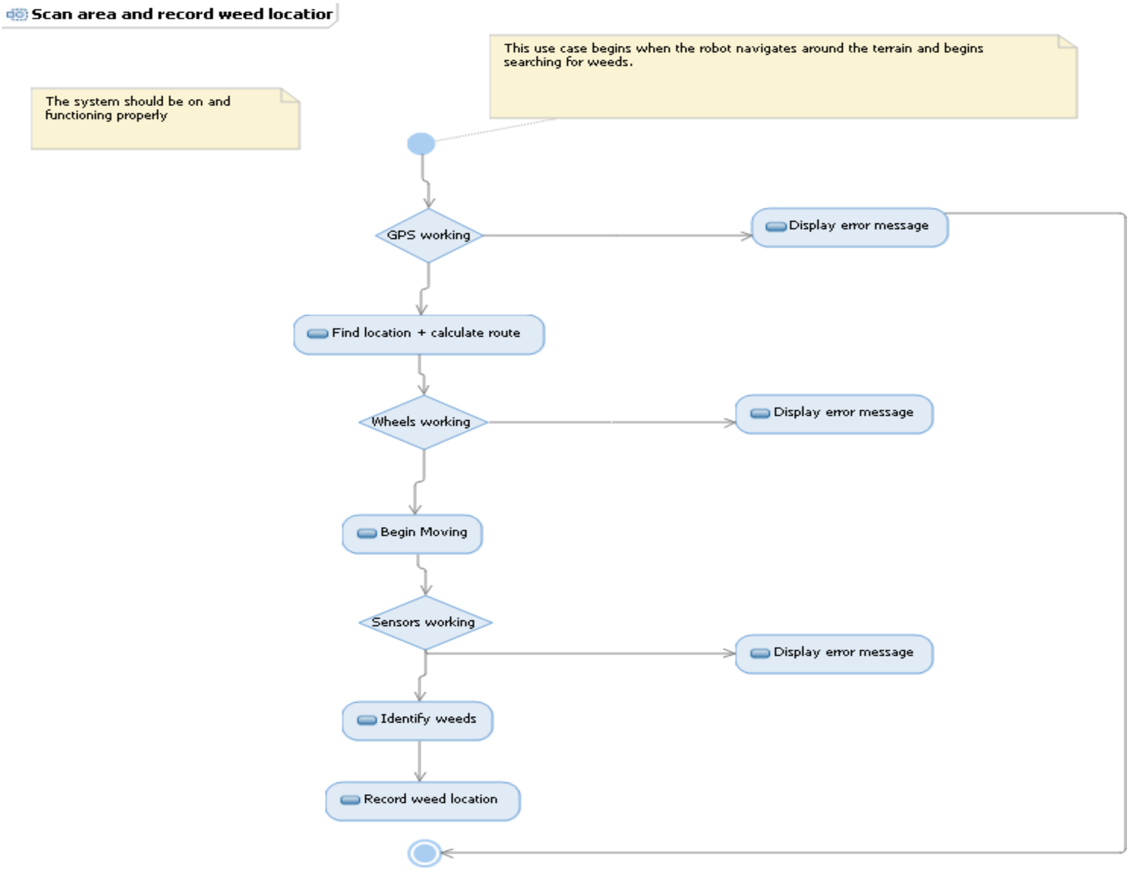
A literature review on the sub problem of heat air reveals several key findings and trends in the field. Numerous studies have focused on the effects of heat air on human health and comfort, particularly in indoor environments such as homes and offices. Researchers have explored various strategies for heat air control and mitigation, including the use of ventilation systems, insulation, and air conditioning units. Additionally, studies have investigated the impact of heat air on energy consumption and sustainability, highlighting the need for efficient heating and cooling solutions to reduce carbon emissions and address climate change.

Dispense hot air/Precision spraying

The sub problem of dispensing hot air is a crucial aspect in various industries, including HVAC systems, industrial processes, and even cooking appliances. A literature review on this topic reveals several key findings and advancements. One important area of focus is the development of efficient and precise hot air dispensing mechanisms. Researchers have explored various methods, such as using pneumatic systems, electric heating elements, and even advanced thermal control algorithms to ensure accurate and consistent hot air distribution. Additionally, studies have examined the impact of different nozzle designs and airflow patterns on heat transfer and dispersion, aiming to optimize energy efficiency and reduce wastage.

Another aspect addressed in the literature is the control and regulation of hot air dispensing. Researchers have proposed advanced feedback control systems to maintain a desired temperature profile and ensure reliable heat distribution. This involves the integration of sensors, actuators, and intelligent algorithms to monitor and adjust the hot air output based on real-time conditions. Furthermore, studies have explored the use of machine learning and artificial intelligence techniques to optimize the hot air dispensing process, considering factors such as ambient temperature, humidity, and desired heating rate. These advancements in control and regulation offer opportunities for improved precision, energy savings, and enhanced performance in various applications that rely on hot air dispensing.

2.4 Activity diagram for use case 1



2.5 Outline use case specification

2.5.1 Use-Case Specification: Scan area and record weed location

Brief Description

This sub-problem performs the work of scanning the area, identifying the weeds in the area as well as recording the weed location. It uses a camera as a scanning mechanism as well as a GPS to navigate the area and determine which areas still need to be scanned.

Use Case Diagram (Participating Actors)

GPS, Sensors, Wheel.

Flow of Events

This use case begins when the robot navigates around the terrain and begins a weed search

Basic Flow

1. GPS working correctly
2. Find starting location and calculate route
3. Wheels working
4. Begin navigating the terrain
5. Sensors working correctly
6. Identify weeds
7. Record weed location
8. Use case ends

Alternative Flow

1. GPS not working
2. Wheels not working
3. Sensors not working
4. Cannot record weed location

Sub Flows

None

Key Scenarios
Success Scenarios

Scan area, identify weeds and record weed location: Basic flow

Failure Scenarios

1. GPS not working: Basic flow, GPS not working.
2. Wheels not working: Basic flow, Wheels not working.
3. Sensors not working: Basic flow, Sensors not working.
4. Cannot record weed location: Basic flow, Cannot record weed location

Preconditions
The system should be on and functioning correctly.

Post condition

The system should have scanned the whole area, identified all of the weeds in the area and recorded the location of the weeds.

Extension Point
None

Special Requirements

None

Additional Information

None

Detail use case specification

Use-Case Specification: View current temperature & humidity

Brief Description

This sub-problem performs the work of scanning the area, identifying the weeds in the area as well asrecording the weed location. It uses a camera as a scanning mechanism as well as a GPS to navigatethe area and determine which areas still need to be scanned.

Use Case Diagram (Participating Actors)

GPS, Sensors, Wheels
Flow of Events

This use case begins when the robot navigates around the terrain and begins searching for weeds.

Basic Flow

1. GPS working correctly

2. The system should ascertain that data can be read from the GPS and that it isworking correctly.
3. Find starting location and calculate route

4. The system should use the GPS to find the starting location and the most efficientroute to navigate the area. Wheels working

5. The system should ascertain that the wheels of the robot are working correct

6. Begin moving

7. The system should begin moving about the terrain in the router specified by theGPS, using the wheels.
8. Sensors working correctly

9. The system should ascertain that data can be read from the sensors and that theyare working correctly.

10. Identify weeds

11. The system uses the sensors to identify the weeds

12. Record weed location

13. The system should store the location of the weed in its memory bank.

14. Use case ends

Alternative Flow

GPS not working

In step 1 the system ascertained that the GPS does not work or cannot be accessed. The systemdisplays an error message to the User on the display screen. The use case ends.

Wheels not working

In step 3 the system ascertained that the wheels do not work or cannot be accessed. The systemdisplays an error message to the User on the display screen. The use case ends.

Sensors not working

In step 5 the system ascertained that the sensors do not work or cannot be accessed. The systemdisplays an error message to the User on the display screen. The use case ends.

Cannot record weed location

In step 7 the system ascertained that the weed location cannot be recorded. The system displaysan error message to the User on the display screen. The use case ends.

Sub Flows

None

Key Scenarios

Success Scenarios

Scan area, identify weeds and record weed location.

Basic flow

Failure Scenarios

1. GPS not working: Basic flow, GPS not working
2. Wheels not working: Basic flow, Wheels not working
3. Sensors not working: Basic flow, Sensors not working
4. Cannot record weed location:Basic flow, Cannot record weed location
5. Preconditions
6. The system should be on and functioning correctly.

Postcondition

The system should have scanned the whole area, identified all of the weeds in the area and recorded the location of the weeds.

Extension Points

None

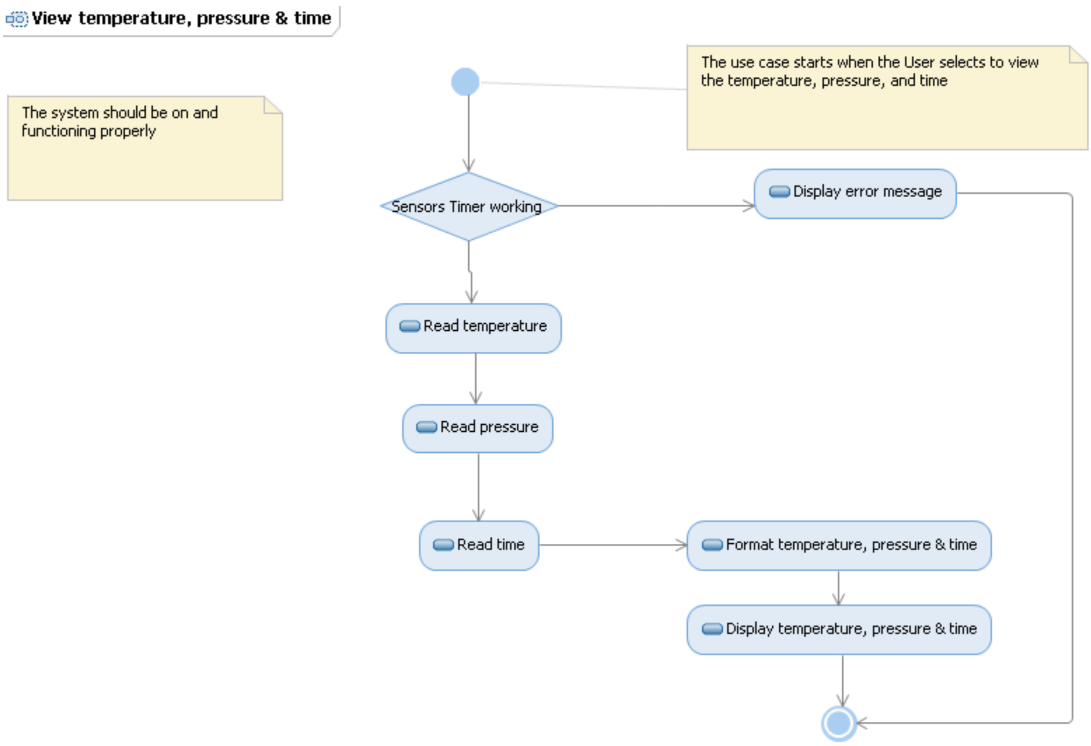
Special Requirements

None

Additional Information

None

2.5 Activity diagram for use case 2



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Outline use case specification

Use-Case Specification: View Air Temperature, Pressure and Time remaining

Brief Description

This use case allows the user to view the temperature and pressure of the hot air being dispersedfrom the robot as well as the time remaining.

