DRONE SIMULATION

UNIVERSITÉ DE TECHNOLOGIE DE BELFORT-MONTBÉLIARD

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CONTENT

CONTENT 3
1. General Presentation 4

1.1. General Description of the Application 4

1.2. Expected Measurements 4

2. Detailled Description 5

2.1. Environment Description 5

2.1.1. Environment Content 5
2.1.2. Environment Dynamics 5

2.2. Intelligent Entities 5

2.2.1. Agent Type 1: Drone agent 5
2.2.2. Agent Type 2: Control station 6
3. Technological Environment 6
4. User Interface 6
5. Work Packages 7

5.1. What is a Work-PACKAGE? ..... **Erreur ! Signet non défini.**

5.1. Work Package 1: Environment 7

5.1.1. Description 7
5.1.2. Inputs 7
5.1.3. Outputs / Deliverables 7

5.2. Work Package 2: DRONE AGENT 7

5.2.1. Description 7
5.2.3. Outputs / Deliverables 8

5.3. Work Package 3: Control station agent 8

5.3.1. Description 8
5.3.2. Inputs 8
5.3.3. Outputs / Deliverables 8

5.4. Work Package 4: User Interface 8

5.4.1. Description 8
5.4.2. Inputs 8
5.4.3. Outputs / Deliverables 8

5.5. Work Package 5: Integration 8

5.5.1. Description 8
5.5.2. Inputs ..... **Erreur ! Signet non défini.**
5.5.3. Outputs / Deliverables 9
6. Risk Assessments 9
A1. Reports for the Sprint Meetings 11

A1.1. Sprint Meeting #1 12
A1.1.1. List of tasks for the current sprint 12
A1.1.2. General Comments 12
A1.2. Sprint Meeting #2 12
A1.2.1 Status of the tasks of the Finished Sprint 12
A1.2.2. List of tasks for the current sprint 13
A1.2.2. General Comments 13
A1.2. Sprint Meeting #3 13
A1.3.1 Status of the tasks of the Finished Sprint 13
A1.3.2. List of tasks for the current sprint 13
A1.3.2. General Comments 14

1. GENERAL PRESENTATION

1.1. GENERAL DESCRIPTION OF THE APPLICATION

The goal of our application is to develop a multi-agent environment for simulating the motion of autonomous drones in the air.

Indeed, we will need to generate several drones which will generate their own path from their starting location to their destination and will then follow it while avoiding obstacles and other agents on the way.

Eventually, we would also like to add the ability for the drones to manage their battery level, meaning they should be able to choose their delivery based on their remaining battery level while ensuring they will be capable to achieve the travel back to the recharge station.

1.2. EXPECTED MEASUREMENTS

The goal of the simulation is to measure the ability of the drones to travel to a defined location autonomously while avoiding each other. Some good measurements could be:

- Measure 1: Time
    - Measure the time it takes for a drone to go from its base location to its desired location and the travel back.
    - It is interesting to analyze this data because time is such an important factor with drones due to their limited autonomy. We could also compare the computed estimated delivery duration with the real delivery times of the drones on the field affected by factors such as obstacle avoidance, wind force and other agents.

- Measure 2: Collision
    - Measure the number of times drones have collided, or at least the number of drones who needed to avoid another one.

    - Another interesting data is the collisions between drones. Our goal is to make agents autonomous while ensuring they do not conflict with one another. We need to be able to quantify this behavior to know the number of times they needed to avoid each other and the number of collisions still happening.

- Measure 3: Battery
    - If we can add battery management to the drone agents, another good measurement would be the battery capacity of the drones remaining after their delivery is achieved.
    - With batteries being so important with drones, being able to measure their ability to complete deliveries while managing their battery level and ensuring they can go back to recharge even with the different delays during the flight is a very important measurement.

2. DETAILLED DESCRIPTION

2.1. ENVIRONMENT DESCRIPTION

2.1.1. ENVIRONMENT CONTENT

The environment will be a 3D environment generated with Unreal Engine. It will be a map of a city with roads and different type of obstacles such as buildings modelized with rectangular shape or also trees. There will also be a control station where drones will get their packages and lift-off.

2.1.2. ENVIRONMENT DYNAMICS

The different dynamics in our environment that will influence our agents are the gravity, but also the wind force to simulate a more real drone behavior.

2.2. INTELLIGENT ENTITIES

2.2.1. AGENT TYPE 1: DRONE AGENT

2.2.1.1. EXPECTED BEHAVIOR

The drone agent will get its package and delivery data from the control station. It must then deliver it autonomously to the customer's house by selecting an optimal path and while avoiding collisions with other drones and obstacles such as buildings.

