Instituto Tecnológico y de Estudios Superiores de Monterrey

Modeling of Multi-Agent Systems with Computer Graphics (301)

Evidence 2. Review 1.

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Campus Guadalajara

- **Team Composition:** Indicate the members of the work team. You must also identify the strengths and areas of opportunity for each of you. As well as your expectations for the block. Subsequently, prepare a brief list of what you expect to achieve and obtain as a work team in this block, as well as your commitments to achieve it.

Name	Strengths	Areas of opportunity	Expectations	Commitments
Anett Martínez Vázquez	Communication Programming knowledge	Lack of experience with graphic engines Lack of experience with simulations	Learn how multi-agent systems work Learn to represent multi-agent systems graphically Improve my teamworking skills	Finish my tasks on proper time Be open to learn new technologies and topics
Sarah Sophia Gutiérrez Villalpando	Programming knowledge and fast learning	Lack of experience with 3D models creation, little knowledge with graphic engines	Learn new skills with blender and strengthen my skills with unity	Finish everything on time, try to meet expectations in the project, and be open to learning.
Annete Montserrat Cedillo Mariscal	Programming knowledge	Lack of experience with 3D modeling softwares	Reinforce my skills in blender and unity	Help the team in everything I can.
Monserrat Morales Cañez	Communication Programming knowledge	Lack of experience with 3D modeling softwares and graphic engines	Learn new things about graphic engines and agent modeling.	Finish everything on time, meet expectations in the project, and be a strong base for the graphic part of the project.

Héctor Ayala Gutiérrez	Programming knowledge and fast learning	Lack of experience with 3D modeling softwares and graphic engines	Learn new things about graphic engines and agent modeling.	Finish everything on time, try to meet expectations in the project, and be open to learning.

- **Creation of Collaborative Work Tools:** You must create a Github repository where all generated documentation and code will be stored, as well as a communication tool among participants.

Github Repository: https://github.com/anettmava/multiAgentSystem.git

Communication tool:

- **The formal challenge proposal must consider:**

Description of the challenge to be developed.

Agriculture plays a crucial role in global food security and even economic stability. However, a large portion of agricultural production is lost annually due to pests, diseases, and plant stress, often caused by the late detection of anomalies in crops. The problem is aggravated by the dependence on manual and visual inspections, the limited availability of trained personnel, and the short harvest windows of high-turnover fruits such as strawberries and cucumbers.

To address this issue, the challenge focuses on the design and simulation of a Multi-Agent System that operates within a virtual greenhouse environment. This system will model the interactions of multiple autonomous agents that collaborate to detect, classify, and respond to anomalies in plants. The goal is to demonstrate how distributed intelligence and coordination among agents can improve the efficiency, precision, and timeliness of agricultural management.

1. Monitoring Agent (Reactive Architecture)

Role and Relationships:

The Monitoring Agent is responsible for continuously observing the virtual greenhouse environment using simulated sensor data (e.g., temperature, humidity, leaf color, and moisture levels). It communicates directly with the Analysis Agent by sending raw or preprocessed data whenever it detects changes that may indicate anomalies.

Architecture Type:

Reactive. This agent responds immediately to environmental stimuli without complex reasoning or planning.

Architectural Components:

- **Perception Layer:** Captures environmental data from sensors and plant indicators.
- **Action Layer:** Triggers alerts or sends the detected data to the Analysis Agent.

2. Analysis Agent (Deliberative Architecture)

Role and Relationships:

The Analysis Agent receives data from the Monitoring Agent and processes it to determine whether the detected changes represent actual anomalies. It uses pattern recognition and predefined rules (e.g., thresholds for leaf color deviation or temperature imbalance) to classify the type of anomaly. Once an anomaly is identified, it informs the Response Agent to take corrective actions.

Architecture Type:

Deliberative. This agent bases its decisions on reasoning and planning processes.

Architectural Components (BDI Model):

- **Beliefs:** Information received from the Monitoring Agent about environmental and plant conditions.
- **Desires:** The goal of accurately identifying and classifying anomalies in crops.

- **Intentions:** The selected actions or decision paths to validate and report detected anomalies.

3. Response Agent (Hybrid Architecture)

Role and Relationships:
The Response Agent is in charge of executing or simulating corrective measures once an anomaly is confirmed (e.g., adjusting irrigation, modifying temperature, or alerting human operators). It interacts with both the Analysis Agent (to receive anomaly reports) and the Monitoring Agent (to verify the effects of its interventions).

Architecture Type:
Hybrid. This agent integrates reactive behavior (to respond quickly to confirmed anomalies) with deliberative reasoning (to plan corrective strategies and evaluate long-term effects).

4. Work Plan

Week 2
Goal: Create the basic structure of the project.

Choose the simulation method (Python scripts, console program, or simple interface). Responsible: Entire team. Estimated effort: 3–4 hours.

Define what information each agent will send and receive. Responsible: Monserrat, Sarah, Hector. Estimated effort: 3–5 hours.