Use Case Diagram (Participating Actors)

User, Temperature sensor, Pressure sensor, Timer

Flow of Events

This use case begins when the User selects to view the current temperature, pressure and remainingtime of the weed killing robot.

Basic Flow

i. Sensors and timer working correctly

ii. Read temperature

iii. Read Pressure

iv. Read time

v. Format temperature, pressure and time remaining

vi. Display temperature, pressure and time remaining

vii. Use case ends

2. **Sub Flows**

None

Key Scenarios

Success Scenarios

Display temperature, pressure and time remaining: Basic flow

Failure Scenarios

Sensors not working: Basic flow, Sensors not working

Timer not working: Basic flow, Timer not working

Information not formatted: Basic flow, information not formatted.

Preconditions

The system should be on and functioning correctly

Post condition

The system should have displayed the current temperature, pressure and time to the User on the display screen, otherwise it should have displayed an error message on the display screen if the sensors or timer are not working.

Extension Points

None

Special Requirements

None

Additional Information

None

Detail use case specification

Use-Case Specification: View current temperature & humidity

Brief Description

This use case allows the user to view the temperature and pressure of the hot air being dispersedfrom the robot as well as the time remaining.

Use Case Diagram (Participating Actors) User, Temperature sensor, Pressure sensor, Timer

Flow of Events

This use case begins when the User selects to view the current temperature, pressure and remainingtime of the weed killing robot.

Basic Flow

1. Sensors and timer working correctly

2. The system should ascertain that data can be read from the sensors and timer andthat they are working correctly.

3. Read temperature

4. The system reads the current temperature from the various temperature sensors inthe system.

5. Read pressure

6. The system reads the current humidity from the various humidity sensors in thesystem.

7. Read time remaining

8. The system reads the current time from the timer in the system.

9. Format temperature, humidity & time remaining

10. The system formats the temperature, pressure and time that was measured from the various sensors and timer throughout the system. This is the information that will be displayed on the display screen.

11. Display temperature, pressure and time

12. The system displays the formatted temperature, pressure and time on the displayscreen, which is a pen segment LCD.

13. Use case ends

Alternative Flow

Sensors and timer not working

In step 1 the system ascertained that the sensors or timer do not work or cannot be accessed. The system displays an error message to the User on the display screen. The use case ends.

Sub Flows

None

Key Scenarios

Success Scenarios

Display formatted temperature, pressure and time: Basic flow

Failure Scenarios

Sensors ot timer not working: Basic flow, Sensors or timer not working

Timer not working: Basic flow, Timer not working

Information not formatted: Basic flow , information not formatted.

Preconditions

The system should be on and functioning correctly.

Post condition

The system should have displayed the current temperature, pressure and time to the User on the display screen, otherwise it should have displayed an error message on the displayscreen if the sensors or timer are not working.

Extension Points

None

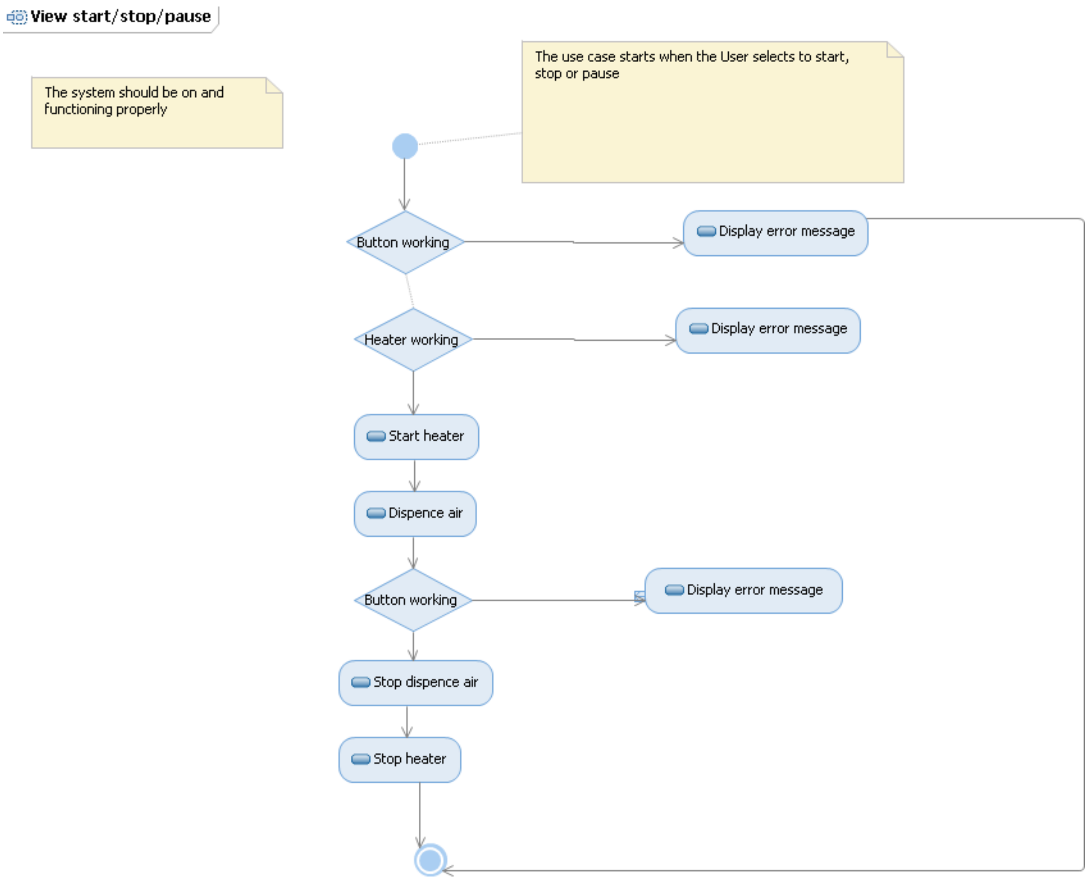
Special Requirements

None

Additional Information

None

2.6 Activity diagram for use case 3



Outline use case specification

Use-Case Specification: Start/Stop

Brief Description

This sub-problem allows the user to start or stop the robot heating and dispensing the air.

Use Case Diagram (Participating Actors)

User, Heater, Pump, Nozzle

Flow of Events

This use case begins when the User selects to start or stop the robots heating mechanism.

Basic Flow

1. Start/Stop button working correctly

2. Heater working correctly

3. Start heater
4. Dispense air

5. Start/Stop button working correctly

6. Stop dispensing air

7. Stop heater

8. Use case ends

Alternative Flow

1. Start/Stop button not working

2. Heater not working

3. Dispenser not working

Sub Flows

None

Key Scenarios

Success Scenarios

Start system, heat air and dispense air: Basic flow

Stop dispenser, stop heater, stop system: Basic flow

Failure Scenarios

Start/Stop button not working: Basic flow, Start/Stop button not working

Heater not working: Basic flow, Heater not working

Pump not working: Basic flow, Pump not working.

Preconditions

The system should be on and functioning correctly

Post condition

The system should have switched on the heater and began heating the air, as well as dispense the hot air. The system should also stop dispensing and heating the air when ‘stop’ is pressed during operation. If this does not happen, the system should have displayed an error message on the display screen detailing which part of the system is not operation.

Extension Points

None

Special Requirements

None

Additional Information

None

Detail use case specification

Use-Case Specification: Start/Stop heating

Brief Description

This sub-problem allows the user to start or stop the robot heating and dispensing the air.

Use Case Diagram (Participating Actors)
User, Heater, Pump, Nozzle

Flow of Events

This use case begins when the User selects to start or stop the robots heating mechanism.

Basic Flow

1. Start/Stop button working correctly
2. The system ascertains that the button is working and performs the correct functions when it is pressed.

3. Heater working correctly

4. The system ascertains that the heater is working properly
5. Start heater

6. The heater begins heating the air

7. Dispense air

8. The pump begins dispensing the hot air from the nozzle.

Preconditions

The system should be on and functioning correctly

Post condition

The system should have switched on the heater and began heating the air, as well as dispense the hot air. The system should also stop dispensing and heating the air when 'stop' is pressed during operation. If this does not happen, the system should have displayed an error message on the display screen detailing which part of the system is not operational

Extension Points

None

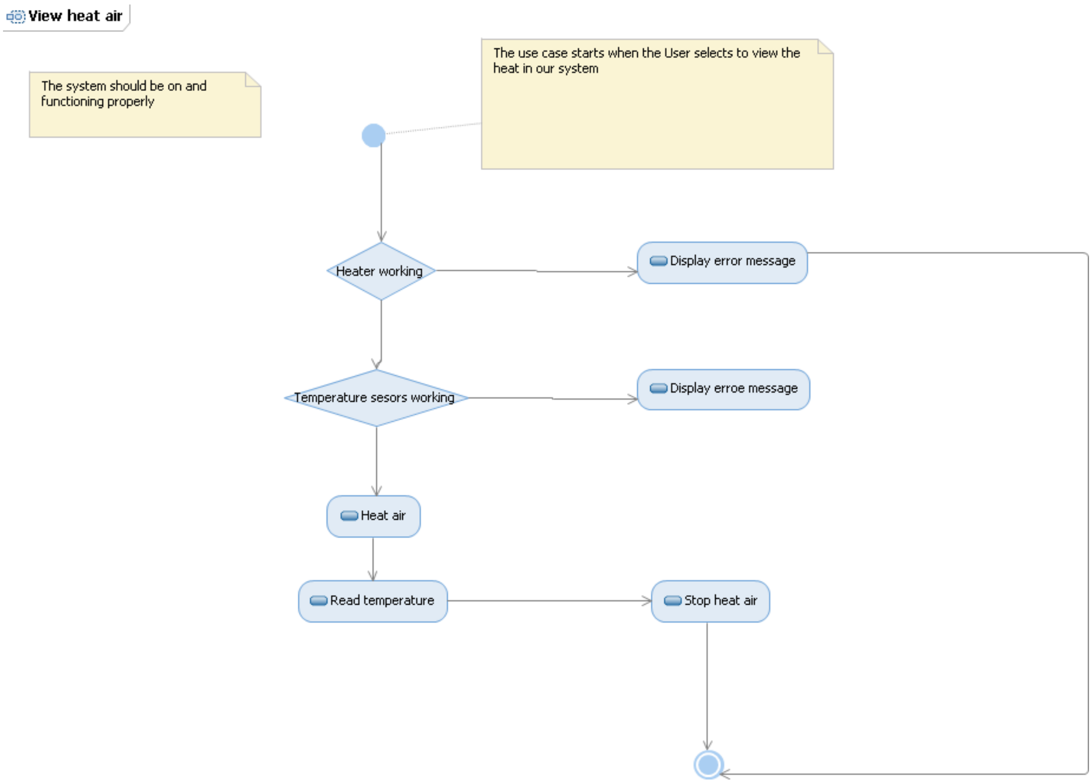
Special Requirements

None

Additional Information

None

2.7 Activity diagram for use case 4



Outline use case specification

Use-Case Specification: Heat Air

Brief Description

This use-case allows the system to heat the air in the robot.

