Tecnológico de Monterrey

Evidence 2. Progress and presentation of the challenge

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August 26th, 2025

TC2008B Modeling of Multi-Agent Systems with Computer Graphics

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Team formation

Luis Ignacio Gómez:

Strengths

- Analytical skills to break down problems: design-first approaches and architectural mindset.
- Knowledge and understanding of teamwork dynamics: recognition that team effectiveness depends on context, compatibility, and project scope.
- Backend development: deep knowledge of architectural systems and OOP.

Areas of Opportunities

- Technical communication: skills in technical documentation and argumentation on technical topics.
- Confidence in execution: guidance needed for implementation on topics that I may have a theoretical approach to but do not feel confident enough to develop on my own.
- Frustration tolerance: When not completely confident on a topic, I do not feel like I am able to add to a team.

I expect to learn from this block to learn about agent architecture and implementation, as well as their ethical and moral points of view. I would like to learn about the backbones of agents, the different approaches to implementing them, their pros and cons, and their trade-offs.

Edgar Osvaldo Navarro:

Strengths

- Strong Technical Foundation: Proven understanding of OOP and experience in translating theoretical concepts into working solutions.
- Self-Directed Learning: Has strong knowledge processing and sharing capabilities. Making it possible to absorb complex information and make it accessible to others.
- Knowledge of C# programming and 3D modeling: previous experience using Unity and making 3D models for simulations and 3D environments.

Areas of Opportunities

- Balance Team Leadership: Instead of working alone to maintain high standards, shift to developing skills to mentor teammates and establish team standards.
- Multi-Agent Systems and Advanced AI Concepts: I do not have experience with these topics, which makes this a perfect opportunity to learn something new and interesting.
- Conflict Resolution: Rather than solving problems through rationality alone, try to solve problems by finding a consensus with the team members.

Expectations: I expect that in this block I will learn how to make multiagents and implement them in simulations. I also expect to learn more about AI and how these work. I also expect to create a valuable project that can reflect my abilities as a programmer and 3D modeler.

José Eduardo Nájera:

Strengths:

- Strong Technical Implementation: Having solid programming skills, combined with knowledge of backend and frontend development.
- Team Leadership: Excellent collaborative skills combined with initiative.
- Systemic approach to problem solving: Combining sophisticated project management with good problem solving methodologies.

Areas of Opportunities:

- Multi-Agent Systems Theoretical Foundation: I do not have much experience or knowledge in multiagent systems.
- Technical Mentoring Skills: Leverage team-oriented mindset and problem decomposition skills by mentoring others, helping teammates navigate complex technical challenges.
- Confidence in teammates: Tends to show limited confidence in teammates, which may hinder collaboration and team growth.

Expectations: I expect to learn how multiagent systems work and how they can solve problems together. I want to use AI to make agents act smarter and adapt in different

situations. With Unity and 3D models, I hope to build simulations where these agents can interact realistically.

Juan Manuel Villalobos Nuño:

Strengths:

- Extensive Spring Boot experience: building REST APIs, backend services, and enterprise-grade applications.
- Strong analytical and problem-solving skills with solid foundations in data structures, algorithms, and multiple programming paradigms (OOP, functional, logical).
- Practical experience in web development and databases (Next.js, TypeScript, NextAuth, SQL), with a disciplined and structured approach to learning and problem-solving.

Areas of Opportunities:

- Deepen software engineering best practices: testing, CI/CD, design patterns, and scalable architecture.
- Gain more real-world team experience: collaborative development, Agile workflows, and code reviews.
- Expand knowledge in cloud technologies and system design to complement backend skills and full-stack capabilities.

Expectations: I expect that in this block I will learn more about the uses of AI, how agents work, and learn how to leverage their advantages in my daily life. I also want to learn about model design as well as sharpen my skills in Unity development.

Diego Iván Rodríguez:

Strengths

- Full-Stack Technical Expertise: Proven ability across the full software development lifecycle, with deep knowledge of OOP and experience on high-level projects.

- User-Centered Design Thinking: Strong focus on UX and design-thinking principles, bridging technical development with real-world usability.
- Problem-Solving Leadership: Trusted go-to for complex technical challenges, with a track record of delivering effective solutions and guiding technical decisions.

Areas of Opportunity

- Collaborative Leadership: Shift from "doing it all" to mentoring others; empower your team by sharing standards and knowledge.
- Structured Methodology: Adopt and apply formal frameworks (e.g., Agile, systems thinking) to make your process repeatable and scalable.
- Mentoring & Coaching: Evolve technical excellence into team-building strength by actively developing others' skills and confidence.