2.2.1.2. KEY PROPERTIES

- Take off management

- Flight control

- Path finding

- Obstacles avoidance

- Environment adaptability (wind, …)

2.2.1.3. INTERACTION WITH OTHER AGENT TYPES

The drones must avoid other drones in the air.

They receive order and pick up the delivery package from the control station.

When the drones are not in flight, they charge and dock on the control station.

2.2.1.4. INTERACTION WITH ENVIRONMENT OBJECTS

Perception of the environment to detect the surface of obstacles such as buildings to avoid them. Adapt the throttle to the wind force.

2.2.2. AGENT TYPE 2: CONTROL STATION

2.2.2.1. EXPECTED BEHAVIOR

The control station agent must assign deliveries to the drones according to their current battery level. This is also the place where drones go back to get their package and recharge.

2.2.2.2. KEY PROPERTIES

- Generate shipping data

2.2.2.3. INTERACTION WITH OTHER AGENT TYPES

Assign deliveries and packages to the drones

Manage the drones' battery level

Recharge and dock the drones

2.2.2.4. INTERACTION WITH ENVIRONMENT OBJECTS

None

3. TECHNOLOGICAL ENVIRONMENT

For the agent-oriented language we decided to use SARL as we do not have prior knowledge in the subject, and it perfectly fits our needs.

We will also run the drone simulation in a 3D environment, and we decided to use Unreal Engine with its plugin AirSim as it is the go-to for research in the field and it will help us kickstart and focus on the agent programming.

4. USER INTERFACE

The user will have in interface to start the simulation. Through it, he should be able to set up the number of drones/deliveries it will simulate, to manage the wind force, … He should also have buttons to choose what is displayed on screen, such as: a top view camera, a camera focused on a specific or a free camera.

5. WORK PACKAGES

5.1. WORK PACKAGE 1: ENVIRONMENT

5.1.1. DESCRIPTION

This work package will be dedicated to design the environment in which the simulation will take place.

List the tasks:

- T1.1: Design the buildings/roads/obstacles
- T1.2: Add the gravity settings
- T1.3: Implement a windy weather (turned on/off)

5.1.2. INPUTS

The settings that user will define on the start menu. The map size.

5.1.3. OUTPUTS / DELIVERABLES

The generation of the 3D environment + the 2D map.

5.2. WORK PACKAGE 2: DRONE AGENT

5.2.1. DESCRIPTION

The drone agent is the main agent of the project, it is supposed to design/generate the drone and implements all its features.

List the tasks:

- T2.1: Set up the take-off parameters
- T2.2: Implement the drone's flight management (movements controls)
- T2.3: Path finding algorithm
- T2.4: Obstacles avoidance (sensors data analyzing)
- T2.5: Environment adaptability

5.2.2. INPUTS

The drone's agent should get access to the 2D environment's map to determine an itinerary and get several sensors to adapt to not predictable events.

5.2.3. OUTPUTS / DELIVERABLES

The updated deliveries list and the measured data file.

5.3. WORK PACKAGE 3: CONTROL STATION AGENT

5.3.1. DESCRIPTION

The control station should assign the deliveries to the docked drones.

List the tasks:

- T3.1: Assign deliveries (location + package) to drones
- T3.2: Manage battery capacity of the drones

5.3.2. INPUTS

The list of the drones that are docked to it

5.3.3. OUTPUTS / DELIVERABLES

The delivery locations for the drones

5.4. WORK PACKAGE 4: USER INTERFACE

5.4.1. DESCRIPTION

Design the user interface for our simulation

List the tasks:

- T4.1: Design the interface to launch the simulation and choose its settings
- T4.2: Design the interface to select the camera view

5.4.2. INPUTS

Unreal engine User Interface tutorials

5.4.3. OUTPUTS / DELIVERABLES

Code for User Interface

5.5. WORK PACKAGE 5: INTEGRATION

5.5.1. DESCRIPTION

The purpose of this work package is to link the features of the agent programming language SARL with the simulation environment AirSim

List the tasks:

- T5.1: Link SARL Agents to AirSim simulation
- T5.2: How the Unreal 3D environment is perceived by the Agents in SARL