Use Case Diagram (Participating Actors)

Heater, Temperature sensor

Flow of Events

This use-case begins once the user selects to start the system and the system begins heating the air.

Basic Flow

1. Heater working correctly
2. Temperature sensors working correctly
3. Start heating air
4. Read temperature
5. Stop heating air
6. Use case ends

Alternative Flow

1. Heater not working
2. Temperature sensors not working
3. Heater not stopped

Sub Flows

None

Key Scenarios

Success Scenarios

Heat air to predetermined temperature

Failure Scenarios

Heater not working: Basic flow, Heater not working

Temperature sensor not working: Basic flow, Temperature sensor not working

The user should have selected to start the system and the system should have started.

Pre-condition

The system should be on and functioning correctly

Heater not stopped: Basic flow, Heater not stopped.

Post condition

The system should have heated the air to the predetermined temperature and have stopped the heater, otherwise it should have displayed an error message on the display screen detailingwhich part of the system is not operational.

Extension Points

None

Special Requirements

None

Additional Information

None

Detail use case specification

Use-Case Specification: Heat Air

Brief Description

This use-case allows the system to heat the air in the robot.

Use Case Diagram (Participating Actors)

Heater, Temperature sensor

Flow of Events

This use-case begins once the user selects to start the system and the system begins heating the air.

Basic Flow

1. Heater working correctly
2. The system should ascertain that the heater is working correctly.
3. Temperature sensors working correctly
4. The system should ascertain that data can be read from the sensor and that it isworking correctly.
5. Start heating air
6. The system begins heating the air by pushing a current through a heating element.
7. Read temperature
8. The system reads the current temperature from the sensor in the system.
9. Stop heating air
10. The system switches off the heater after the desired temperature has been reached.
11. Use case ends

Alternative Flow

Sensors and timer not working

In step 1 the system ascertained that the heater or temperature sensor do not work or cannot be accessed. The system will not proceed to heat or dispense the air. The use case ends.

Sub Flows

None

Key Scenarios

Success Scenarios

Heat air to predetermined temperature: Basic flow

Failure Scenarios

Heater not working: Basic flow, Heater not working

Temperature sensor not working: Basic flow, Temperature sensor not working

Heater not stopped: Basic flow, Heater not stopped.

Preconditions

The system should be on and functioning correctly

The user should have selected to start the process and the process should have started

Post condition

The system should have heated the air to the predetermined temperature and have stopped the heater, otherwise it should have displayed an error message on the display screen detailing which part of the system is not operational

Extension Points

None

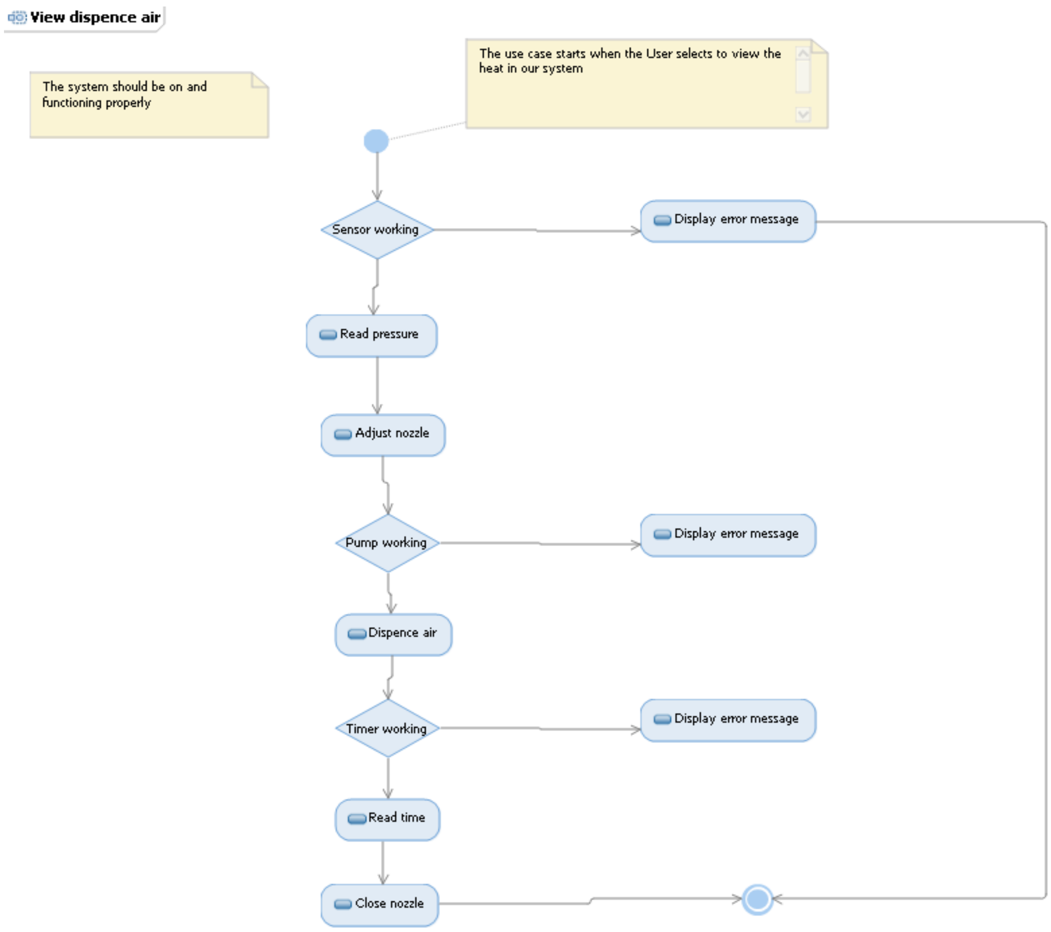
Special Requirements

None

Additional Information

None

2.8 Activity diagram for use case 5



Outline use case specification

Use-Case Specification: Dispense air

Brief Description

This sub-problem executes the main work of this system by dispensing the hot air that kills the weeds.

Use Case Diagram (Participating Actors)

Pump, Nozzle, Timer

Flow of Events

This use case begins once the temperature sensor has detected the preset temperature and the pressure sensor has adjusted the nozzle to suit the preset pressure. Once the nozzle has opened the hot air will be ejected for a period of time set by the timer. After the expiration of the time, the dispensation will stop.

Basic Flow

a. Pressure sensor working

b. Read pressure

c. Open and adjust nozzle

d. Pump working

e. Dispense air

f. Timer working

g. Read time

h. Close nozzle

i. Use case ends

Alternative Flow

Pressure sensor not working

Nozzle not working

Pump not working

Timer not working

Sub Flows

None

Key Scenarios

Success Scenarios

Dispense hot air for predetermined time at predetermined pressure: Basic flow

Failure Scenarios

Pressure sensor not working: Basic flow, Pressure sensor not working.

Nozzle not working: Basic flow, Nozzle not working

Pump not working: Basic flow, Pump not working.

Timer not working: Basic flow, Timer not working.

Preconditions

The system should be on and functioning correctly

The user should have selected to start the process and the process should have started.

Post condition

The system should have dispensed the hot air at the predetermined pressure and closed the nozzle, otherwise it should have displayed an error message on the display screen detailing which part of the system is not operational.

Extension Points

None

Special Requirements

None

Additional Information

None

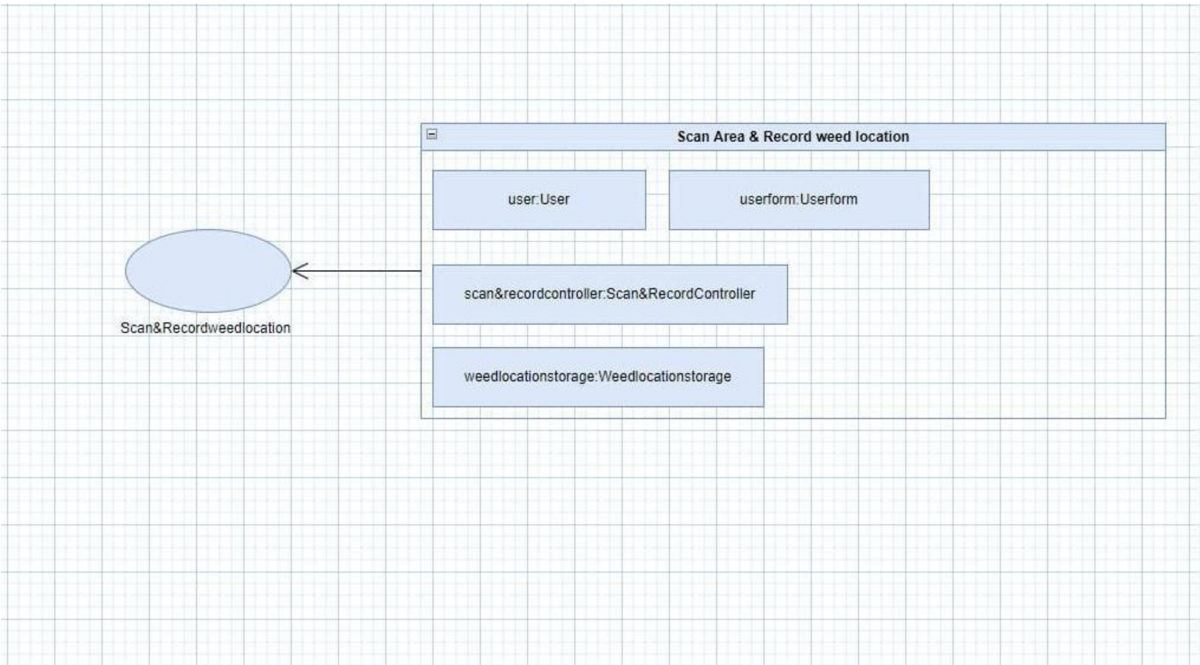
Chapter 3: Analysis model

3.1 Introduction

In this section, a short introduction should be provided, which introduces the Chapter and what will be discussed in the Chapter.

In this section, the analysis artefacts which describe the sub-problem/use case should be included. If one of the artefacts are not included directly here, it can be placed as an appendix at the end of the document. If it is done as an appendix, a short statement should be placed to indicate that the artefact is placed in the appendix.

