Modelling and analysis of dice-based stochastic games

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1 Status report

1.1 Proposal

1.1.1 Motivation

When designing and balancing games, various aspects of a game must be considered in order to create games which are interesting, enjoyable and replayable. These aspects are often considered manually, which is time-consuming and potentially inaccurate. Model checking aims to provide more rigorous evaluations of different game designs, for many different classes of games. One of the most commonly methods of implementing random elements in a game is via using dice, offering a tactile and simple way of introducing random elements. However, dice are usually assumed to be fair, when in practice dice are often biased to particular values, and this bias can significantly impact how a game is played.

1.1.2 Aims

This project will develop three case studies of various dice-based games, generating models whose properties can be verified using model checking. These results will then be analysed, discussing the implications of these results with respect to the game's design. These case studies will be chosen to emphasise different aspects of game design, such as hidden information and the differences between concurrent and turn-based decision making. Finally, the impact of weighted dice will be examined in order to analyse the extent to which optimal play depends on both luck and strategy.

1.2 Progress

- Developed background knowledge of PRISM (including the PRISM-games and PRISM-pomdps off-shoots)
- Created preprocessor and experiment automation environment to create replicable experiments
- Completed core modelling for Shut The Box, and the bulk of the analysis/visualisation
- Started basic modelling for Liar's Dice using POMDPs

1.3 Problems and risks

1.3.1 Problems

- Experimental development versions of PRISM do not contain the full subset of features such as manual simulation and strategy generation, limiting the set of properties which can be considered.
- Some models take a long time to generate data, slowing down the process of analysis and visualisation.

1.3.2 Risks

- Third game currently decided but may end up being more complex than expected **Mitigation**: Will use knowledge from modelling first two games to help scope the third game. Will focus on core mechanics of game first, adding extra mechanics if time permits.
- Final analysis from considering weighted dice may take more time than originally planned. **Mitigation**: Will focus on simple example of weighted dice first on all 3 games, then extend later on if time is available.

1.4 Plan

- Week 1: Plan structure of dissertation. **Deliverable**: A table of contents with section titles and approximate page counts.
- Weeks 1-3: Finish core modelling and analysis of 3rd game. **Deliverable**: A set of 2 Jupyter notebooks, similar to Shut the Box - one performs all relevant model checking, while the other creates visualisations.
- Weeks 3-4: Start writing up background sections of dissertation. **Deliverable**: A mostly complete background chapter incorporating supervisor feedback.
- Weeks 4-6: Include consideration of weighted dice in analysis of each game. **Deliverable**: New sets of data from each game, considering the impact of weighted dice, including new visualisations.
- Weeks 5-8: Write up dissertation section for each game. **Deliverable**: Three dissertation sections, including sending chapters to supervisor for feedback on a regular basis.
- Weeks 9-11: Write and record presentation. **Deliverable**: Slides and video of project presentation.
- Weeks 9-10: Write up remaining sections of dissertation (mainly conclusion). **Deliverable**: A mostly complete draft of dissertation.
- Week 10-11: Final polishing/tweaking of dissertation based on supervisor feedback. **Deliverable**: Final dissertation.

1.5 Ethics and data

This project does not involve human subjects or data. No approval required.