Create a simple 2D map or grid of the greenhouse to represent the plants. Responsible: Annete and Anett. Estimated effort: 4–5 hours.

Expected result of Week 2: We have the simulation method selected, the greenhouse grid ready, and a clear plan for communication between agents.

Week 3
Goal: Build data structures and create the first working agent.

Create the plant data structure (ID, position, health, anomaly status). Responsible: Anett and Annete. Estimated effort: 5–6 hours.

Build the Data Storage and Knowledge Agent that saves plant information and history. Responsible: Hector. Estimated effort: 5–7 hours.

Make a simple version of the Sensor Analysis Agent that can detect example anomalies. Responsible: Sarah. Estimated effort: 4–6 hours.

Expected result of Week 3: The system can save plant information and show when a plant has a possible anomaly.

Week 4
Goal: Add reasoning and information flow between agents.

Create the Prioritization and Reasoning Agent, which decides which anomalies are important. Responsible: Sarah and Monserrat. Estimated effort: 6–8 hours.

Connect the Sensor Agent to the Data Storage Agent and then to the Reasoning Agent, forming a full pipeline. Responsible: Entire team. Estimated effort: 5–7 hours.

Start creating the Notification Agent, which will generate warning messages for workers. Responsible: Annete. Estimated effort: 3–4 hours.

Expected result of Week 4: When the Sensor Agent detects something, the system saves it, analyzes it, and creates a warning message.

Week 5
Goal: Finish all agents, integrate everything, and test the system.

Complete the Notification Agent, creating alerts and small reports with suggested actions. Responsible: Monserrat and Anett. Estimated effort: 4–6 hours.

Connect all agents into one system (Sensor, Storage, Reasoning, Notification). Responsible: Entire team. Estimated effort: 6–8 hours.

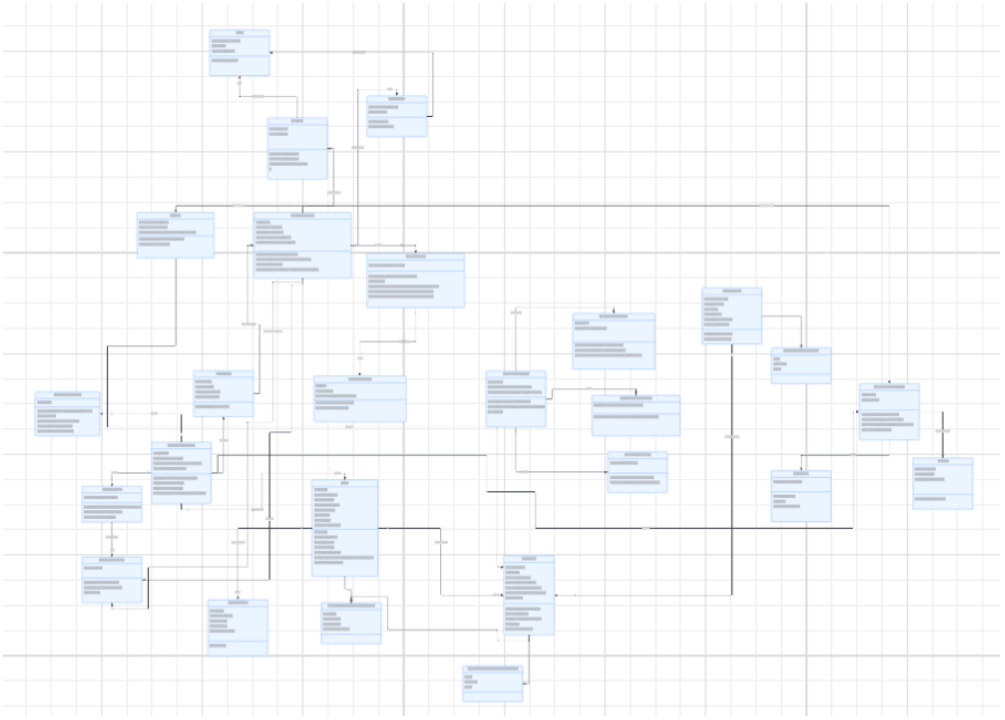
Test the simulation with different sample cases and complete the documentation.
Responsible: Entire team. Estimated effort: 5–7 hours.

Expected result of Week 5: The complete system detects plant anomalies, stores information, analyzes severity, and informs the greenhouse workers through alerts or reports.