3.2 Use case realization



3.2.1 Analysis classes for use case 1

Table 1.1 Analysis classes for Scan area and record weed location use case

Boundary	
Control	ScanArea&RecordWeedLocationController
Entity	Area WeedLocation

Table 1.2 Noun extraction for Scan Area & Record location use case

Candidate Noun	Is this candidate inside our system boundary?	Is this candidate an Entity?	Does this candidate have identifiable behaviour for our problem domain?	Does this candidate have relationships with any other candidates?	Is the candidatea Class?
Area	**Yes**	**Yes**	**No**	**Yes**	**Yes**
Weed Location	**Yes**	**Yes**	**No**	**Yes**	**Yes**
GPS	**No**	**No**	**Yes**	**Yes**	**No**
Camera	**No**	**No**	**Yes**	**Yes**	**No**

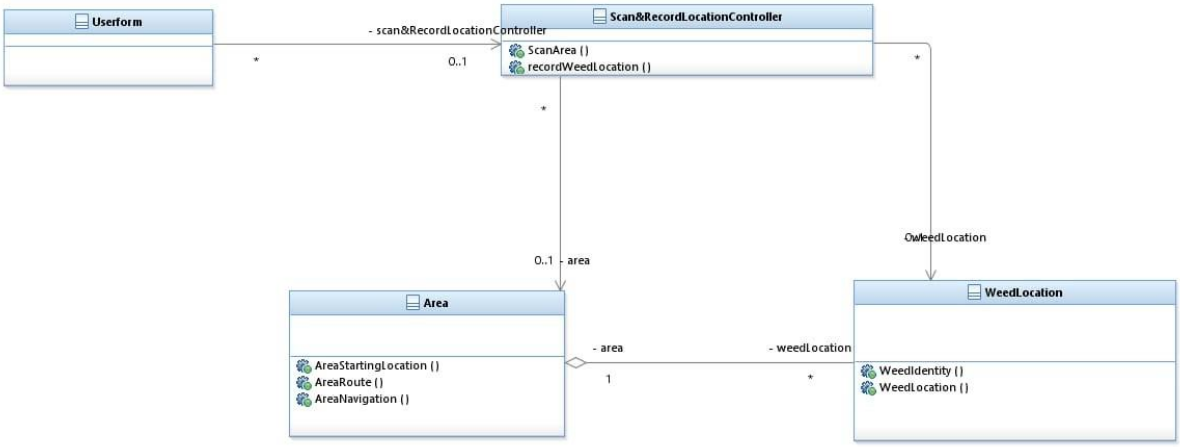
Table 1.3 Area class responsibility collaboration card

Class Responsibility Collaboration Cards **Area**	
RESPONSIBILITY	**COLLABORATION**
Know starting location	**GPS, Camera**
Know area route	**GPS**
Know area navigation	**GPS**

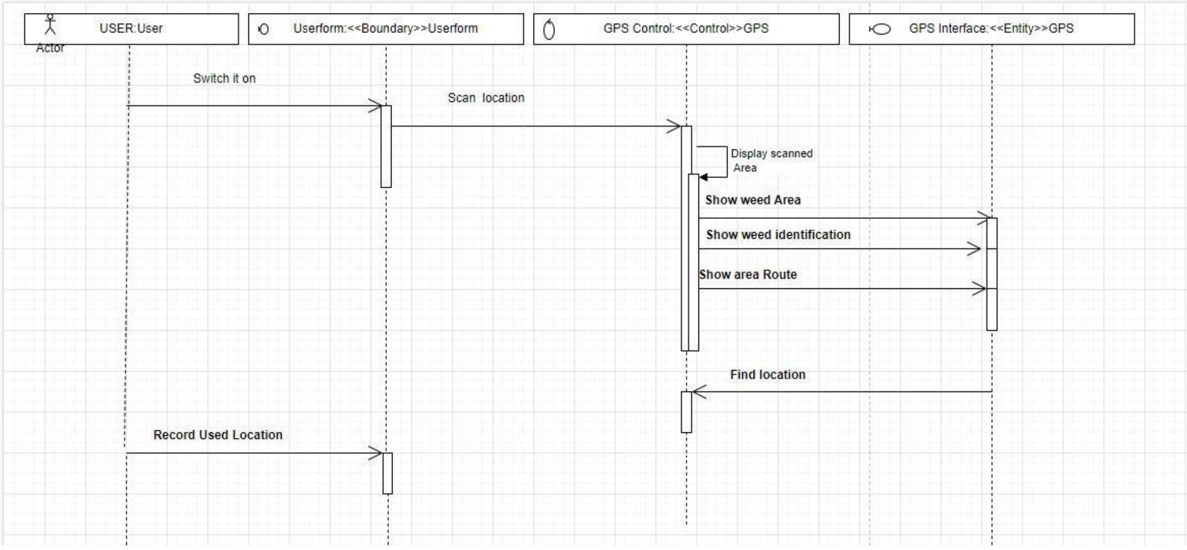
Table 1.4 Weed Location Class responsibility collaboration card

Class Responsibility Collaboration Cards **Weed Location**	
RESPONSIBILITY	**COLLABORATION**
Know weed identity	**Camera**

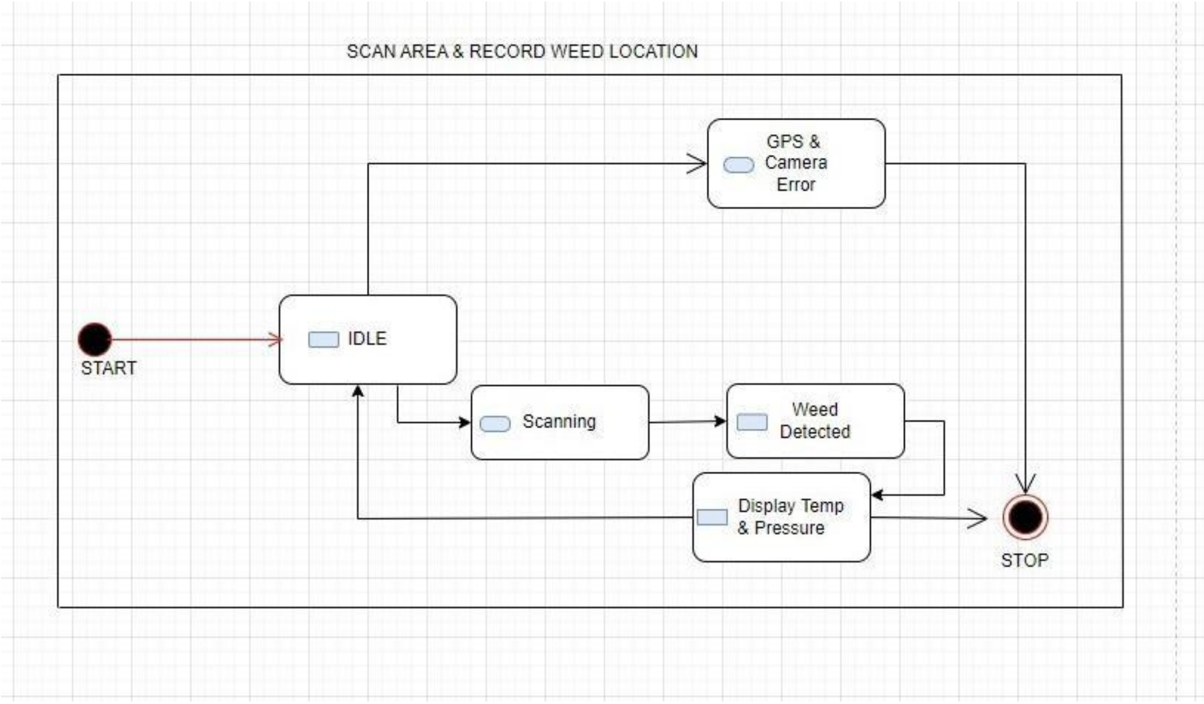
3.2.2 Class diagram for use case 1



3.2.1 Sequence diagram for use case 1



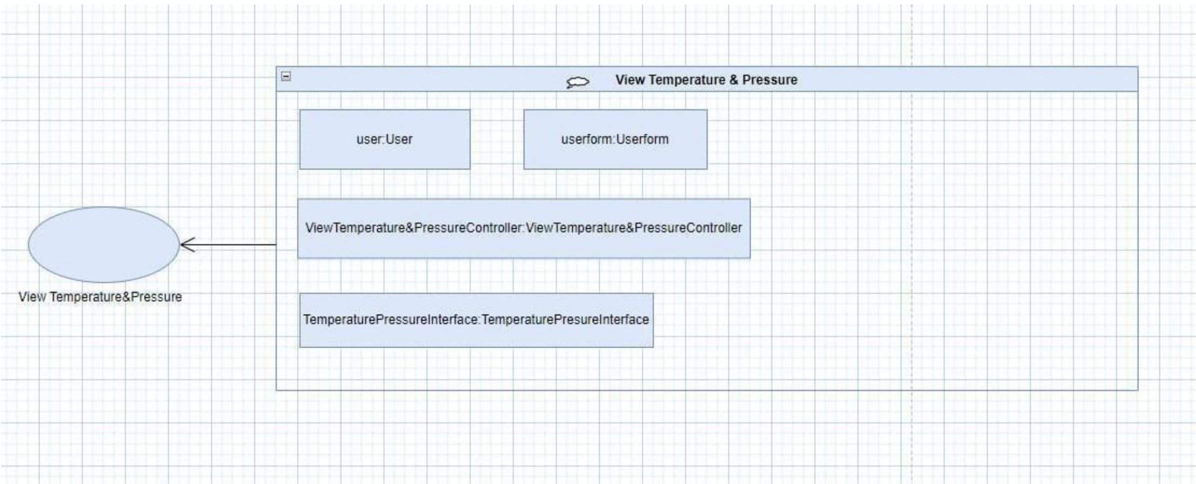
3.2.1 State-chart for use case 1



3.3 View Temperature, Pressure and Time

Remaining Use case

3.3.1 Use case realization



3.3.2 Analysis classes for use case 2

Table 2.1 Analysis classes for View Temperature and Pressure use case

Boundary	Userform ViewTemperatureForm
Control	ViewTempPressTimeController
Entity	TempuraturePressureTime

Table 2.2 Noun extractions for View Temperature and Pressure use case

Candidate noun	**Is this candidate inside our system boundary**	**Is this candidate an Entity? Is it a person/place/ concept/object/even which the organization/ system need to store data**	**Does this candidate have identifiable behaviour for our problem domain?**	**Does the candidate have relationships with any other candidates?**	**Is the candidate a Class?**
User	No	Yes	Yes	No	No
Temperature	Yes	Yes	Yes	Yes	Yes
Pressure	Yes	Yes	Yes	Yes	Yes
Time	Yes	Yes	Yes	Yes	Yes
Sensor	Yes	No	Yes	Yes	No

