भारतीय प्रौद्योगिकी संस्थान भिलाई

Indian Institute of Technology Bhilai

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Artificial Intelligence Project Report

Drone System for Weed Elimination

Indian Institute of Technology, Bhilai

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Introduction:

To make a Drone Game to address real-world agriculture and environmental management challenges. The scenario simulates an environment where **drones eliminate weeds within a cultivated field.** The practical implications of this problem statement extend to the agricultural sector, where weed control is a critical aspect of ensuring crop health and maximizing yield.

Weeds pose a significant threat to crop growth and yield in agricultural settings. Uncontrolled weed growth competes with crops for water, sunlight, and nutrients, reducing agricultural productivity.

The project leverages drone technology to address the weed control challenge in agriculture. Drones equipped with **liquid-spraying mechanisms** simulate a scenario where aerial devices can eliminate weeds. This reflects the ongoing advancements in agriculture, where technology is harnessed to enhance the efficiency and sustainability of farming practices.

We first tried the multi-agent game for this problem statement and then the single-agent because of less computing power.

The multi-agent system incorporates rewards for successful weed elimination, strategic battery management, and efficient use of charging points. Collisions between drones result in significant penalties, leading to game termination. The project explores discrete movement actions, spray actions for weed elimination, and charge actions for battery recharge in the drone's action space.

Game Components:

Grid (Field):

- The playing area consists of a grid with dimensions of 600 by 600 units, representing the field where weeds are distributed. The placement of weeds varies for each game session.

Drones:

- Six drones equipped with liquid-spraying mechanisms are deployed for weed elimination. Each drone has a limited battery life, and its functionality ceases if it is fully depleted. Players must strategise drone movements to eliminate weeds while avoiding battery exhaustion efficiently.

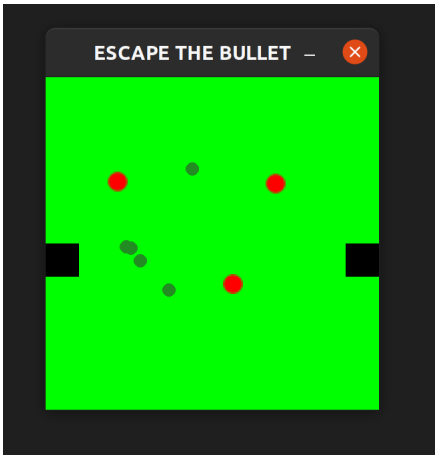
Weeds:

- Weeds are scattered across the grid, with six weeds at any time. The primary objective of the drones is to navigate the grid and eliminate these weeds.

Charging Points:

- Three charging points are strategically placed on the grid, allowing drones to recharge their batteries. Efficient use of charging points is essential for prolonged gameplay.

Game Rules:



Weed Elimination:

- Drones must navigate the grid, identify weeds, and spray liquid to eliminate them.
- Each successfully eliminated weed contributes to the player's score.

Battery Management:

- Drones have limited battery life, depleting with movement.
- Players must plan strategic movements and utilise charging points to prevent battery depletion.

Collision Detection:

- Collisions between drones lead to the termination of the game.
- Players must carefully plan drone movements to avoid collisions.

Game Over Conditions:

- The game concludes when the battery of any drone fully depletes or if two drones collide.
- Players earn points for each successfully eliminated weed.

Environment for the Multi-agent:

Rewards:

- Weed Elimination Reward: Positive reward for successfully eliminating a weed.
- Battery Management Reward: Positive reward for moving towards the charging point with a battery level below 20%.
- Charging Point Utilisation Reward: Positive reward for effectively using charging points.
- Collision Penalty: Significant negative reward for drone collisions, leading to game termination.

Movement (Action Space):

- Discrete Movement: Agents can move in different directions on the grid (north, south, east, west) or stay in the same position.
- Spray Action: Agents can eliminate weeds at their location, consuming a small battery (5%).
- Charge Action: Agents can move towards charging points to recharge batteries, which is crucial for long-term survival.

