McGill | School of Computer Science

FACULTY OF SCIENCE

COMP 424 - ARTIFICIAL INTELLIGENCE

Project Report: Saboteur

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Contents

1 Introduction

The project is based on a on a specific version of a card game called Saboteur, which was originally introduced back in 2004. In this version, there are 5 types of cards available, namely Tile, Malus, Bonus, Destroy, and Map, on a restricted board of size (15,15). The goal of the project is to implement a computer agent with artificial intelligence called `StudentPlayer` defined in `public class StudentPlayer extends SaboteurPlayer`. The AI agent is supposed to beat another predefined agent whose move in the game is set to be random.

There are many constrains to our project, both from the scope of the project itself and several external factors. In the end, the result we obtained was satisfactory. We had a success rate of 33.33% from our testing rounds of play and we have satisfied all the requirements from the project specification document.

2 Technical Approach

2.1 Description

Our strategy is a modified version of the Local Optimization Search to head towards the gold nugget objectives, which is based on the knowledge of Hill Climbing and Simulated Annealing we learned in class. In short, our general strategy is to use the Map cards to find the location of the goal, drop cards that are deemed discardable along the way (to maximize the chances of having a favourable hand), and build a path with the best Tile card in hand, determined by the Local Optimization search, towards the goal.

There is also an idea of critical region which was integrated in the approach. The critical region in the game is defined to be the area below row 8. Inside the region, since it is close to the target, a special aggressive approach was chosen as using the Malus card whenever possible to reduce the winning possibility of the enemy. Thus, the setup of the critical region was not only to ensure that there are enough cards to build a path to the gold nugget with the help of the cards from the enemy in the beginning, but also to steer the enemy away from winning on the path we built or blocked the path.

The details of our approach is listed below in the same order as the logic of our `StudentPlayer` class:

1. Check if the enemy has played a Malus upon the player. If yes, use the the Bonus card in hand if possible.

2. If the location of gold nugget is still unknown, use the Map card in in hand if possible.

3. Drop the dead-end Tile cards in hand if possible to maximize the chances of having a hand of more utility. The dead-end Tile cards are defined as in
   `public static final ArrayList<String> deadEndTileNames`
   in the class constructor. The reason for this discarding move is based on the fact the enemy is completely in random. Hence, we believe it is better to discard those cards in exchange of a potential better hand rather than use those to block the path of the other, since the latter also increases the chance polluting the potential path down to the goal. The over 300 runs of the game we ran proved our prediction.

4. Use the Destroy cards in hand if possible to destroy all dead-end Tile cards currently on the board below the entrance. This is to maximize the chance of successfully reaching down to row 12.

5. Check the previous conditions. If there is still no viable option available, do as in Listing 1:

```java
for (SaboteurMove mov : moves) {
  if (mov.getPosPlayed()[0] >= 5) {
    if (mov.getPosPlayed()[1] <= 7 && (mov.getPosPlayed()[1] >= 3))
      return moves.indexOf(mov);
  }
}
```

   Listing 1: A simple greedy approach when the gold location is unknown.

6. Repeat previous steps until the gold nugget location is revealed.

7. Once the gold location is known, discard the Map cards in hand.

8. Check if the cards has reached down to the critical region (below row 8). If not, perform simple greedy approach in Listing 1.

9. If reached the critical region, play the Malus card in hand at once. As stated before, this is a special aggressive approach to reduce the winning possibility of

the enemy and to reduce the chance that the planned path is being blocked a dead-end Tile.

10. Next, perform enhanced greedy algorithm in Listing 2 where playing the cross-shape and vertical-stroke shape Tile cards has higher preference in the move.

```
// the + and | tiles in the critical area have priority
boolean hasTileVer = false;
for (SaboteurCard card : cards){
    if (card.getName().equals("Tile:8")
    card.getName().equals("Tile:0")
    card.getName().equals("Tile:6")
    card.getName().equals("Tile:6_flip")){
        hasTileVer = true;
        break;
    }
}
if (!hasTileVer) {
    for (SaboteurMove mov : moves) {
        if (mov.getPosPlayed()[0] > 8) {
            if (Math.abs(mov.getPosPlayed()[1] - goldCoord[1]) <= 1)
                return moves.indexOf(mov);
        }
    }}
else{
    for (SaboteurMove mov : moves){
        if (mov.getPosPlayed()[0] > 8 && mov.getPosPlayed()[0] < 12
        && Math.abs(mov.getPosPlayed()[1] - goldCoord[1]) <= 1
        && (mov.getCardPlayed().getName().equals("Tile:8")
        mov.getCardPlayed().getName().equals("Tile:0")
        mov.getCardPlayed().getName().equals("Tile:6")
        mov.getCardPlayed().getName().equals("Tile:6_flip") ))
            return moves.indexOf(mov);
    }}
```

Listing 2: Enhanced greedy approach

2.2 Motivation

There were several other methods that were discussed before we started writing the code, including turning the game into a Constraint Satisfaction Problem (CSP), similar to the 4 queens problem we studied. However, due to the complexity of the Saboteur game, we believed that the CSP approach will not be feasible for us to achieve on time. There was also an attempted approach by Haoran Du of forming the game into a Minimax tree. In the end, the team decided to switch to the Local Search Optimization approach in the end based on the following reasons:

1. There is a total of 56 cards distributed among the players, both starting with 7 cards. Thus, there are only 46 turns, or 23 rounds to discard cards that do not fit one's strategy. Furthermore, only two Malus cards are present in the deck, for twice as many Bonus cards. It increases the chances of countering a Malus, which is unfavourable for an aggressive strategy. However, 6 Map cards are in the deck, thus composing almost a ninth of the deck, favouring a greedy strategy. Three Destroy cards can also compose the deck, which allow the destruction of a tile placed on the board, favourable for path building when one of the 9 dead-end tiles available in the deck are placed. The remaining 28 cards are tunnel tiles permitting route building in various directions.

2. We believe that in order to beat a random agent, the best move would be perform a Local Optimization each time after the enemy has played instead of planning a path from the beginning. We don't suppose a very complex approach or would have a lot more advantages than a greedy algorithm when facing something random.

3. The enemy is completely random rather than rational. Hence, it is almost impossible to make predictions to the next move of the enemy based on which card was played in the last round. This would make several approaches very hard, for example calculating heuristics of the move, or deciding the min/max agent in $\alpha - \beta$ pruning, if also considering the complexity of the moves or tiles.

2.3 Theoretical Basis

2.3.1 Hill Climbing

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2.3.2 Simulated Annealing

2.3.3 Divide and Conquer

3 Summary of Result

3.1 Satisfaction of the Project Specification

3.2 Success Rate

4 Reflect upon the Approach

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5 Future Improvements

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Students' contributions

Both of student partners worked together to understand the problem and write the code in this project.