Game Theory Applications

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1 Abstract

Cyber-security plays an crucial role in the status of technological advancements. In life, we naturally gravitate towards the most secure options presented to us to prevent sorts of inconvenience later down the line. Similar to this mindset, it is natural for us to invest our time into the matters early on, really paying attention to the detail, to make our lives easier ultimately. Alike to these examples, it is important to take the actions necessary to ensure this really is the case, and in order to do so several steps must be taken in order to assure it's safety. In this project, I am aiming to portray how when taking actions towards defending your information and achieving the objective at hand, it can be seen as a game of cat and mouse. This is due to your opponent having similar private information for which you will not realize what this holds, until you take those risks and play by the book of game theoretic applications. I bring this concept to life in my project, Game Theoretic Application Implementation.

2 Introduction

Methods in which game theory applies to our lives and how the world operates within these principles are highly advance. With further applications within cases of Cyber-Security, Economics, Evolution, it can be narrowed down and applied within cases of more simple matters. Starting with a "rock, scissor, and paper" game. For instance, if you were placed within a singular of "rock,paper,scissors", prior to putting up your hand against your opponents, you will not think first off what object their hand may curl into, rather you are acting based upon your own instinct because you will have no basis to how you should move, rather this will be all according to the knowledge of what you may see the opponent moving towards alongside a sort of expectation.

Within the game, for instance, if your opponent were to present a 'rock', you may have been able to make that conclusion based upon their pattern between the three options. In return, proposed a 'paper' to rebuttal, however if you did not have this prior experience then you have no sort of basis to predict from. This sort of information that the opponent is keeping is their private information, and similarly, you also have your own private information to which you keep from the opponent, some of which they will never directly face as you are not to reveal this information. Rather what will occur between you and the other player involved will stay unknown, and as the game progresses, you will be able to make a solid judgement of the correct moves to make from that time forward. This is how you grow your chances of winning, or rather, avoid any sorts of defeats. If you look at it within a cyber-security standpoint, this game is similar to putting out what you feel is right: rock, paper, scissors, and upon the opponents move you will see whether that approach failed or not and get an idea to any sort of pattern that they are following. Ultimatley, the goal is to have these concepts brought to life in a much more applying form, where it will be applying into a cyber-security defence application within future works.

The premise of my paper consists of the status of my research findings, and more background upon what you as the audience will need to fully grasp in order to understand the motives of my project. I will be going in-depth of what game theory really is and the concepts within game theory that will be applied to my project, aspects of computation complexity, diving deeper into the relations of cyber-security in which the logic will be applied, and how it applies to real world applications.

3 Game Theory

Game Theory is essentially the study in the dynamics within how game play, more-so, the decisions going into these very choices and the rationality present throughout the process occur. Is there a reasoning behind each and every move when you are playing chess, or are you blindly moving the pieces back and forth? This sort of study is more focusing known as ”the study of the ways in which interacting choices of economic agents produce outcomes with respect to the preferences (or utilities) of those agents, where the outcomes in question might have been intended by none of the agents.”[Ross 2021]. The type of game theory that we are narrowing in on for my project in particular is going to be the non-cooperative kind to which we will be able to apply these concepts towards further development into your cyber-attacking defense prototype. [Borad 2009]

Within non-cooperative games, there is an objective that is to be made by all the character in the game, with no sort of support from other characters. They all work towards this objective, their goal revolving around victory all while implementing complex critical thinking behind each move. On the other hand, cooperative game is when you use your fellow characters to act as a boost towards your victory. They will find the most reward as they work together, and cheating is not a trait in this collaborative effort as it would not benefit them in any sort of way. Rather, working together is how they will be able to maximize coming closer to the goal.

4 Method

Within my project, I will be using the non-cooperative game concepts as it involves two characters, one computer based, and one human operated where both will try their best to meet their personal objective goals, regardless of the status of their opponent. The human based character is given properties of being able to attack the enemy and the traps with a sword feature, and open the doors of the chamber by hovering over the switch, however upon attacking the if not defeating the enemy or trap immediately, it will face collision repercussions.