5.5.2. INPUT

SARL to AirSim interface code on GitHub

5.5.3. OUTPUTS / DELIVERABLES

Working simulation

6. RISK ASSESSMENTS

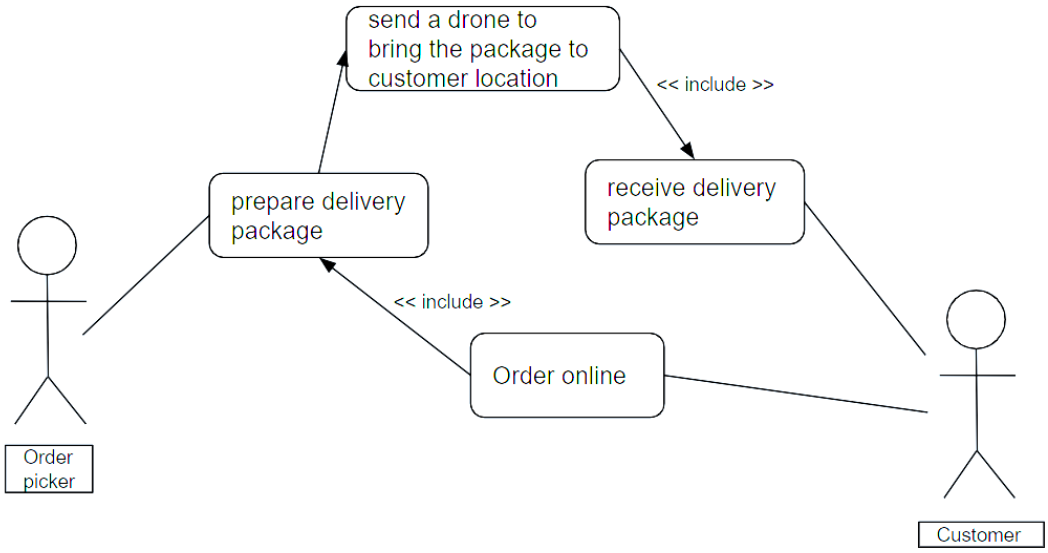
Description of the risks that you could see and they may avoid you to finish your project.

Risk may be of different types :

- **Management :** related to the project management
  - Example 1: one member of the group leaves the group.
  - Example 2 : conflict between members on decisions.
- **Methodology :** related to the application of the agile methodology
  - Example 1: one member of the group does not deliver the outcomes on time.
  - Example 2: difficulties to determine the tasks of the next sprint.
- **Technological:** related to one of the technologies you have selected
  - Example 1: the selected technology cannot run enough agents under real-time constraint.
  - Example 2: the technology cannot be used for implementing a specific feature.

ID	Type	Description	Mitigation
R1	Technological	AirSim simulator has a number of drones limited	…
R2	Technological	Difficulties to use AirSim simulator with SARL	…
R3	Methodology	Schedule risk: an activity may take longer than expected	Take a margin

ANNEXES



Use case diagram

A1. REPORTS FOR THE SPRINT MEETINGS

A1.1. SPRINT MEETING #1

Date: 01/04/2021

A1.1.1. LIST OF TASKS FOR THE CURRENT SPRINT

ID	Problem or Task Description	Possible Solution	Assigned to	Validation by (if applicable)
S1.1	How to link SARL and AirSim?	Use the SARL to Airsim interface plugin	Malek	All
S1.2	How the SARL Agents will perceive the AirSim 3D environment ?	Start to implement the environment in SARL	Enzo	All
S1.3	How to implement the drone's take-off?	Start the agent programmation	Théo	All

A1.1.2. GENERAL COMMENTS

We discussed about the environment we wanted to generate, the goal we are aiming and the features we wanted to implement.

A1.2. SPRINT MEETING #2

Date : XX/XX/20XX

A1.2.1 STATUS OF THE TASKS OF THE FINISHED SPRINT

ID	Validated
S1.1	Yes/No

S1.2	Yes/No

A1.2.2. LIST OF TASKS FOR THE CURRENT SPRINT

ID	Problem or Task Description	Possible Solution	Assigned to	Validation by (if applicable)
S2.1	Design of ….	n/a	X	Y
S2.2	Implementation of…	n/a	Z	X

A1.2.2. GENERAL COMMENTS

Write here some general comments that are discussed during the sprint meeting.

A1.2. SPRINT MEETING #3

Date : XX/XX/20XX

A1.3.1 STATUS OF THE TASKS OF THE FINISHED SPRINT

ID	Validated
S2.1	Yes/No
S2.2	Yes/No

A1.3.2. LIST OF TASKS FOR THE CURRENT SPRINT

ID	Problem or Task	Possible	Assigned to	Validation by (if

	Description	Solution		applicable)
S3.1	Design of ….	n/a	X	Y
S3.2	Implementation of…	n/a	Z	X

A1.3.2. GENERAL COMMENTS

Write here some general comments that are discussed during the sprint meeting.