Dominic Calkosz

Simultaneous Draft Strategies in a Zero-Sum Game, and Applications to Match Formats in Hearthstone [Working Title]

Research Project Proposal

Faculty Mentor

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[CMU webpage, personal webpage]

Project Web Page

https://dominic-calkosz.com/HearthNash

Project Description

Hearthstone is a 1-vs-1 digital card game in which two players, each with their own independently preconstructed decks of 30 cards, aim to destroy the opposing hero before their own hero is destroyed. Assuming both players act optimally during the game, a certain winrate probability could be determined between every possible pairing of decks. We can consider players' preparation for a single game, in which each player chooses their deck simultaneously (without information about the other's choice). Assuming that no single deck has a dominant (> 50%) winrate against all other decks, it follows that each player (acting optimally) will use a mixed-strategy to choose probabilistically among the set of "viable" decks. If we interpret winrates as corresponding payoffs for each player, this defines a finite zero-sum metagame, and thus always has at least one Nash equilibrium. This metagame becomes more complex when players must choose multiple decks and play multiple games in order to defeat their opponent. The particular rules of this multi-deck, multi-game system constitutes a match format, and can be structured in a variety of ways.

This research will be an attempt to formalize and solve the game theoretic problem of choosing Hearthstone decks for a particular match format, given fixed winrate probabilities across all available decks (hereafter "meta state"). Solving this metagame in the general case will mean developing a tool which is applicable to any match format (within some formalized bounds), and any meta state (within some computationally reasonable bounds). We expect that a variety of mixed-strategies will emerge as optimal, dependent on the format and meta state.

Given a resulting mixed-strategy of deck subsets, it will also be possible to measure some qualities of desirability. For example, How diverse is the pool of decks that may be

picked? and How many games will be close games as opposed to blowouts? For each match format, we intend to do a qualitative analysis across many possible meta states to determine how desirable it is. This will include data with respect to particular types of meta states (e.g. format A is good for a "near rock-paper-scissors" meta state, but bad for other meta states), as well as optimizing for the worst case when all possible meta states are taken into account (e.g. format A is on average better, but format B has a higher floor).

Furthermore, we hope to study the generalizability of this type of game, the corresponding optimal strategies, and the qualities of its possible match formats, both in theory and practice. One possible extension is towards games in which any subset of moves has internal interactions, such as selecting a subset of characters to construct a team of 5 in a MOBA (a 5-vs-5 game). Another possible extension is for games which include a draft process that is not simultaneous. This applies to many MOBAs, as well as to physical sports and fantasy sports leagues.

Project Goals

75%

At minimum, we intend to produce a tool for game theoretic analysis of multiple match formats for Hearthstone, each with respect to multiple possible meta states. The success of this stage can be measured by the correctness, scope, and usability of the tool.

100%

If all goes as expected, we will also be able to measure a variety of desirable qualities for each match format. In particular, there are 4 match formats that have been used in official Hearthstone tournaments, and 2 qualities that we have already identified. We can measure the success of this stage according to how many match formats quality combinations we are able to cover, and how meaningful those results are.

125%

If things go faster than expected, we will attempt to extend the scope of our tool(s) to similar contexts, and thus generalize our results. This may mean applications to subset games with internal interactions, to subset games with non-simultaneous drafts, or to another similar game type which we have not considered. We can measure the success of this step using our measures of success at 75% and 100% but with respect to whichever new context(s) we are able to cover.

Milestones [Todo]

Describe the milestones for your project, both for 15-300 and 15-400.

1st Technical Milestone for 15-300

What do you plan to accomplish by the last day of this semester (in 15-300)?

Bi-weekly Milestones for 15-400

Describe your milestone targets for the following dates in the Spring, 2020 semester: January 27th, February 10th, February 24th, March 16th, March 30th, April 13th, and April 27th. 4

Literature Search [Todo]

What papers and other background materials have you collected and/or read so far to help you in your project? Are you missing anything?

Resources Needed [Todo]

What software will you need to conduct your study? Do you have a copy of this software already? (If not, how will you get it?) What hardware or machines will you need to run this software? Do you have all of the resources that you need to conduct this study?