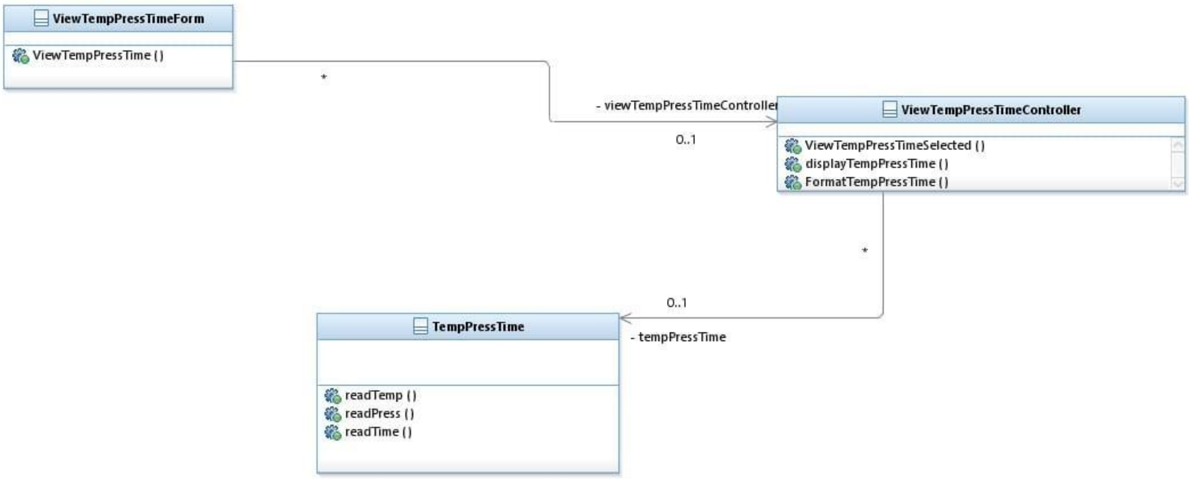
Table 2.3 Temperature Class responsibility collaboration card

Class Responsibility Collaboration Cards Temperature	
RESPONSIBILITY	**COLLABORATION**
Read temperature	**Sensor**

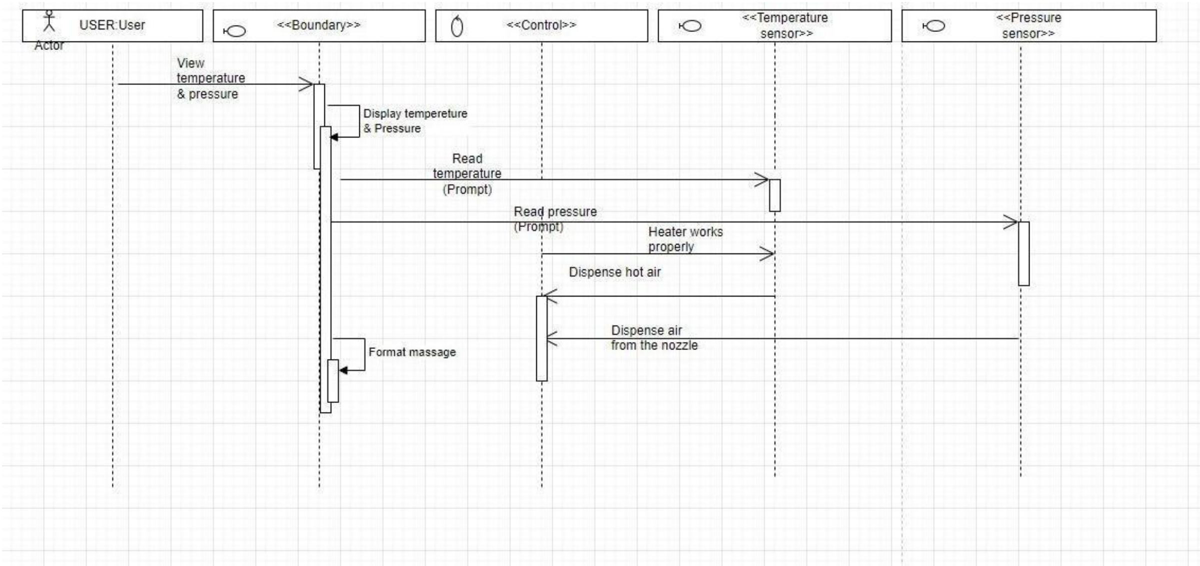
Class Responsibility Collaboration Cards Pressure	
RESPONSIBILITY	**COLLABORATION**
Read pressure	**Sensor**

Class Responsibility Collaboration Cards Time	
RESPONSIBILITY	**COLLABORATION**
Read time remaining	**Timer**

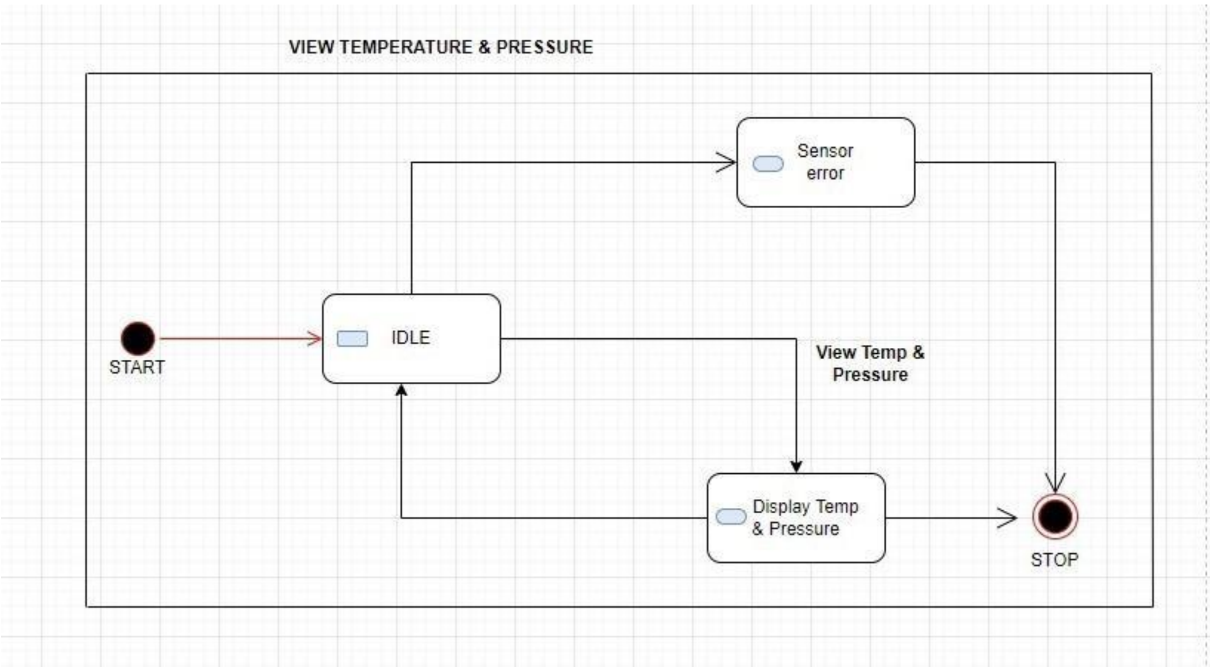
3.3.2 Class diagram for use case 2



3.3.3 Sequence diagram for use case 2



3.3.4 State-chart for use case 2



3.4 Start/Stop Heating

3.4.1 Use case realisation

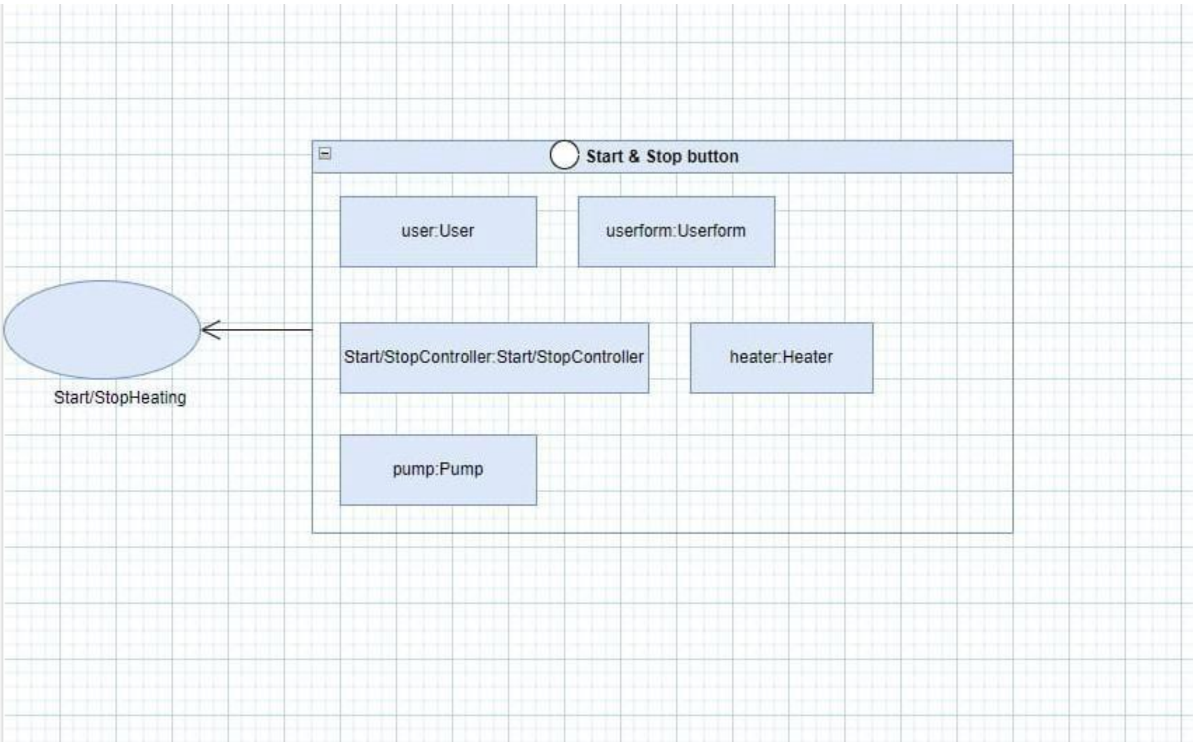


Table 3.1 Analysis Classes for Start/Stop Heating use case

Boundary	StartStopHeatingForm
Control	Start/StopHeatingController
Entity	Heater Pump