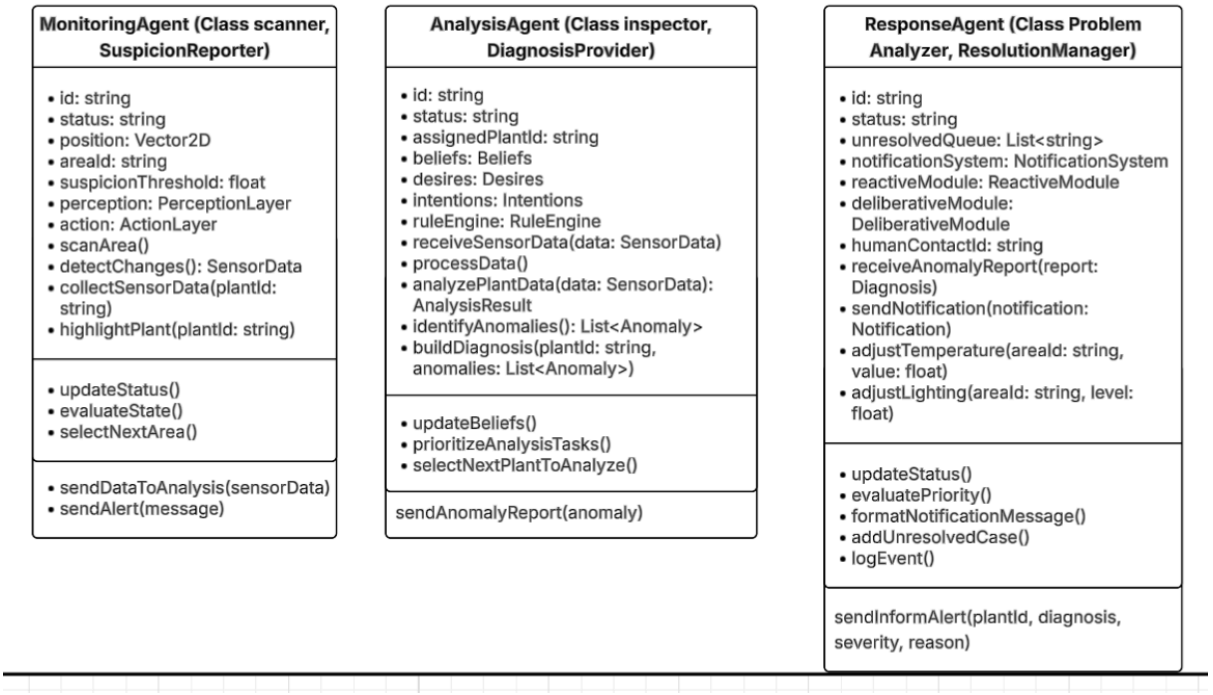
Multi-Agent Systems

- Standard Class Diagrams to describe the agents' subsystems.

Due to formatting limitations, the diagram appears reduced in size. Please use either of the following links to view the full-size diagram: Lucidchart StandardClassDiagram (3).pdf