I expect from this block to be able to implement and develop multi-agent systems that communicate and work together in order to tackle an obstacle. I also expect to be able to develop and improve the areas of opportunity previously identified.

What we hope to achieve:

- Implement successfully a multi-agent system to solve the challenge utilizing computational models.
- Design a complete and functional agent class and interaction protocol diagrams that represent proper agent relationships.
- Develop at least 60% of the agent code and graphical interface by Review 3.
- Establish and maintain organized collaborative tools.
- Produce clear, consistent, and well-documented evidence, including diagrams and code.

Commitments:

- Collaborate consistently
- Adhere to the work plan
- Leverage individual strengths
- Ensure high-quality documentation
- Reflect and improve after each review.

Description of the challenge

The challenge's objective is to implement multiagents that can control micro aerial vehicles to identify a specific individual within a designated search area.

The multiagents must be able to interpret complex commands, navigate autonomously, and identify targets through computer vision.

The structure of the mission is as follows:

- The multiagents receive a mission in a natural language description and interpret it.
- The MAV takes off, flies, and navigates automatically, following instructions from the multiagents but without human intervention.
- The MAV begins a search pattern, scanning people and analyzing the data that it was given until it finds the individual that fits the description.
- The MAV lands safely in a 2-meter radius from the individual without making contact.

The challenge is considered a success if the MAV can correctly identify the person and land near them automatically.

Identification of agents involved

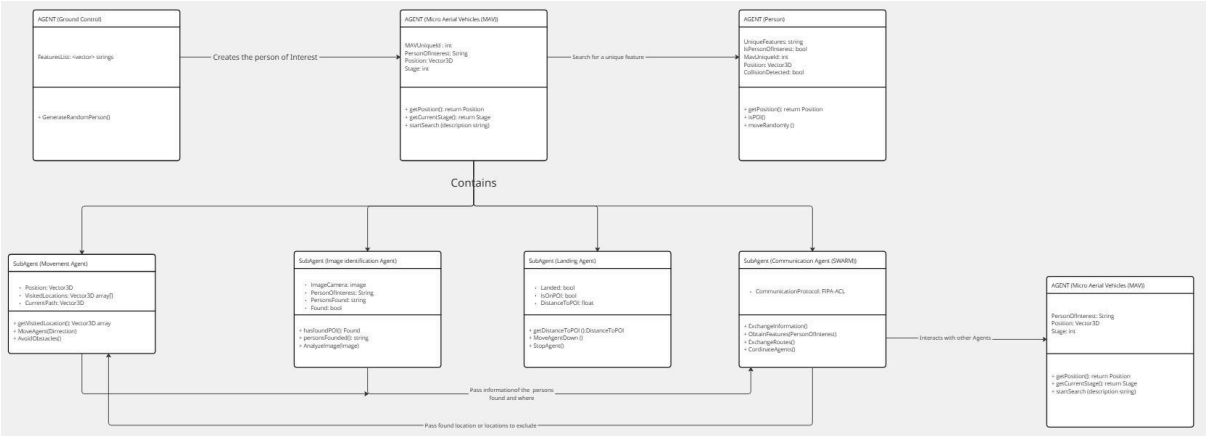
- **Micro Aerial Vehicles** (MAV) (Main Agent)
    - **Image identification Agent (Systems)**
        - This subagent is in charge of processing that data obtained from the cameras of the MAV. Also, it detects distinct persons and the person of interest.
    - **Movement Agent (Systems)**
        - This subagent is in charge of coordinating the different motors of the physical MAV to move the physical agent. At the same time, it is able to determine the better movement path.
    - **Landing Agent (Systems)**

        - This subagent is in charge of making sure the agent lands safely within 2 meters radii of the individual, without making contact.
    - **MAV communication agent (SWARM) (Systems)**
        - This subagent is in charge of handling the communication between different MAV's and within the own agent. Also, this agent should be able to interpret the natural language description of the person of interest.
- **People** (the individuals who are present in the search area)
    - **Person of Interest**
        - **T**his agent is the specific person that the MAV agent is searching for through the MAV SWARM system.
        - In this simulation, this agent will be moving in random directions.

- **Ground Control**
    - This agent is in charge of giving the feature characteristics of the person of interest to each micro aerial vehicle.

Review 2

Agent Class diagram



The change was the elimination of the direct interaction between the Movement and Image Identification Agents, while also the Landing agent with the latter. This will ensure the subagents only communicate through the communication agent.