Table 3.2 Noun extraction for Start/Stop heating use case

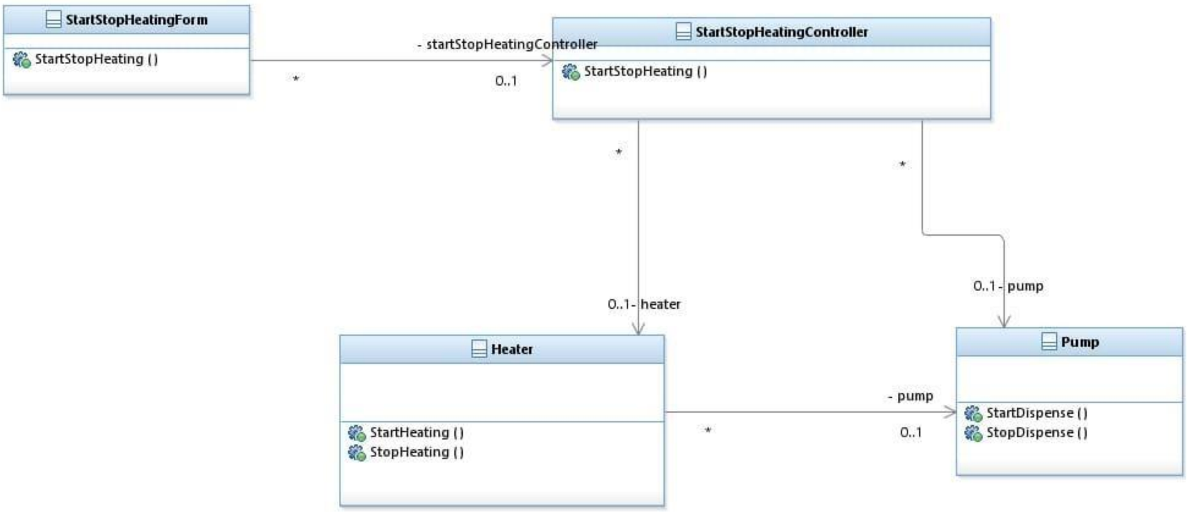
Candidate Noun	**Is this candidate inside our system boundary?**	**Is this candidate an Entity?**	**Does this candidate have identifiable behaviour for our problem domain?**	**Does this candidate have relationships with any other candidates?**	**Is the candidatea Class?**
User	No	No	No	**Yes**	**No**
Button	Yes	**No**	**Yes**		
Heater	Yes	**Yes**	**Yes**	**Yes**	**Yes**
Pump	Yes	**Yes**	**Yes**	**Yes**	**Yes**
Air	Yes	**No**	**Yes**	**No**	**No**
Nozzle	Yes	**Yes**	**Yes**	**Yes**	
Sensor	Yes	**No**	**Yes**	**Yes**	**No**

Table 3.3 User Class responsibility collaboration card

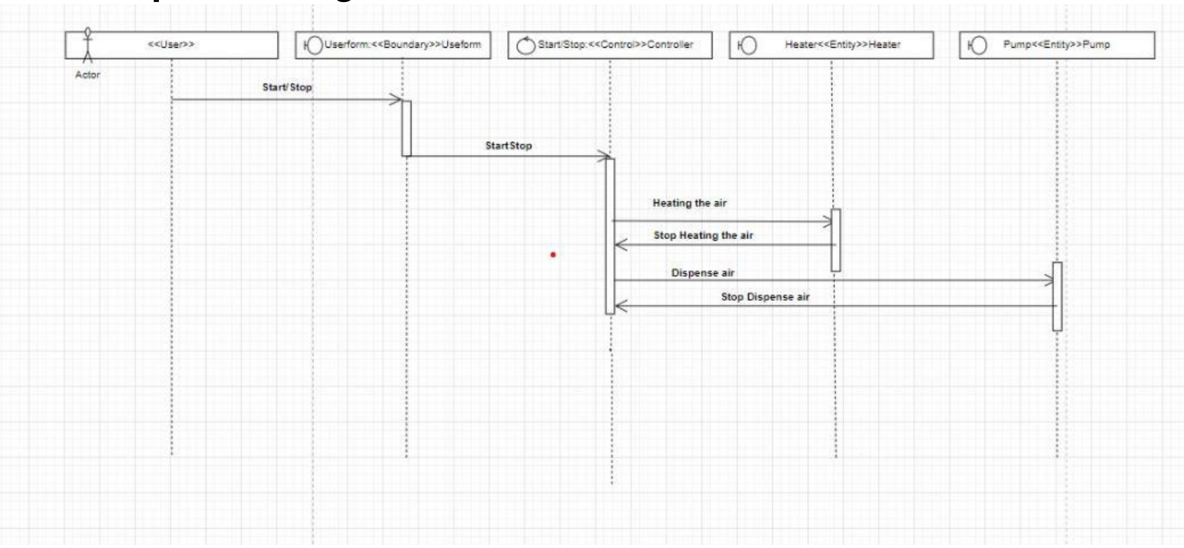
Class Responsibility Collaboration Cards Heater	
RESPONSIBILITY	**COLLABORATION**
Know heater function	
Know heater temperature	**Sensor**

Class Responsibility Collaboration Cards Pump	
RESPONSIBILITY	**COLLABORATION**
Know pump function	
Know pump pressure	**Sensor, Nozzle**

