Quantum Hack 2025. Quantum Simulation of Battlefield Scenarios

Introduction

Simulating battlefield scenarios is a critical challenge in optimizing strategic decision-making. In these contexts, the ability to predict and adapt to multiple variables—such as positions, movements, attack ranges, and interactions between units—is essential to ensure mission success. However, classical simulation methods, which often rely on heuristic approximations, face significant limitations. These approximations may overlook key possibilities, leading to risky decisions or even unfavorable outcomes.

Nevertheless, quantum computing emerges as a promising alternative. Its ability to explore complex combinatorial spaces through superposition, entanglement, and interference enables the evaluation of multiple scenarios simultaneously, potentially accelerating strategy optimization in dynamic environments. This advantage is especially relevant in combat scenarios, where unit interactions and environmental uncertainty demand efficient evaluation of all possibilities.

The challenge proposed in this hackathon seeks to explore how quantum techniques can be applied to simulate and optimize unit behavior in a simplified combat scenario. Participants must design quantum algorithms that model the interaction between two rival teams—the Quantum Team and the Classical Team—and assess their effectiveness compared to traditional methods.

Challenge Definition

The combat scenario is defined on a **two-dimensional grid** where two teams compete to defeat each other. Each team has units with specific characteristics:

- **Soldiers:** High endurance, medium strenght and short range.
- **Archers:** Low endurance, medium strength and long range.
- **Knights:** Medium endurance, high strenght and short range.

The game is played in alternating turns following a structure of movement and combat phases:

- **Movement phase:** Each team moves its units according to predefined rules. In this phase, the teams differ in how their movements are calculated.
- **Combat phase:** Interactions between units on the grid are resolved.
- **Turn switch:** Control passes to the opposing team.

The team that eliminates all enemy units or reaches the turn limit with the larger number of remaining units is declared the winner.

The **Classical Team** uses a **random-walk-based strategy** to move its units, while the **Quantum Team** must implement a quantum model to make optimal decisions. This contrast between classical and quantum approaches is the core of the challenge: can quantum computing outperform traditional methods in the simulation of complex scenarios?

Challenge Objectives:

The main objective is to demonstrate that quantum computing can offer significant advantages in simulating combat scenarios, enabling the identification of optimal strategies more efficiently than classical approaches.

Participants must:

1. **Simulate unit behavior** using quantum techniques, exploring possible evolutions of the scenario.

2. **Determine optimal movements** for each Quantum Team unit, expressed as (x, y) coordinates.

3. **Ensure that the Quantum Team wins in most of the simulated scenarios.**

The challenge will be evaluated across four initial grid configurations:

1. **Frontal positions:** Both teams face each other directly.

2. **Encirclement:** One team surrounds the other.

3. **Reverse encirclement:** The surrounded team initiates the action.

4. **Irregular distribution:** Units are scattered with no predefined patterns.

Example Simulation Flow

Step 0: Preparation

Units (type and number) for each team will be defined, as well as their arrangement on the grid (of appropriate size). Units of the same team may occupy the same cell.

Step 1: Quantum Team Turn

Movement for each unit is determined using quantum techniques. The use of Quantum Random Walks, the Quantum Approximate Optimization Algorithm, mappings to quantum systems, or QML techniques is recommended. Once the circuits are measured, the agents' positions will be updated based on the most probable outcome. Then the attack phase begins.

During the attack phase: Check range requirements for enemy units and execute attacks. Update the Classical Team's health values. Units with health below 0 are removed for subsequent turns.

Step 1.2: Victory Condition Check

The Quantum Team wins if, after Step 2, the Classical Team has no remaining units on the battlefield. Otherwise, proceed to Step 3.

Step 2: Classical Team Turn

The Classical Team moves its units using a Random Walk technique. Once each agent has moved, the attack phase begins, during which range requirements are checked and the Quantum Team's health values are updated. Units with health below 0 are removed for subsequent turns. You will have access to the code implementing this on GitHub.

Step 2.1: Victory Condition Check

The Classical Team wins if, after Step 2, the Quantum Team has no remaining units on the battlefield. Otherwise, proceed to Step 4.

Step 3: Turn Reset

If the maximum number of turns has been exceeded, the simulation stops and the team with the most units remaining on the battlefield wins. Otherwise, return to Step 1.