**CS 5150 Game AI Project Proposal**

**Team Name:** ZK-Team

**Members of team:**

* **Jialin Gao:** project manager
* **Yiren Ding:** development engineer
* **Tianhao Fang:** development engineer
* **Shubhi Mittal:** development engineer
* **Title of Project:** Zombie Killer

**Overview of Project:**

After doing researches, our group finds a good game coding platform for competition which is given in Tools section below. Among all games on that platform, we choose to use “Code-VS-Zombies” as our project base. There is only one agent who has a powerful weapon in this game. He needs to protect humans from being killed and kill all zombies around in a closed map. Since it is an online competition, we cannot know the internal codes for the movement of zombies. So in our project, we will be using game AI techniques learned in class and other techniques via doing researches to make the only agent accomplish his goal. In addition, we will try to figure out which kind of movement of the agent can maximize the score the agent can earn (the agent can earn higher scores by killing multiple zombies in succession, and the lost of human will reduce score dramatically). Fortunately, that platform provides enough test cases for us to test our codes. Furthermore, if the time permits, we will come up with the second idea and make comparison between two solutions.

**Rule Detail**

The game is played in a zone 16000 units wide by 9000 units high. You control a man named Ash, wielding a gun that lets him kill any zombie within a certain range around him.

Ash works as follows:

1. Ash can be told to move to any point within the game zone by outputting a coordinate X Y. The top-left point is 0 0.
2. Each turn, Ash will move exactly 1000 units towards the target coordinate, or onto the target coordinates if he is less than 1000 units away.
3. If at the end of a turn, a zombie is within 2000 units of Ash, he will shoot that zombie and destroy it. More details on combat further down.
4. Ash could only see the surroundings (zombies, other people) within 3000 units

Other humans will be present in the game zone, but will not move. If zombies kill all of them, you lose the game and score 0 points for the current test case.

Zombies are placed around the game zone at the start of the game, they must be destroyed to earn points.

Zombies work as follows:

1. Each turn, every zombie will target the closest human, including Ash, and step 400 units towards them. If the zombie is less than 400 units away, the human is killed and the zombie moves onto their coordinate.
2. Two zombies may occupy the same coordinate.

The order in which actions happens in between two rounds is:

* Zombies move towards their targets.
* Ash moves towards his target.
* Any zombie within a 2000 unit range around Ash is destroyed.
* Zombies eat any human they share coordinates with.

Killing zombies earns points. The number of points you get per zombie is subject to a few factors.

Scoring works as follows:

* A zombie is worth the number of humans still alive squared x10, not including Ash.
* If several zombies are destroyed during on the same round, the nth zombie killed worth is multiplied by the (n+2) th number of the [Fibonacci sequence](https://wikipedia.org/wiki/Fibonacci_number) (1, 2, 3, 5, 8, and so on). As a consequence, you should kill the maximum amount of zombies during a same turn.

**Previous Research:**

Because this is a brand new open and online competition, the previous research is quite limited. But we still get some strategies from other competitor.

The easiest approach is to use random move. It is the easiest way to implement an AI, but having few chance to pass simplest test case. A better approach lots people use is to let the agent petrol around human to protect them. This approach could let agent go through many test cases, but the score is relatively low. On opposite, some people use score oriented strategy. They only design their AI to get highest score. However, there are high possibility it cannot pass many test cases. A more advanced approach on discuss board is to calculate the centroid of upcoming zombies and let agent go to that point to intercept lots of zombies at single turn.

Many high level competitors provide possible ideas to reach highest score. Such as genetic algorithm, the guy who use genetic algorithm is at rank 38th world wide with score 100000. That could be 8th in North America area, and that is our goal to reach.

In addition to strategies used in this competition, we also do researches on previous results. By looking the rank of all competitors, we find that python is one of most used languages to solve this problem. Furthermore, the current winner of this competition used Python, and there are good numbers of competitor who use Python are ranked in top 50. That is the reason why we chose Python as our programming language.