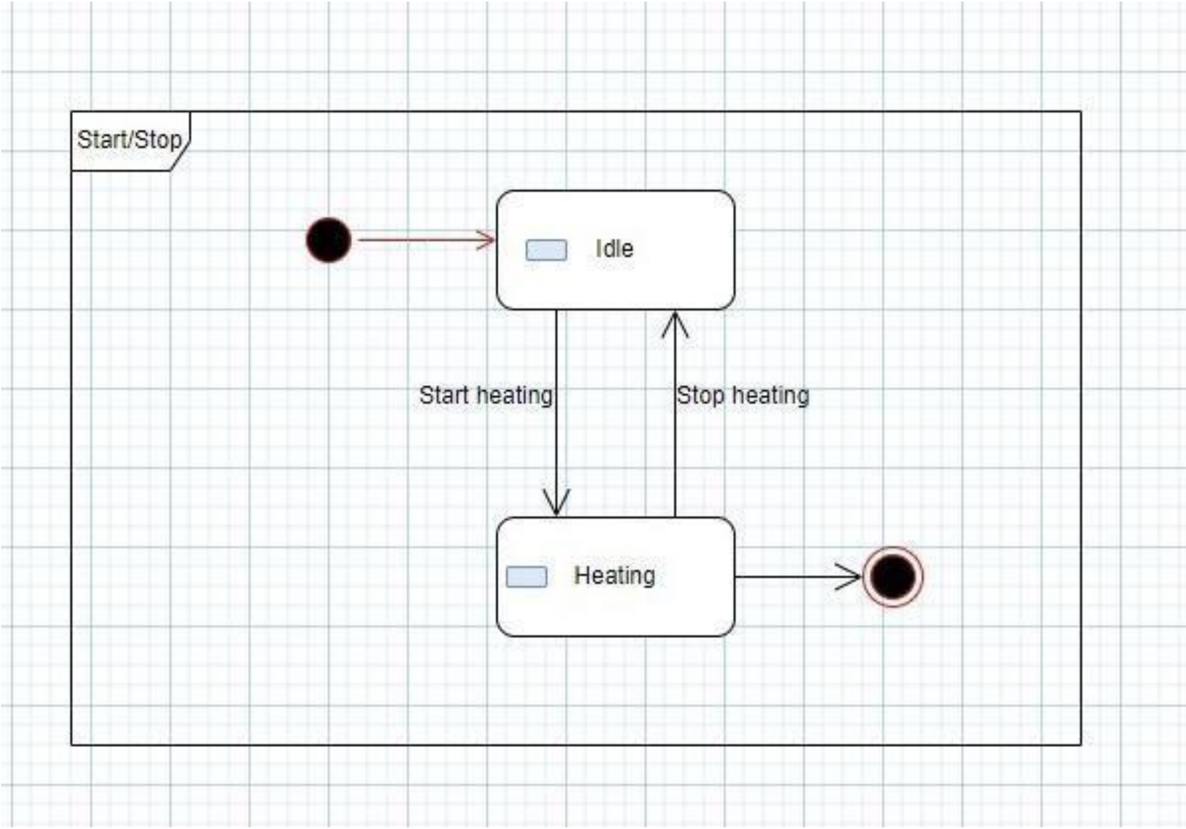
3.4.2 Class diagram for use case 3



3.4.3Sequence diagram for use case 3

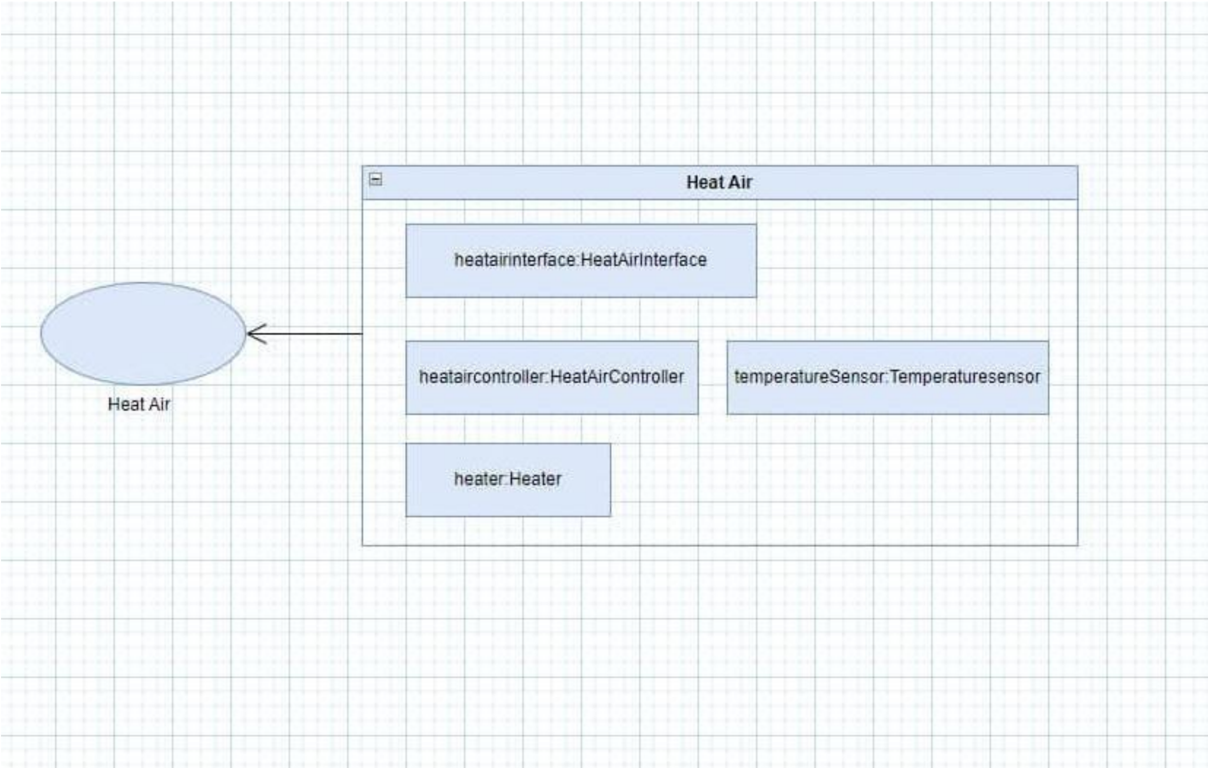


3.4.4 State-chart for use case 3



3.5 Heat Air

3.5.1 Use case realisation



3.5.2 Analysis classes for use case 4

Table 4.1 Analysis classes for Heat Air dispense use case

Boundary	Userform HeatAirInterface
Control	TemperatureSensor
Entity	Heat

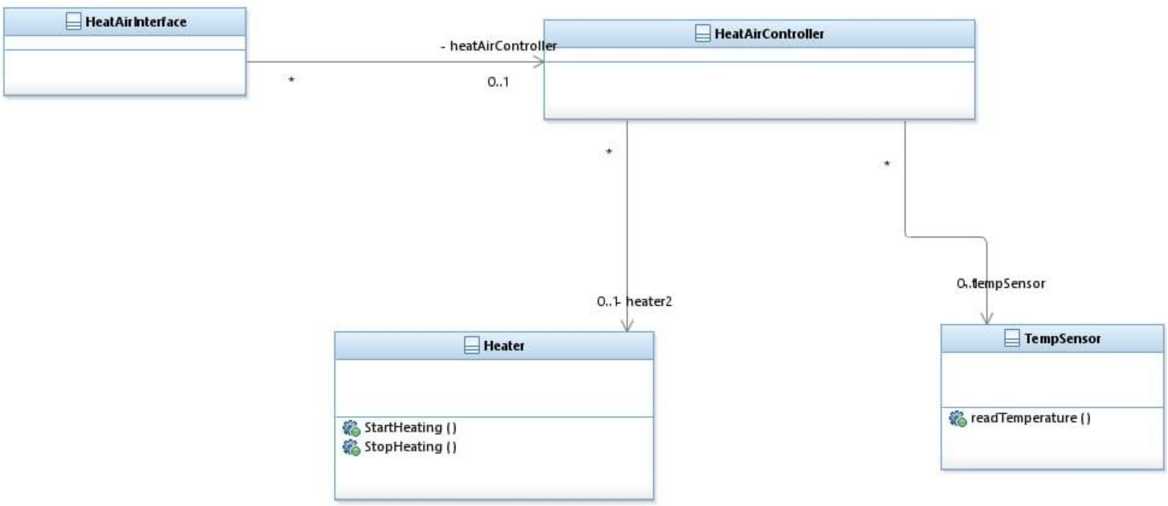
Table 4.2 Noun extraction & Class responsibility cards

Candidate Noun	Is this candidate inside our system boundary?	Is this candidate an Entity?	Does this candidate have Identifiable behaviour for our problem domain?	Does this candidate have relationswith any other candidates?	Is this candidate a Class
Heat Air	Yes	Yes	Yes	No	No
Temp Sensor	Yes	Yes	No	No	No

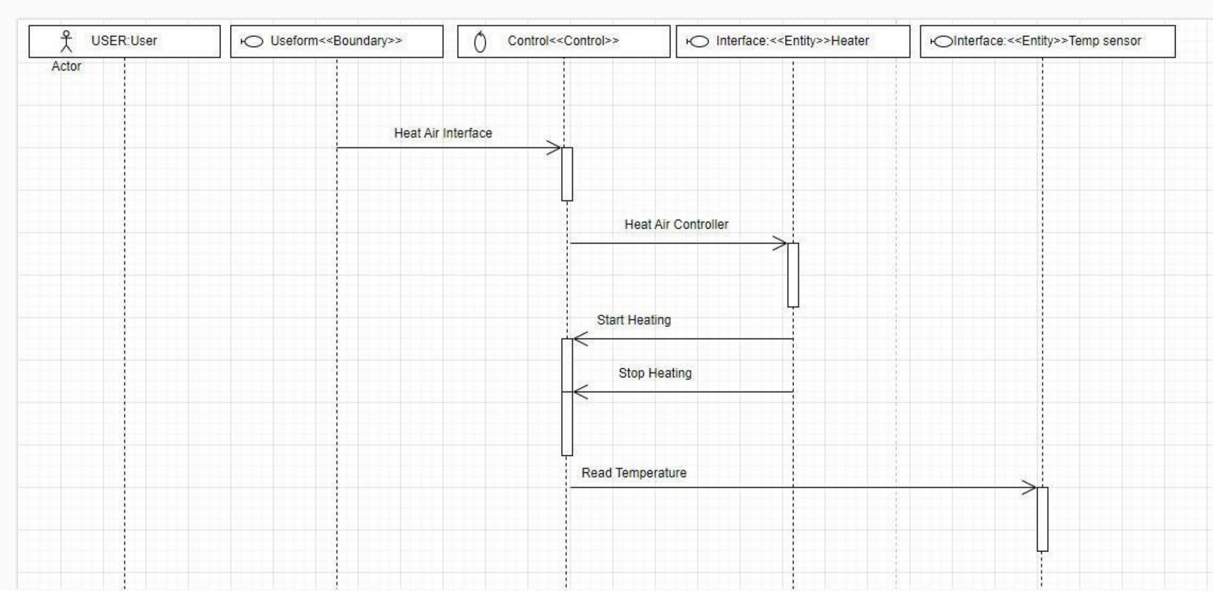
Table 4.3 Class responsibility collaboration cards

Class Responsibility Collaboration CardsHeat Air	
ONSIBILITY	ABORATION
Sensor’s name	er Sensor
Sensor’s model	er Setting
sensor’s description	strays weed without harming soil or water and operates autonomously, eliminating the reliance on manual laborers. This heater applies temperature as high as 1200 Degree Fahrenheit to wilt and burn invasive and pesky problem plants.
ensors	on

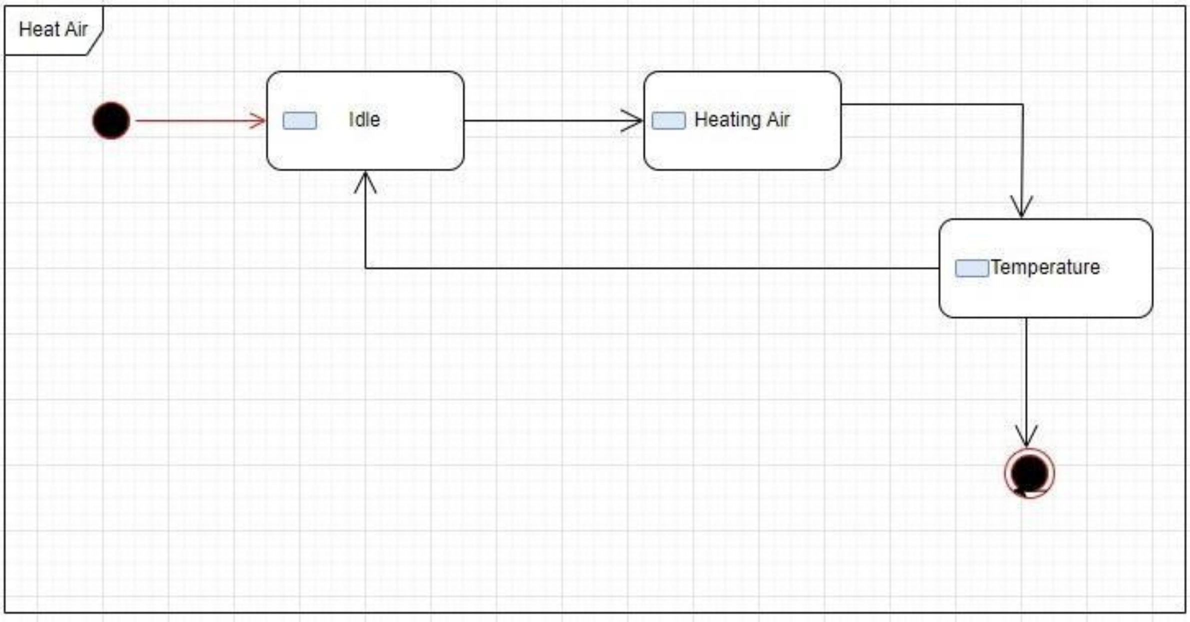
3.5.3 Class diagram for use case 4



3.5.4 Sequence diagram for use case 4

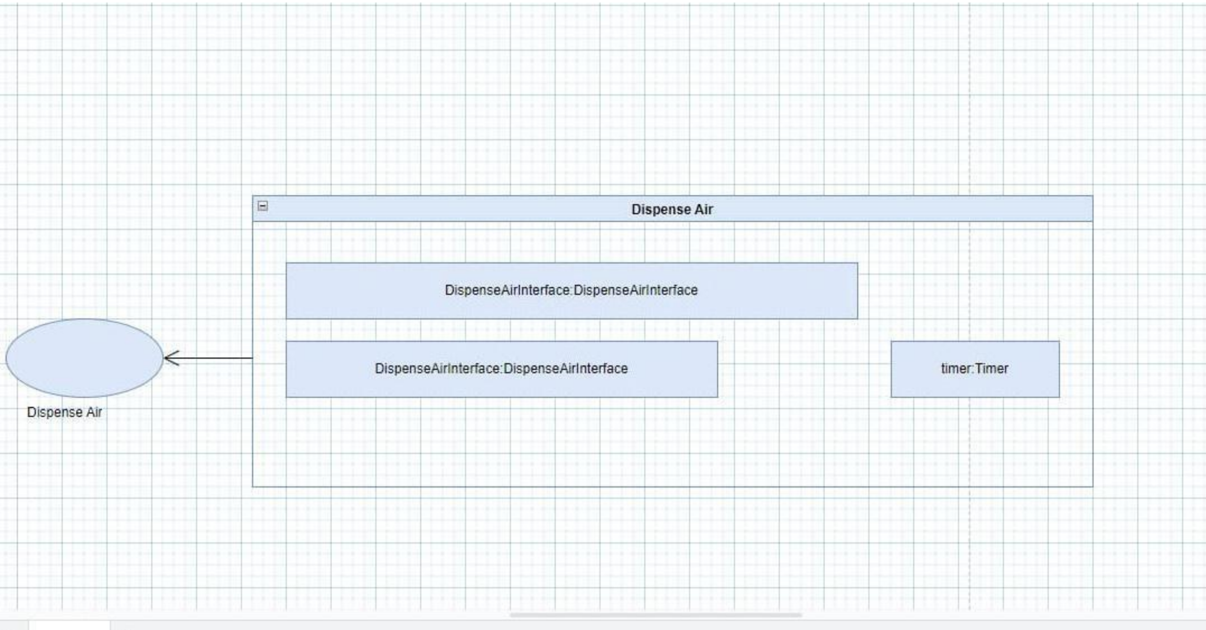


3.5.5 State-chart for use case 4



3.6 Dispense Air

3.6.1 Use case realisation



3.6.2 Analysis classes for use case 5

6.1 Analysis classes for Dispense Air use case

Boundary	UserFom ReadPressure ReadTime
Control	ReadPressure&Time
Entity	

Table 6.2 Noun extraction for Dispense Air use case

			our problem domain?		
User	No	No	No	Yes	No
Pressure	Yes	Yes	Yes	No	No
Sensor	Yes	Yes	Yes	Yes	Yes
Nozzle	Yes	Yes	Yes	Yes	Yes
Timer	Yes	Yes	Yes	Yes	No
Candidate Noun	Is this candidate inside our system boundary?	Is this candidate an Entity?	Does this candidate have Identifiable behaviour for	Does this candidate have relationswith any other candidates?	Is this candidate a Class