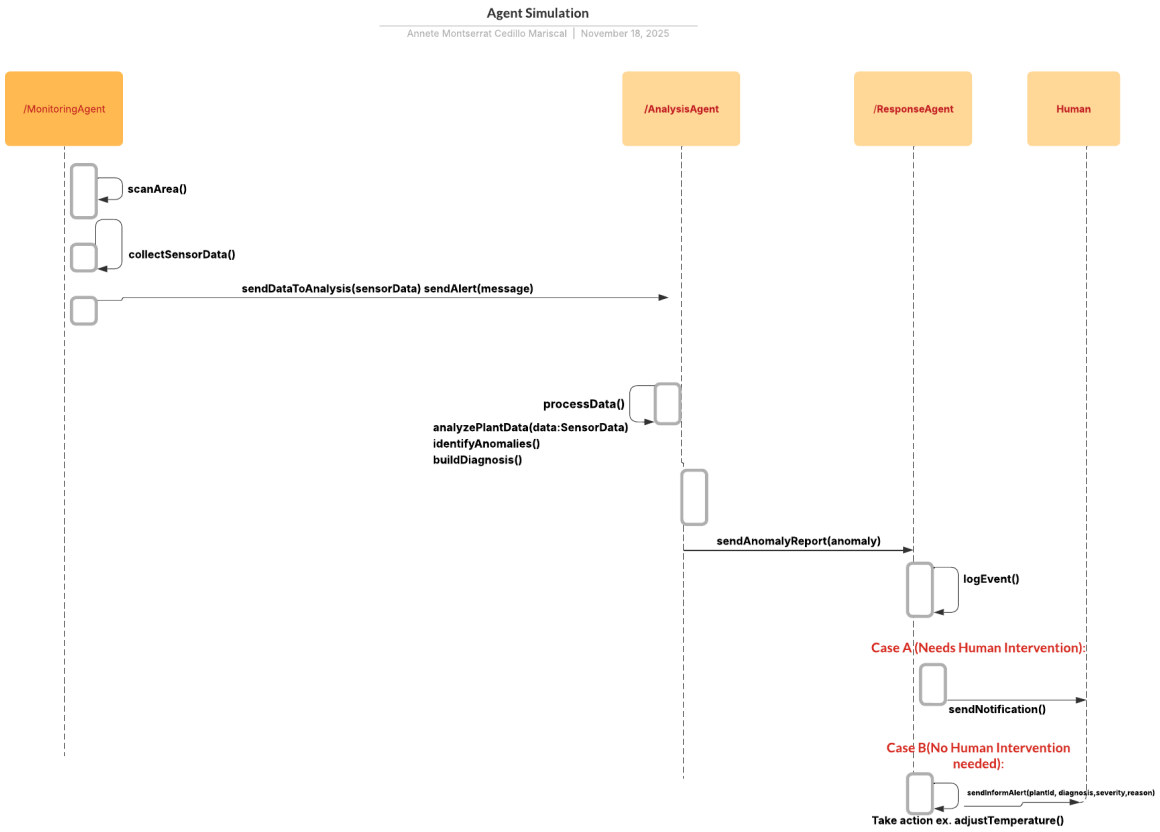


Agent Class Diagram



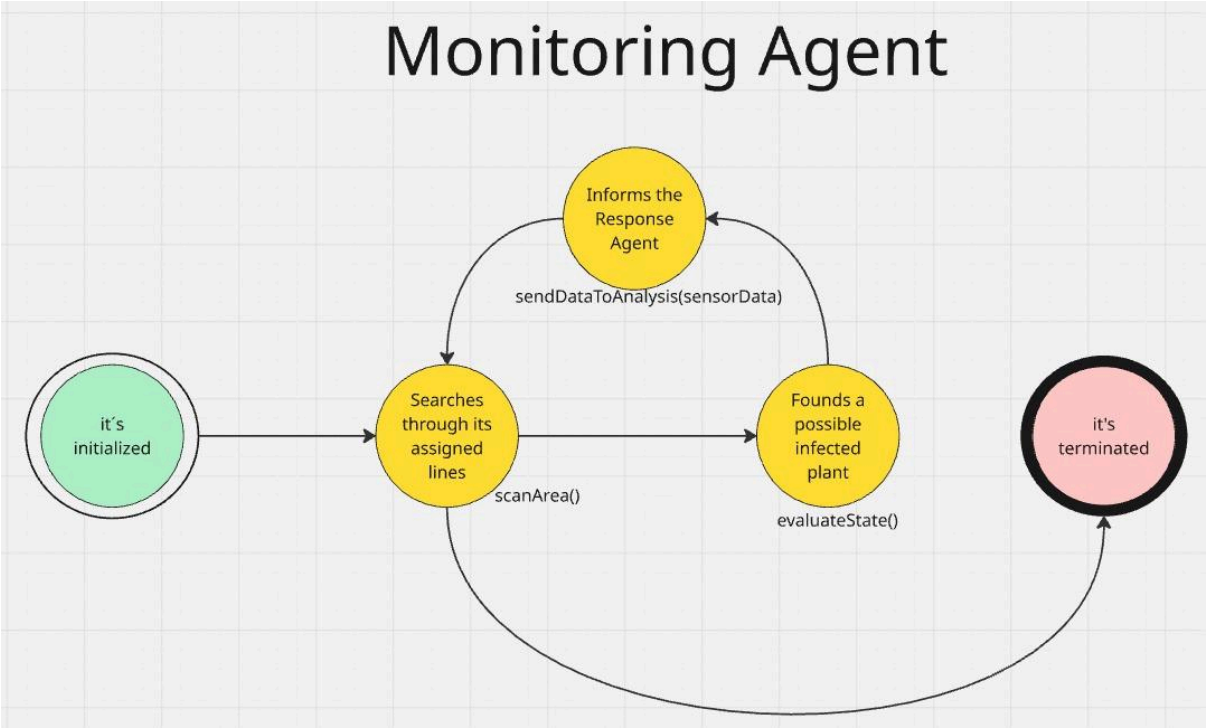
The diagram shows three agents: Monitoring gathers data, Analysis diagnoses issues, and Response applies minor adjustments or alerts the human operator.

Interaction Diagrams (AIP)