How MAV's receive an instruction and interpret it

The main strategy for the reception and interpretation of instructions is based on the communication agent. Each MAV will first receive a natural language description of the mission from the Ground Control system. Once the information is received, the communication agent will process the text and translate it into structured commands that can be used by the subagents of the MAV. For example, it will separate navigation tasks (GPS points to search), recognition tasks (features of the person of interest), and coordination tasks (share data with swarm). This way, the MAV will be able to transform a high-level human instruction into a set of low-level autonomous actions.

The MAV receiver will first set the intention (Performative) of the request of the MAV sender, the reason behind this is that the instruction will always start with the performative word such as "warn", "inform", "declarate" or "ask". Followed by the content of the message itself which needs to be as simple as possible giving enough context to being understood. Once the information is received, the agent will process the instruction and answer according to it. The message will be passed as a json.

For the interpretation, the agents will first call the property of Intention in the json, and be prepared to receive an instruction of that type, then, the Content property will be called and the agent will receive the data behind it. And respond in case it is needed. For instance:

```JSON
{
   "Intention": "Ask"
   "Content" : "Current position"
}
```

The receiver MAV will answer as following:

```JSON
{
   "Intention": "Inform"
   "Content" : "[]"
```

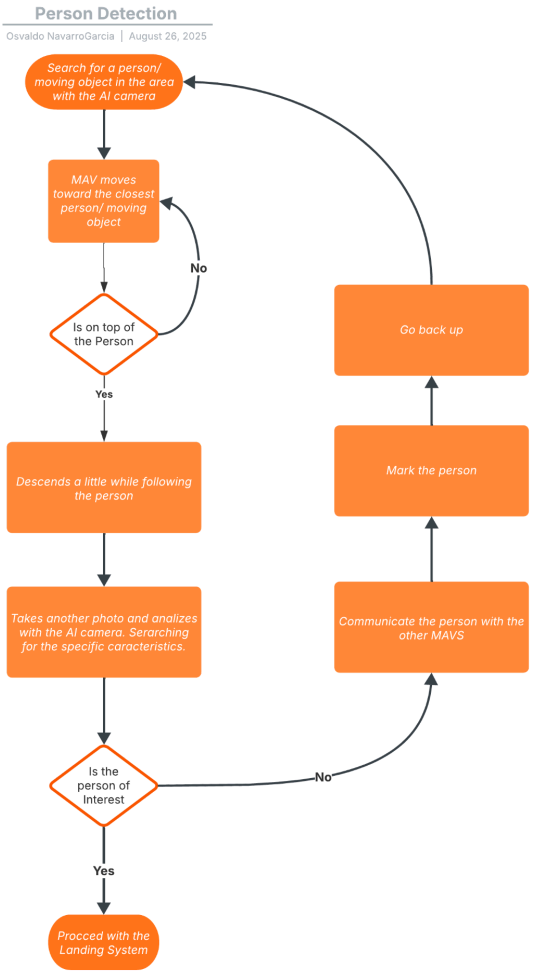
```
}
```

MAV’s strategy to navigate

The navigation strategy will consist of the following. After receiving the instructions and having interpreted them, the MAV will fly towards the coordinates that were indicated, there, it will divide the zone in a grid like area, and will then systematically search each section, finding the person of interest in its way and assuring it maintains an organized structure while flying as it is important that it knows which areas the person is not in while searching the ones it does not know whether the person is in. While they navigate, the MAV will try to be in different areas; however, if they somehow end up searching the same area for the same person, they will communicate with each other to explore different parts of the grid and optimize the searching.

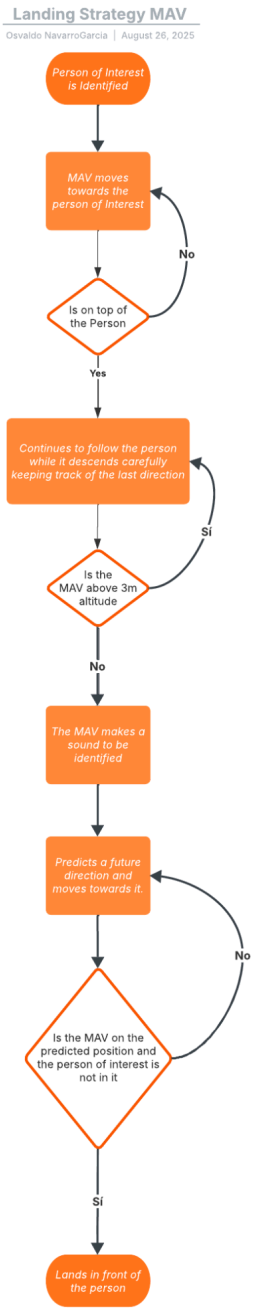
MAV’s main strategy to identify a person

