# Laboratory assignment

**Component** 4

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## 1 Problem definition

Design and implement a multi-agent system where autonomous agents impersonating players participate in a competitive team-based game on a 2D map. Each player can move, sense the environment, and shoot opponents. The game continues until only one team remains. The MAS should simulate realistic agent behaviors such as decision-making, cooperation (within teams), and adversarial interactions (between teams). The goal is to create agents that can work together tactically to survive and eliminate the opposing team(s). Each agent aims to optimize its performance through reinforcement learning techniques, adapting its strategy based on interactions with the environment and other agents. The agents are expected to make decisions such as movement and shooting to maximize their cumulative rewards over time.

## 2 High-level MAS specification

### 2.1 The MAS system

The MAS is provided the game state, consisting of map data and initial agents' states.

Map data is a bounded grid-based representation of an environment containing free zones (that players can step on) and obstacle areas. The agent starts with an initial position, health and team affiliation. Additionally, parameters that control game mechanics are included: movement speed, shooting range, damage, field of view.

The MAS outputs real-time agent actions obtained as a result of agents decisions. Such actions include movement commands (direction and speed), shooting a target.

### 2.2 Types of agents

- The agents interacting in the MAS are shooting agents. They are autonomous entities capable of navigating the environment and engaging in combat with other agents. The agents are distinguished by their decision backend. They can be dummies (agents taking random decision), heuristic (agents that take simple logical decisions) and learning agents (those who are subject to Reinforcement Learning). These agents takes as input a partial observation from the state.

- Also, there is a special agent, the Moderator, which will notify any agent that has a teammate which observed an enemy with the direction of that enemy relative to the agent that receives the message. This agent can also notify randomly the shooting players about the position of some enemy.

### 2.3 Agents specifications

Based on its position and direction, a shooting agent takes perception from its local environment around it based on a ray shooting vision system. Rays are casted from its position covering its visual range, keeping recordings of the distance between the player position and the intersection between a ray and an object (border, obstacle, team mate or enemy).

The agent outputs an action from the following:

- Move forward in the current direction by a number of units or until hit an obstacle
- Rotate left or right by a number of degrees
- Shoot (this action spawns a projectile that lives until it hits something and is handled by the simulator - agents don't have perception of the projectiles)
- Idle (wait until it it time to perform an action)

The task of an agent is to help its team win the game by eliminating all the enemies.

The Moderator agent will perceive as input from the state each agent's position and all the rays and, if an agent observes an enemy, it will notify all its teammates the direction of an enemy. This agent's action doesn't directly impact the game state, its role is only to notify the shooting agents on some information about the state. Its role is to inform agents about the enemy agents in order to prevent the game from stalling.

### 2.4 Communication system

Agents that are part of the same team communicate using a blackboard architecture, which is a shared, centralized memory used by agents with read/write access, enabling coordination and communication without direct message passing. It acts as a common workspace where teammates post information that may be relevant to others.

Only the Moderator agent will introduce information in the blackboard, namely it will send messages intended for players to get information about enemies position. The agents that will read from the blackboard are the Shooting Agent.