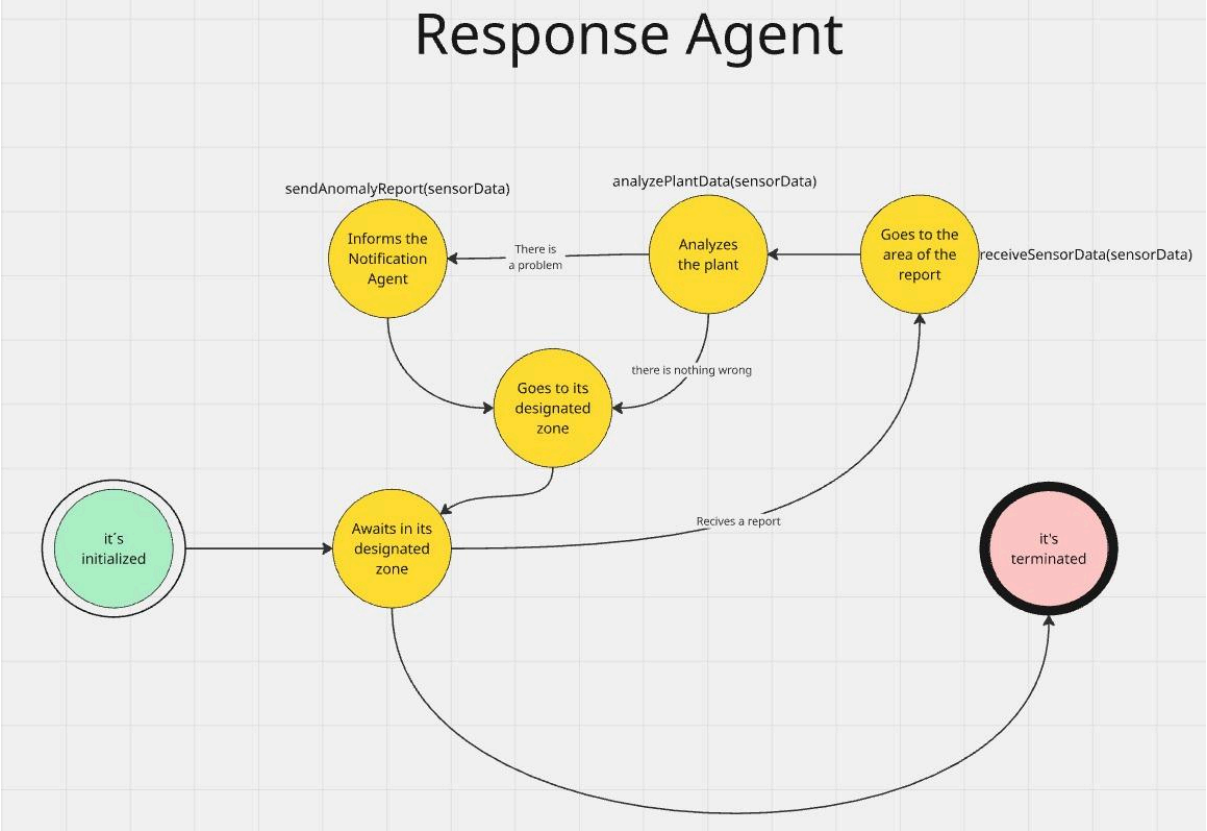


This diagram shows the interaction between the three types of agents: Monitoring, Analysis, and Response agents. The workflow is simple and well-explained in the diagram. It shows both cases, when human intervention is needed and when it is not.

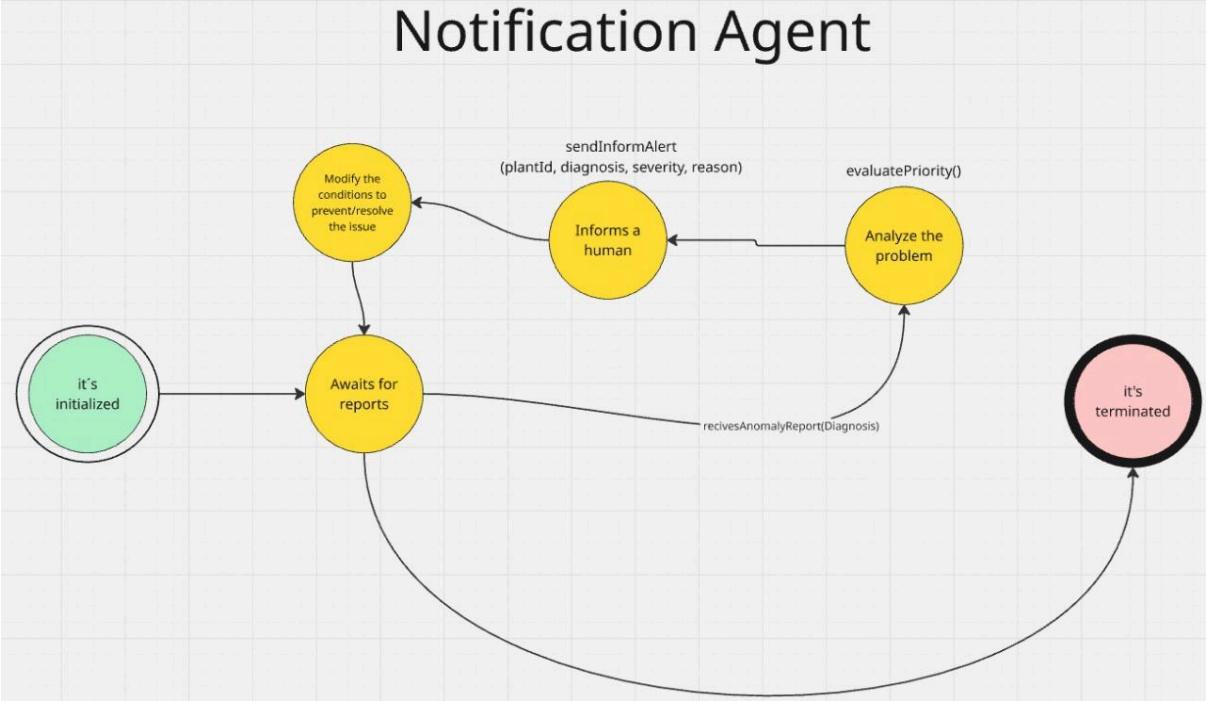
State Diagrams:



The Monitoring Agent begins by initializing its parameters and then continuously scans its assigned crop lines to gather sensor data. When it detects a potentially infected plant, it evaluates the anomaly and sends the relevant information to the Response Agent. After reporting, it returns to its scanning routine. The agent repeats this cycle until the system ends its operation and transitions to a terminated state.