**Draft of the Idea:**

After our discussion, our group thinks that we can apply Decision tree, as well as Centroid and Maximin algorithm on our project. We divide our project into 2+1 stages.

In first stage, our primary goal will be go through all test cases, regardless how many score we can get. Decision Tree is commonly used to identify a better strategy to reach the goal. Centroid will be helpful for us to determine how to protect humans and kill zombies in succession in the meanwhile. We plan to use predefined decision tree in our first step, since it could be easy and fast to test all of our ideas. We will design strategy and movement for possible situation. So we assume in stage 1 we can reach victory result after running all test cases. Compare to assignment 3, in this game, the agent have more complex task and will encounter more tricky situation than agent in pacman. We did a research on test cases they provide, they have comprehensive strategies to test our algorithm. For example, they have different test cases for different number of overall zombies, zombies comes from all different direction, human that we need to protect stay together or separated in several clusters. So the pattern of zombies are much more complex and has more combination than ghost in Pacman.

In second stage, we will focus on improve our scores. Go through all levels doesn't mean you can reach the best score. Since if the agent are able to kill lots of zombies in one turn, it will gain a lot of score at once(see game rules). This will be our major challenge in this project. We want to try simply add more situation in our fixed decision tree first. Add extra parameter that record potential zombie threat. If the risk is relatively low, the agent will keep zombies alive and try to kill them at one turn to gain more score.

Then we will transform our predefined decision tree to a trained decision tree. We will use supervised learning to train our decision tree. The feature of game that can be used for our tree node will be the distance between zombie and its closest human, the position of agent and the human in most danger, time remained, which zombies are in a cluster, and so on.

Our potential training data set will be the data from hard coded decision tree and human player. The algorithm we can select is ID3 or C4.5 to generate our decision tree. We will compare the performance difference between our trained decision tree and hardcode decision tree.

In third stage, we want to design a new AI by using Maximin algorithm. Maximin algorithm is applied on tree search for next movement based on forecast further possible movements. It can help reduce branches in each level of tree search. The whole process contains two aspects. First, we want to use a learning algorithm such as Q-learning to train our AI and make it able to recognize the pattern of zombies in each level. Second, we would like to build a search tree that have nodes represent for every movement in the future and an associated value generated by calculating the winning probability of next several moves. The agent can perform optimal move based on prediction to future incoming zombies and prediction of winning probability of possible moves, since using maximin algorithm can cut down unnecessary branches in advance to make search vast more efficient. The big challenge of this algorithm will be set strategy of how to evaluate the possibilities of win and the score to get.

**Focus:**

* Complete all test cases (no death) (Jialin)
* How do we get maximum scores (Yiren and Tianhao)
* How do we keep as many as possible humans alive (lose game if and only if all humans are killed) (Shubhi)

**Development Plan:**

The following is our group’s project timeline. Each iteration is one week.

* 3/6 - 3/12: determine project topic, complete project proposal, and get feedback from professor and TA
* 3/13 - 3/19: modify the proposal if we need, analysis on given game rules, research on decision tree, centroid, and monte carlo algorithm.
* 3/20 - 3/26: Implementation stage 1- fixed decision tree, and pass all test cases
* 3/27 - 4/2: Implementation stage 2- build more complex decision tree and develop supervised training decision tree.
* 4/3 - 4/9: Implementation stage 3 if stage 2 is completed successfully. Or continue on stage 2.
* 4/10 - 4/16: Continue on stage 3 and prepare for presentation and demo
* 4/18 : Final Presentation

**How do you know you are done:**

**Stage 1**

* All test cases pass.
* Get victory condition after run official contest.

**Stage 2**

* Get score as high as possible. There are thousands of competitors, 100% pass test score will give you around 15000 score, our bottom line is 30000, which double the pass score. And our challenge goal is top 10 in North America area. (Above 81490).

**Stage 3**

* Get score as high as possible. None of us implement and test Monte Carlo algorithm before, so we really want to find out its performance compare to decision tree.

**Tools:** Python, game coding platform (see below), github, Google Drive (<https://www.codingame.com/multiplayer/optimization/code-vs-zombies>)