The strategy for the MAV recognition system is to use the AI camera provided by Nuclear Solutions. Assuming this is imperfect, we plan to not only search for the specific characteristics of the person of interest. Instead, it will first search for a person or a moving object in the area. Once this object/person is identified, the MAV will move towards the closest person and descend a little bit to have a better image of the area. This new image will be passed through the AI camera to search now for the specific features searched by each MAV. In case it does not meet the person of interest description, the MAV will mark the target, fly up again to the height, and share the information with the other MAVs. In case it meets the description, it will proceed with the landing system.



MAV's main strategy to land near the person

The main strategy integrated for the landing of the MAVs near the persons of interest is the following. First as it was established before we plan to count with a landing agent (system), this subagent in theory would be in charge of the landing, but as this is a simulation it will be a system the one in charge of the landing. After entering this system with the MAV having identified the person of interest will move towards the person of interest until it is on top. Once it is at the top, it will start to slowly descend until it reaches a height of three meters on top of the person. While it descends, the MAV will be moving towards the person, keeping track of the last movement direction. Once it reaches that height, the MAV will make a signal to the person to stop moving and once it makes the signal, the MAV will move toward the direction of where the person was moving and try to anticipate the position of the person to land right in front of them.

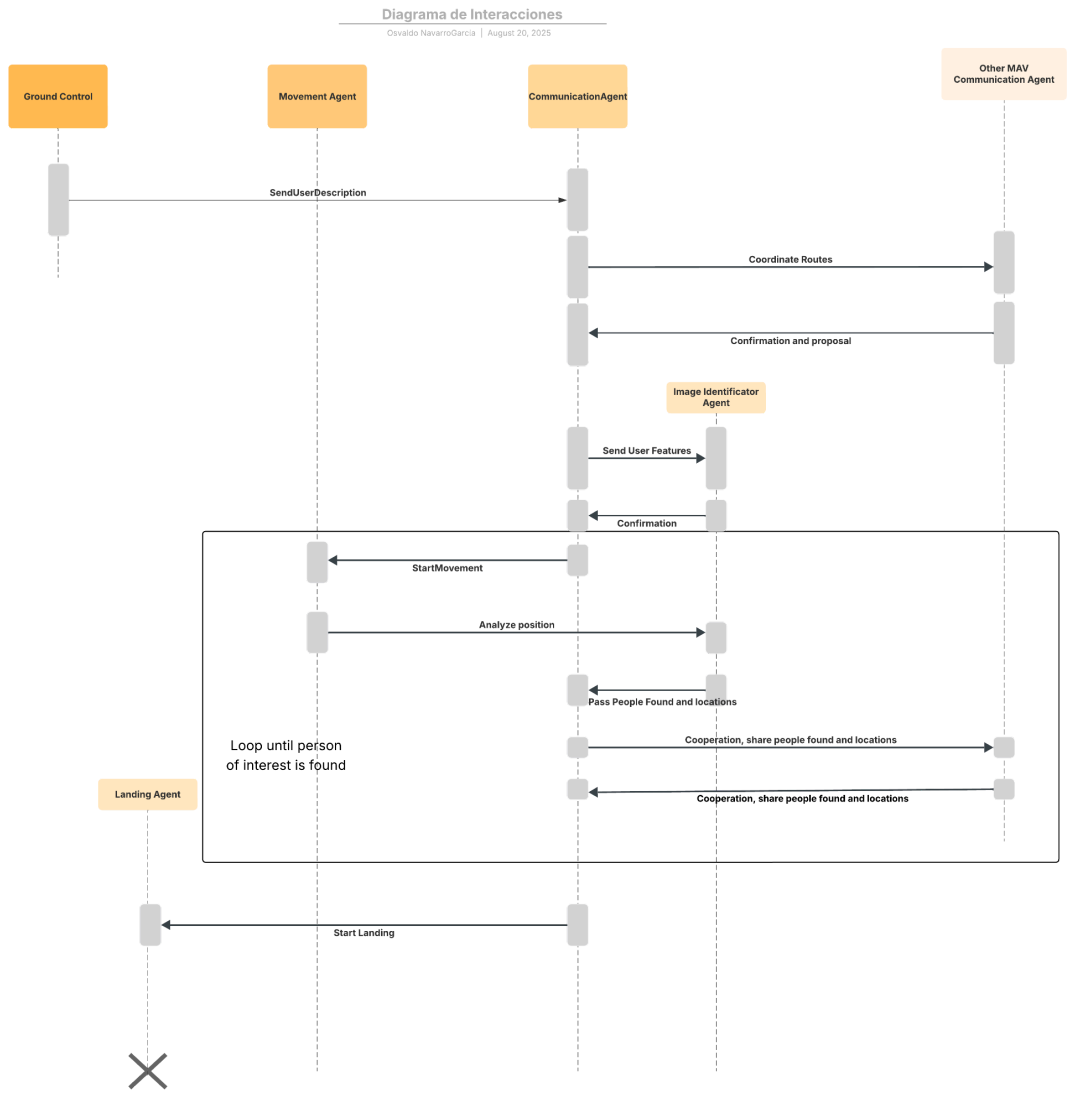


MAV's main strategy to communicate and collaborate

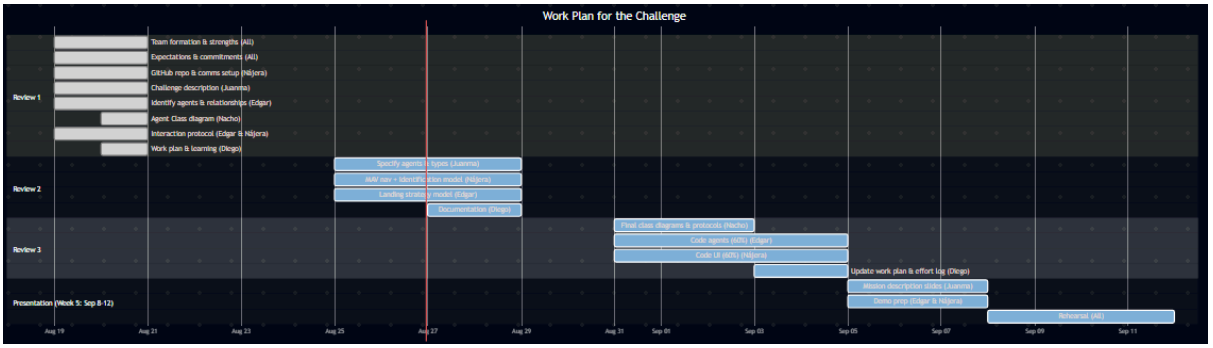