The Response Agent starts by waiting in its designated zone until it receives a report from the Monitoring Agent. Once it gets the data it travels to the reported location to further analyze the plant, then it determines whether an issue exists or if there was nothing wrong. If no problem is detected, it simply returns to its zone; if an anomaly is confirmed, it sends an anomaly report to the Notification Agent. It then resumes waiting for further reports or transitions to termination when required.



The Notification Agent initializes and waits for anomaly reports from the Response Agent. When a report arrives, it analyzes the problem to determine severity and priority. Depending on the evaluation, it may notify a human operator or adjust environmental conditions to prevent or resolve the issue. After taking action, it returns to its waiting state until the system is terminated.

Computer Graphics

How do you visualize the visual world?

The visual world will simulate an orchard in a 60 x 85 terrain, maintaining the same visual characteristics of the space. There will be 24 lines of tomato crops, each separated by a 1.5 distance between them. The orchard will have searcher agents (drones) flying in between each line.

What virtual elements (buildings, objects, etc.) are key to your proposal?

- Drones
- Tomato plant
- Tomato plant holder
- Tomatoes
- Sensors
- Cameras
- Terrain

How do you visualize the models of the agents and other relevant objects?

Searcher

This agent will have the characteristics of a drone; it will have “legs” and will have a diamond-like shape. The size of the agent will be small enough to fit between each line of crops and should be lightweight. The color of the agent will be white. The agent will include a camera and an IR sensor on the bottom of its body.

Specialist

Will have the same physical characteristics as the searcher, except for the color of the agent, the specialist will be blue. The difference will rely on it having a higher-quality camera and vision sensors.

Controller

This agent will control the crops; it is not a unique physical object but a “computer” that will receive information from sensors located in the area and will send actions to objects as water dispensers, etc. In other words, the controller is not a visible object, but a computer agent.

Tomato Plant

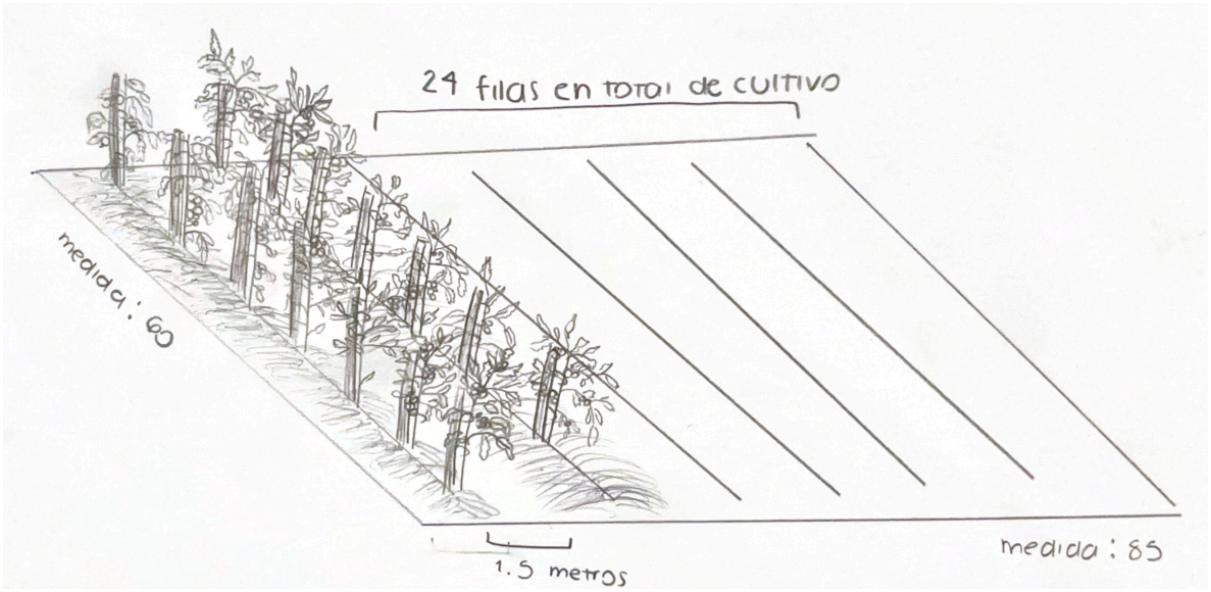
The plant will have a range of 8-12 tomatoes per plant. It will have green leaves if it is a healthy plant or stained leaves if unhealthy. The plant will be held by a wooden stick and a band.

