The Second Practical Test Report

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***Abstract*—This paper contains a description of the snowball game and a study on possible optimal strategies for winning it when playing several rounds with different opponents.**

I. Introduction

In this paper, I am trying to develop the best strategy for an agent to play snowball game, which is a variation of the prisoner's dilemma. As we know, there is no optimal strategy for solving this kind of games. To win the game, you need to try to guess which strategy my opponents will choose. I compete together with my classmates, with whom we have already played similar games together, and I have assumptions about how they can behave.

II. Problem Description

We are dealing with snowball fight. There are two players in the game placed on fields A and B, also there is an empty field C named hot field where snowballs are melted. Players have Snowball Cannons (SC) with help of which they can send snowballs to the opponent's field or to the C field. The game consists of 60 rounds. Each player starts with 99 snowballs in his zone and gets 1 snowball from Snowball Generating Machine (SGM) each round. The number of snowballs that player can shoot in sum to both fields during one round is defined by formula:

$$f(x) = \left\lfloor \frac{15 \times e^x}{15 + e^x} \right\rfloor$$

where x is number of round passed from the last shot. The goal of the game is to minimize number of snowballs on your field.

III. Game Environment Investigation

Our agent influences the game with his shots. The number of shots that can be made is limited by the number of snowballs on your side, the formula that determines the number of snowballs that can be shot during the round and the number of rounds. For the greatest influence of the agent on the game, I want to choose the optimal intervals between shots such that they will allow the maximum possible snowballs to be fired from the cannons.

Let's firstly consider our equation for maximum number of snowballs that can be shot.

$$\lim_{x \to \infty} \frac{15 \times e^x}{15 + e^x} = \lim_{x \to \infty} \frac{15}{\dfrac{15}{e^x} + 1} = 15$$

Now I want to investigate rounded function values for time periods available in our game. Let's take a look at TABLE 1. We know that there is exactly 60 rounds in our game that is why we can plan shooting strategy. I want to maximize number of snowballs shot during these rounds, so we can represent our problem as **unbounded knapsack problem**. We have several instances of all the items, their weight is time interval and their value is corresponding number of snow balls. In the first round we are unable to make a shot that is why capacity of our knapsack is 59.

The optimal solution for our case is 14 shots every 4 minutes and 1 shot in 3 minutes. In total we can shoot 162 snowballs (14 * 11 + 1 * 8 = 162) in 60 rounds.

TABLE I
Snowball shot by interval

Interval	Snowballs
0	0
1	2
2	4
3	8
4	11
5	13
6	14
...	...
59	14

IV. Strategy

I will build my strategy based on the experience gained while playing **The Evolution of Trust** during the lab. We are dealing with a recurring prisoner's dilemma with a known number of rounds. There is no optimal strategy for this type of game. To win, I have to try to anticipate my opponents' strategy and build my best strategy based on this assumption.

I developed simulation system which is similar to tournament in which I am participating to analyze performance of agents. I extended some agents from **The Evolution of Trust** to play snowball game.

I need to minimize the number of snowballs on my side. There are 159 snowballs are being given and generated during the game on my side. I will be able to consume them fully only by the last shot in the end of the game as maximum possible number of snowballs being shot is 162 (provided that the opponent did not send me a single snowball).

My final strategy is modified version of GRUDGER (at first cooperates and then always betrays once being betrayed) from **The Evolution of Trust**. In my implementation there are two possible ways of agent behaviour. As it was counted above the most optimal way to shoot is to do it every 4 minutes all the time and shoot in a 3 minutes interval only once. I will use 3 minutes shot of 8 balls to the hot field as the first move of my agent. If the opponent will betray and will send me some snowballs, from this moment I will send him 11 snowballs every 4 minutes until the end. If the opponent will send all his snowballs to the hot field I will do it either except last move. I can not shoot the last ball generated by the SGM, so I will have 158 snowballs in total. In the penultimate move, my agent will shoot 7 snowballs at the hot field and the last shot in the last minute will be 11 snowballs to the opponent field (8 + 12 * 11 + 7 + 11 = 158).

Why it should work? During the lab we gained that COPY-CAT (at first cooperates and then copy previous move of the opponent) strategy gives the best payoff. Here we do not have a chance for a random mistake that is why GRUDGER (at first cooperates and then always betrays once being betrayed) strategy will give me the same good result. The strategy I use came to mind independently to several of my comrades. There are at least 5 of us with more or less the same strategy. Also we know that our classmates tried to agree to implement the COOPERATOR strategy (to send all snowballs to the warm zone). As I tested in my simulation if number of CHEATERs (sends snowballs to the opponent's field) is not very big then agents similar to mine win the game. In worst case agents similar to mine become the second place in the tournament. I think that not that very big number of people will implement clear COOPERATOR strategy because the temptation to send snowballs to the opponent in the last move, when he can no longer respond, is too great.

References

[1] Nicky Case, 'The Evolution of Trust'. [Online]. Available: https://ncase.me/trust/. [Acessed: 7- Nov- 2022].