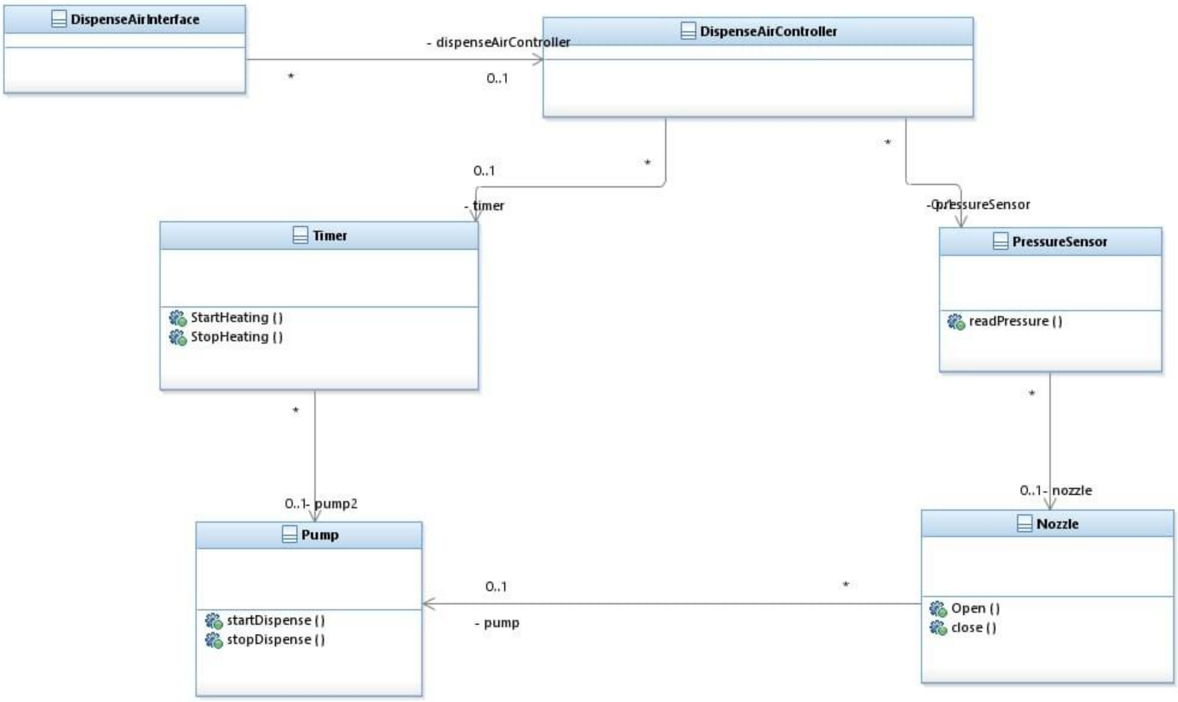
Table 5.3 User Class responsibility collaboration card

Class Responsibility Collaboration Cards Sensor	
RESPONSIBILITY	COLLABORATION
Know sensor’s name	
Know sensor’s model	
Know sensor’s description	As it drives itself down rows of garden, park or farm, its 12 cameras scan the ground. An onboard computer, powered by AI, identifies weeds and the robot’s carbon dioxide lasers then zap and kill the weed.
Get sensors	View Pressure working controller

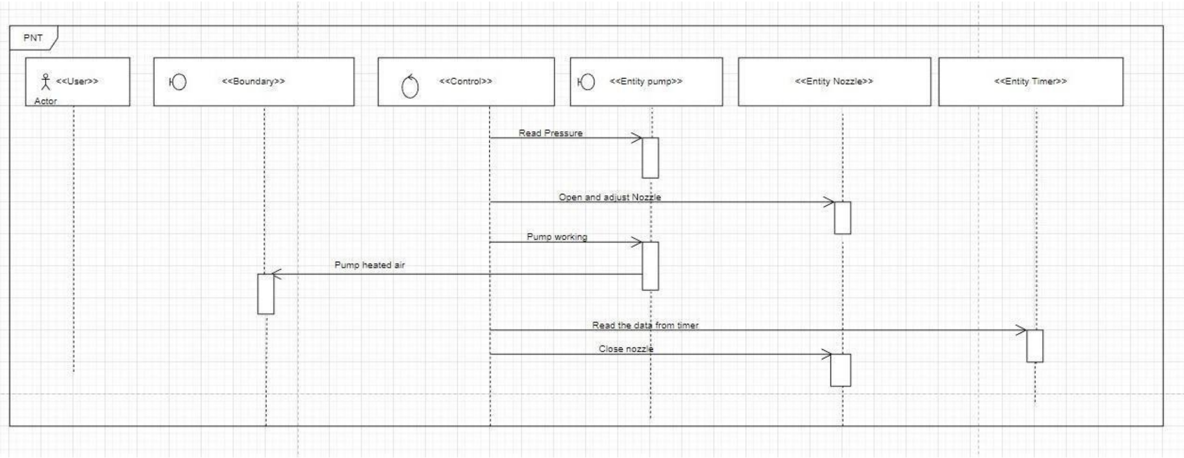
Table 5.2 Nozzle Class responsibility collaboration card

Class Responsibility Collaboration Cards Nozzle	
RESPONSIBILITY	COLLABORATION
Know nozzle name	
Know type of nozzle	
Get nozzle	View & adjust nozzle controller

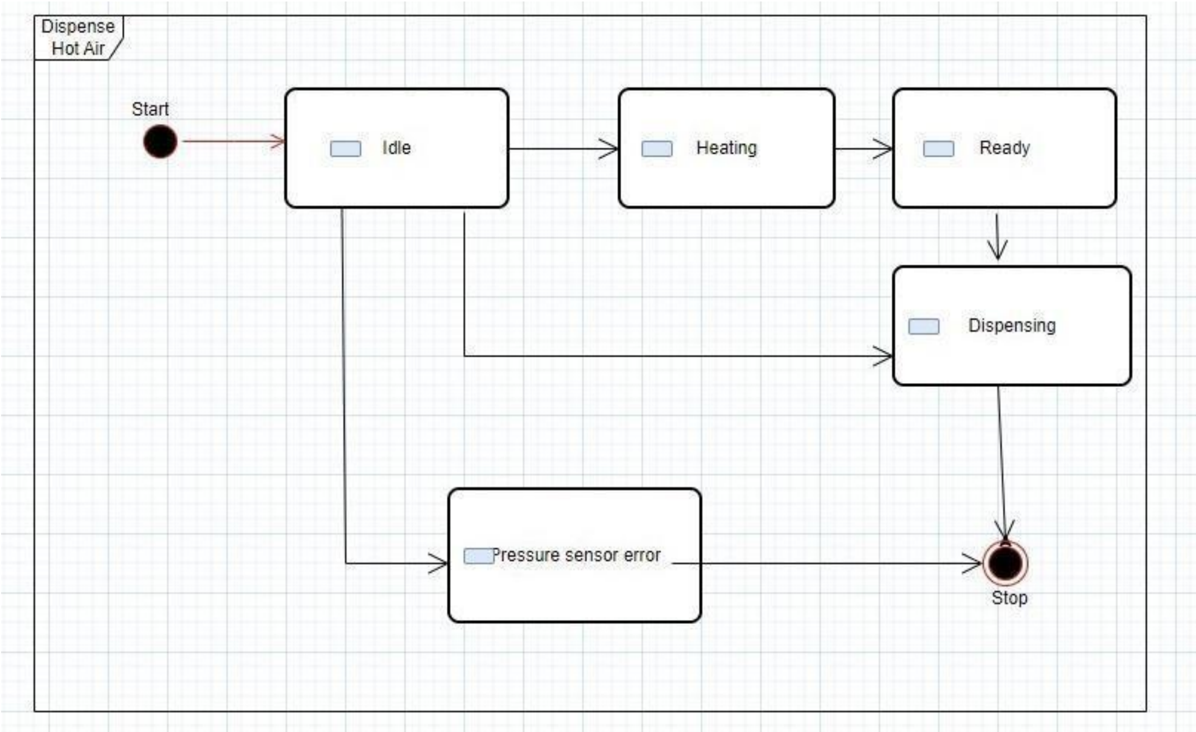
3.6.3 Class diagram for use case 5



3.6.4 Sequence diagram for use case 5



3.6.5 State-chart for use case 5



3.7 Summary

In this chapter the requirement and analysis for the 5 use cases was completed. A well-written summary provides a concise overview of the project work for the specific sub-problem/use case. Analysis and all classes' helps to comprehend, clarify, identify and know requirements of your domain problem also to identify its components and helps to overview the system as you want it to be.

CHAPTER 4: Reassessment of the original problem

Introduction

This chapter will discuss how the problem presented in chapter 1 was solved by the system, along with recommendations as well as an outlook for the future.

Re-statement of the original problem(s)
State the sub-problems and briefly state how they were solved.
<u>Scan area and record weed location</u>
This sub-problem performs the work of scanning the area and identifying the weeds in the area.
The robot solves this sub-problem by using sensors as a scanning mechanism, wheels to get around, as well as a GPS to navigate the area and determine which areas still need to be scanned. The weed location is then recorded in the robot's internal memory.

<u>View temperature and pressure and time remaining</u>
This sub-problem allows the user to view the current temperature, pressure and time remaining of the weed-killing robot.
The robot solves this sub-problem by using sensors to detect the temperature and pressure as well as a timer for the time remaining. The data from these sensors is then read, formatted and displayed to the user on the display screen.

<u>Start/Stop heating</u>
This sub-problem allows the user to start or stop the robot heating and dispensing the air.
The robot solves this sub-problem by providing a button for the user to press to start or stop the system. Once this has happened the system will then begin heating the air using the heater and once the air has been heated, it will be dispensed by the system's pump. When the button is pressed again (stop function) the pump will stop dispensing the air and the heating will stop as well.

<u>Heat air</u>
This sub-problem does the work of heating the air in the robot.

The robot solves this sub-problem by implementing a heater and a temperature sensor. Once the system has been switched on and the user has selected to start the process, the robot will switch on the heater. The temperature of the air will increase until it reaches a certain temperature, predetermined by the robot. The temperature sensor will continuously read the temperature during this stage and will notify the system once the set temperature has been reached.

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