Tomatoes

There will be different types of tomatoes, healthy and “unhealthy” tomatoes. Healthy tomatoes will have a green stem and a red fruit color. Unhealthy tomatoes will vary in color as they will resemble the physical appearance of a “sick” tomato.

Include schematics or hand-drawn sketches to support these descriptions.

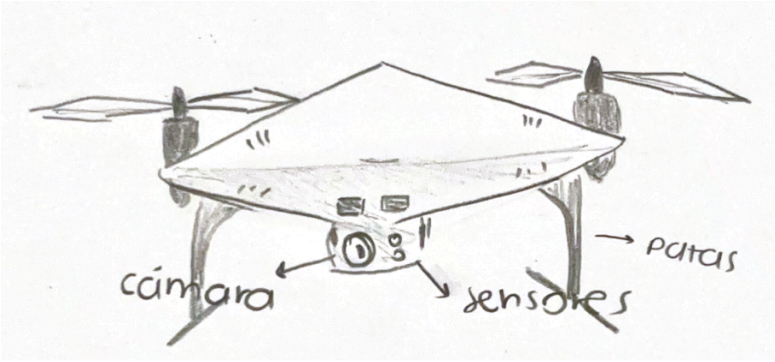
Terrain



Tomato Plant

Tomatoes

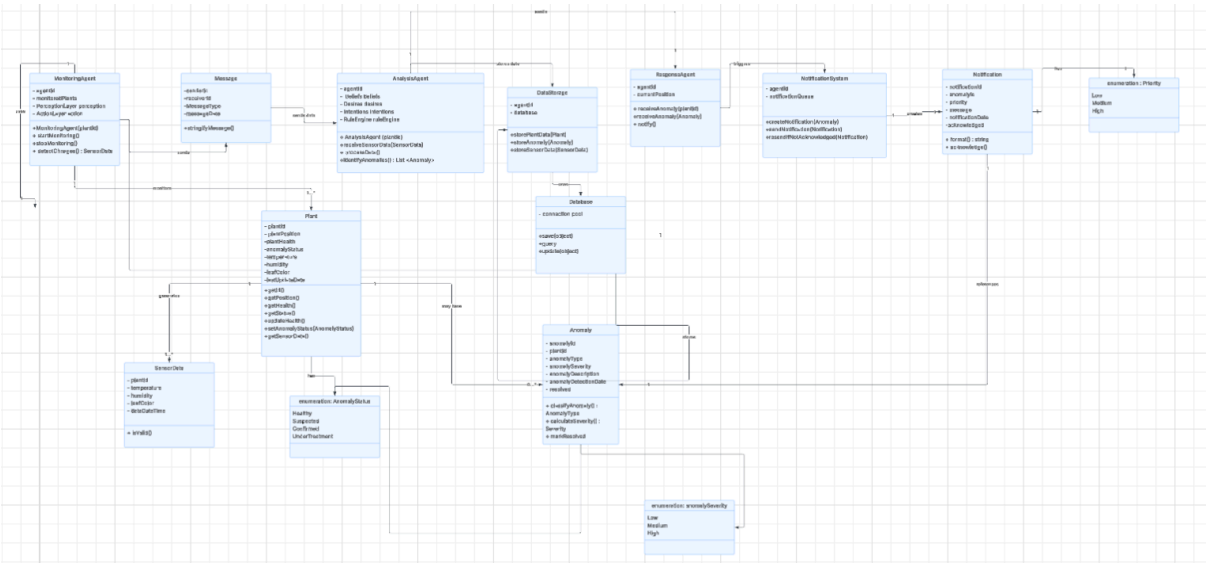
Searcher and Controller Agents



Evidence 2. Review 3

Final UML Diagram

Some classes were eliminated as the team thought were not necessary to implement the final simulation.