Observation Space:

- Drone Position: Each drone's current position (coordinates) is on the grid.
- Battery Level: The remaining battery level of each drone.

- Weed Distribution: Current distribution of weeds on the grid.
- Charging Point Location: Position of the charging points.

Termination:

The game terminates under specific conditions:

- Battery depletion for any drone.
- Collision between two drones.
- Successful elimination of all 50 weeds without collisions and sufficient remaining battery resulted in a completion reward for agents.

SINGLE AGENT

Game Components:

Grid (Field):

- The playing area is a grid representing the field where weeds are distributed.
- The grid dimensions and weed distribution are fixed for each game session.

Drone:

- A single autonomous drone is available for weed elimination.
- The drone is equipped with a liquid-spraying mechanism for weed annihilation.
- The drone starts with a fully charged battery.

Weeds:

- There are a total of 50 weeds scattered across the grid.
- At any given time, five weeds are present on the grid.

Charging Points:

- One charging point is available for the drone to recharge, and it is located at the centre of the grid.
- The player must strategically plan drone movements to utilise the charging point effectively in such a way that in the process of killing weeds, it should not drain its battery completely.

Game Rules:

Weed Elimination:

- The player must navigate the drone to locate and spray liquid on weeds for elimination.
- Each successfully eliminated weed contributes to the player's score.

Battery Management:

- The drone has a fully charged battery at the start.
- A 5% battery discharge occurs after successfully eliminating each weed.
- If the battery depletes entirely, the game ends.

Charging:

- The player can navigate the drone to the charging point to recharge its battery.
- Charging is necessary to prevent the drone's battery from reaching zero.

Game Over Conditions:

- The game ends when the drone's battery fully depletes.
- The number of eliminated weeds determines the score

Environment for the Single-agent:

Rewards:

- Destroying a Weed: Reward: +100 points for each weed destroyed.
- Moving Towards a Weed with Battery > 50%: If the battery charge is above 50% and the drone moves towards a weed, (i.e.,the distance between the new position after taking a step and the weed decreases when compared to the previous position) positive reward of 2 points is given.
- Battery Level Below 30%: If the battery charge drops below 30% and the drone is moving towards charging point, a positive reward of 10 points is given.
- Battery discharge to 0%: Significant penalty of -300 points.
- In between 30% and 50% of battery, the drone learns to do what's best whether to kill a weed or to charge the battery depending on the circumstances.

Movement (Action Space):

- Discrete Movement: Agents can move in different directions on the grid (north, south, east, west) or stay in the same position.
- Spray Action: Agents can eliminate weeds at their location, consuming a small battery (5%).
- Charge Action: Agents can move towards charging points to recharge batteries, which is crucial for long-term survival.

Observation Space:

- Drone Position: current position (coordinates)of the drone is on the grid.
- Battery Level: The remaining battery level of each drone.
- Weed Distribution: Current distribution of weeds on the grid.
- Charging Point Location: Position of the charging points.

Termination:

The game terminates under specific conditions:

- Complete Battery depletion of the drone.
- Else it continues as there are infinite weeds.

Training for the Single Agent:

Stable Baselines:

Known for its simplicity and modularity, Stable Baselines is a Python package that offers well-implemented reinforcement learning algorithms including A2C and PPO.

Advantage Actor-Critic or A2C:

It is an on-policy reinforcement learning algorithm that enhances learning stability and efficiency by combining advantage functions with actor-critic techniques.

Proximal Policy Optimisation, or PPO:

It is an on-policy reinforcement learning technique that ensures stability and effectiveness during training by preventing significant policy alterations.

Iterations and Episodes:

The number of iterations in training refers to how many times the learning algorithm updates based on experiences, while episodes denote the number of simulations the agent performs within the environment during training, impacting learning progress and convergence.

A LOT OF TWEAKS ARE CHANGED WITH EXPERIENCE AND WE CAME OUT WITH DIFFERENT ENVIRONMENTS WILL BE DISCUSSED IN PPT.