These collisions will decrease a life within the health bar, which comes with six chances of collision before the game ends and essentially the enemy wins. We will be displaying how the enemy, computer controlled character, will be able to avoid this visible trap and avoid any sort of collision. Our final goal is to implement our algorithm that will teach the enemy how to defend the switch in which if it does collide, it will also lose health.

5 Computation Complexity

Computation Complexity is calculated based upon the algorithms incorporated into systems of games and puzzles. How the problem is solved accordingly, the optimization result will be able to define how it is computed. The computation complexity of our project is NP Hard. A few different definitions of the complexities include NP Complete, NP Hard, Co-NP, NP and P class.
P class stands for ”polynomial class”, in which it is the collection of decision problems(problems with a “yes” or “no” answer) that can be solved by a deterministic machine in polynomial time. [Paschos 2009] Problems that are of P class are harder problems that are much more difficult looking, and can provoke intimidation, however it is shocking as to how simple the solution can really be to these problems. Opposing, NP class problems, also known as Non-deterministic Polynomial class, include some of the most difficult problems to exist. The solutions to these problems are seen as the hardest to find, however the verification process of the problems allow the process to be much more doable.
We will mostly focus on the NP classification problems as ours is NP Hard. NP Hard problems. NP Hard Problems are ”known to be as hard as the hardest problem in every NP Hard problem. This makes them incredibly difficult calculate.

6 Future Applications

There are several application that we will be able to gain from this project, including the application that we can further apply through this prototype. This ranges from learning much much more about the principles that we applied as testing will further reveal more about how the complexity applies towards video games with individual to multiple objectives. We will be able to apply this to levels of Cyber Security. As stated earlier, human nature is wanting the most optimal solution for ourselves in which we will be able to have peace for the time that come after. This project ties this concept together in which my future plan with what I have taken away through my conducted research is applying this to an actual application that will do just that. There will be a simulation that will portray this similar insight in a method that will in real life provide that end goal. Features within our application include the ability to test between a range of cyber-attacks, including cross-site scripting, injection, fuzz testing, zero day and more. Game theory has been used in cybersecurity to observe the nature of a cyber incident— where network defenders, attackers, and users, interact with each other and produce an outcome. [Attiah, Chatterjee, Zou 2016] Looking at the different components of a potential security breech, lets take into consideration the role of each side between the attackers and the defendants. The defendants are going to want to be able to protect their belongings and are bound to also have private information of their own that they will be keeping from the attacker as this is considered private information. Similarly, the attacker will try to tackle the sort of weak spot of the defendant and try its best to find that weak spot that will lead them to triumph. This is mirroring what our game is trying to prove, in which each sides have their own private information of the traps which will harm the opposing side and the opposing sides will have no clue as to what is it, other than the clues of how the other player moves.

Citations

- Parsons, S. (n.d.). Games. Games — Special Issue : Real World Applications of Game Theory. Retrieved July 8, 2022, from https://www.mdpi.com/journal/games/special$_i$*ssues/r*
world − applications

*Fightingcyberattackswithgametheory.ThreatpostEnglishGlobalthreatpostcom.(n.d.).RetrievedJuly*8, 20
*//threatpost.com/trapx−fighting−cyber−attacks−with−game−theory/*156545/ : :
text = now

Jameson, K.(2013, *December*13)*.GametheoryanditsApplications−St.CatherineUniversity.GameTheory*
//sophia.stkate.edu/cgi/viewcontent.cgi?article = 1078*amp*; *context = undergraduate*$_r$*esearch*$_s$*ymposiu*

Berthelsen, M.L.T., amp; *Hansen, K.A.*(2020, *January*15)*.Onthecomputationalcomplexityofdecisionpro*
*playerNashEquilibria.arXiv.org.RetrievedJuly*8, 2022, *fromhttps : //arxiv.org/abs/*2001.05196