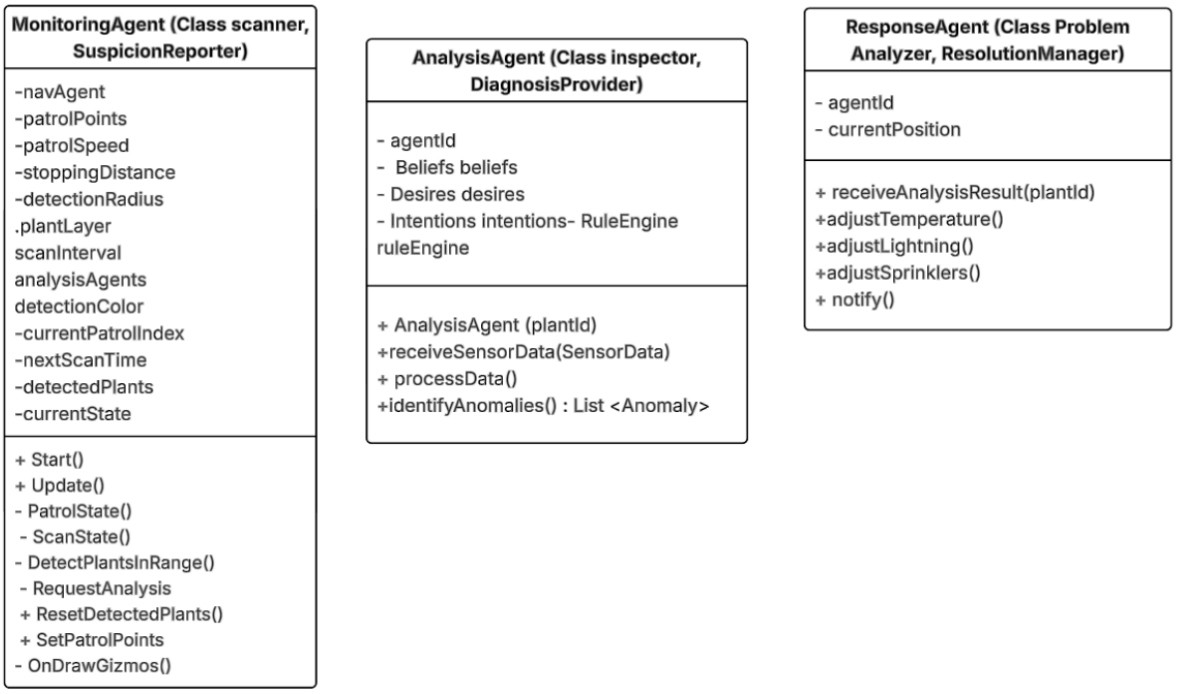


Link to final UML Diagram

https://lucid.app/lucidchart/ec8b4e8c-2d9d-42be-a058-274a84a2804f/edit?viewport_loc=-2862%2C-219%2C5611%2C2440%2C0_0&invitationId=inv_d73b03c9-f2b9-4aaa-bb5b-b497db3a10d5

Final AUML Diagrams

We changed most of the attributes and methods as we noticed most of them were redundant and for simplicity of the simulation, they were changed.



Code and Models can be seen implemented in the unity simulation

Work plan and lessons learned

Pending activities

- Connect all agents to enable communication between agents, this will be implemented for the next and final deliverable

Planned activities:

Names and tasks	Dates for working	Effort range
Monserrat Morales and Sarah Gutierrez Villalpando: connect the memories of the agents in unity and test the final functionality.	During all week 5	8/10

Annete Cedillo, Héctor Ayala, Anett Martinez: Implement code for memory sharing and communication	During all week 5	8/10

What was completed on the last weeks:

Week 2
Goal: Create the basic structure of the project.

Choose the simulation method (Python scripts, console program, or simple interface). Responsible: Entire team. Estimated effort: 3–4 hours.

Define what information each agent will send and receive. Responsible: Monserrat, Sarah, Hector. Estimated effort: 3–5 hours.

Create a simple 2D map or grid of the greenhouse to represent the plants. Responsible: Annete and Anett. Estimated effort: 4–5 hours.

Expected result of Week 2: We have the simulation method selected, the greenhouse grid ready, and a clear plan for communication between agents.

Actual result: Everything done on time and we spent around 2-3 hours for each task

Week 3
Goal: Build data structures and create the first working agent.

Create the plant data structure (ID, position, health, anomaly status). Responsible: Anett and Annete. Estimated effort: 5–6 hours.

Build the Data Storage and Knowledge Agent that saves plant information and history. Responsible: Hector. Estimated effort: 5–7 hours.

Make a simple version of the Sensor Analysis Agent that can detect example anomalies. Responsible: Sarah. Estimated effort: 4–6 hours.

Create the tomato final version of the tomato plant, with the healthy tomatoes and the support around it. Responsible: Monserrat. Estimated effort: 4-6 hours.

Expected result of Week 3: The system can save plant information and show when a plant has a possible anomaly.

Actual result: Everything done but we used week 4 too to implement this on time and we spent around 3 hours for each task, excepting the creation of the tomato plant, which had an estimated duration of 6 hours.

Week 4
Goal: Add reasoning and information flow between agents.

Create the Prioritization and Reasoning Agent, which decides which anomalies are important. Responsible: Sarah and Monserrat. Estimated effort: 6–8 hours.

Connect the Sensor Agent to the Data Storage Agent and then to the Reasoning Agent, forming a full pipeline. Responsible: Entire team. Estimated effort: 5–7 hours.

Start creating the Notification Agent, which will generate warning messages for workers. Responsible: Annete. Estimated effort: 3–4 hours.

Expected result of Week 4: When the Sensor Agent detects something, the system saves it, analyzes it, and creates a warning message.

Actual result: The communication flow between agents is still missing and we simplified the anomaly detection system, we plan to finish the work on Week 5.