The strategy used to communicate and collaborate between the MAVs is the following. First, as the ground control sends the people's information, the MAVs will communicate with each other and share information about the areas they have already gone to, this will avoid having to visit a single area multiple times. Once an MAV starts with the recognition process and identifies the people in that space, the MAV, through the communication agent (SWARM),

will pass the information of the location of each person in the area and if they have been identified or not. Once an MAV sets its target with one person and identifies the person, then the MAV shares this person's characteristics with the other MAVs and the rough position of it in case there exists an MAV who is searching for the person. In case there exists a person of interest for one MAV and this is located by another MAV, then the MAV who is searching for that person will request the founder MAV to follow the person until the interested MAV reaches a close location. In other words, the MAVs collaborate with each other by sharing information about the persons and locations identified.

Agent Interaction protocol diagram



Work plan



The full diagram can be found on the following link: https://shorturl.at/cSa6N.

Link for UML diagrams is the following:

UML Class Diagram:

https://miro.com/welcomeonboard/eDI1YWV4YWI4UXcxWFpLd1BocUw5Ymd4VFpucHpvRElvZFdOSUcxVzE1eXp5QVNIWUc3dHJpNDg0dVJ1blBhQUoxb2ZFRFZuVDdnVnhBL1RsOEl6Sm1wVlRvQ3NQc2tZa1REWkNWN2FzNXVPM2FjRnpGTVNzTWFvVlNQbzIrOGxBS2NFMDFkcUNFSnM0d3FEN050ekl3PT0hdjE=?share_link_id=570803199089

Agent Interaction Protocol Diagram

https://lucid.app/lucidchart/7a82582f-6146-4e67-9c8f-810c9bf44765/edit?viewport_loc=-2088%2C-591%2C4199%2C1957%2C0_0&invitationId=inv_1f9c3e1f-3832-479b-9c49-16e681b0a959

Diagrams of Sequence

https://lucid.app/lucidchart/4cb11f9c-b91f-4162-ae7e-aeadb293eaf9/edit?viewport_loc=-2952%2C-653%2C4201%2C1958%2C0_0&invitationId=inv_877038b6-c09d-4478-821e-987606d3691b