# CITS3001 Report: Bayesian Opponent Modelling and the Effect of *Ex Ante* Collusion Amongst Spies

## PLAN

1. What the research question is;
2. Why the question is interesting;
3. How you intend to answer the question;
4. What data you collected; and
5. What the data tells us about the question.

## Introduction

### Background

Resistance is a game of 5-10 players in which each player is designated a role as either a resistance member or a spy. The goal of resistance members is to ensure missions go ahead and that they succeed. The goal of spies is to either prevent missions from going ahead by voting against them or by ensuring that enough spies are on the mission to sabotage it causing it to fail.

Resistance players are unaware of the spies within the group however spies are provided with information as to who the other spies are and therefore know the type, either resistance or spy, of all players in the game. As moves are made simultaneously the resistance and spies are both playing a game of imperfect information. It is however the case that spies have more information at the start of play than the resistance.

### Research Question

The goal of this project was initially to create an agent using a Bayesian Opponent Model (BOM) that could outperform a deterministic agent both as a member of the resistance and as a spy. Using the win/loss as a series of Bernoulli trials to determine whether this goal had been achieved. To test this various scenarios were created to test the effect of the changes. First was to bench mark the win/loss for the agent acting as both spy and resistance. Secondly the various agents would be assigned a role based on their type e.g. all spies are Bayesian agents and all resistance deterministic. The last part was to check how a single agent acting as either role could effect the outcome of a game consisting of entirely different agents.

In the process of building the deterministic baseline agent it was discovered that collusive behaviour could be built into the spies standard operating procedure allowing them determine which spies on a mission would sabotage it without requiring communication. This would have the benefit of minimising the footprint of sabotage on a mission by ensuring only the minimum number of spies required would betray the mission in effect minimising the suspicion for all agents on the mission by maximising the uncertainty over betrayal.

At this point the goal became split between building an agent using BOM and determining how *ex ante* collusion would effect an agent designed to beat that agent with and without collusion.

## Literature Review

Research exists within the realm of generating collusion within models however the use of collusive tactics within simultaneous games is an approach that does not appear to be have much literature as it is somewhat against the spirit of the game.

It is somewhat similar to the generation of predator prey models in which the predators and/or prey are able to work in teams to avoid

Resistance is a game of imperfect where players make moves simultaneously and must balance all possible outcomes on when making a decision.

* Finitely repeated game of five rounds where spies must weigh the prospect of immediate gain by sabotaging a mission vs the long term game preventing three missions from succeeding.
* Information Asymmetry

Learning is acquired through experience.

* There is limited scope for cooperation other than in the voting round. Even then agents do not know who they are meant to be cooperating with.

Internal policy of the game is based on parameters.

Dutta, P.K. (1999). Strategies and Games: Theory and Practice. Cambridge, MA, The MIT Press. Chapters 14-15 for Repeated Games. Chapter 20 for Games with Incomplete Information.

[We are using a model of another agent to predict it’s goals and beliefs.](https://www.cs.utexas.edu/~larg/ijcai17_tutorial/multiagent_learning.pdf)

The side goal of this is to be suitable for ad hoc team work with other agents during the competition round

“Game Strategies and Decision Making” (Harrington)

Test against the baseline. Test against random to make sure it is not modelled specifically for the baseline. Test the baseline against random to compare

## Rationale of Selected Technique

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## Design Description

“AGENT\_NAME” uses Bayesian Opponent Modelling to extend the Baseline Agent’s understanding of the world in order to create a more successful player. The focus of “AGENT\_NAME” is on playing a better resistance character rather than creating a superior spy. That said, understanding how suspect a player, whether spy or resistance, appears to resistance players can help a spy make better choices about how they should act.

Communication is not allowed so the agents required a reliable method for knowing which role they would play in different circumstances. For example saboteur, sleeper agent or co-conspirator.

### Baseline Agent Design

During design of the model agent the baseline agent was continuously reviewed for improvements that could be made based on certainty rather than inference so is somewhat more sophisticated than the initial baseline agent.

The baseline agent was designed using lessons learned from game play as well as various tactics and techniques found while undertaking the literature review. Specifically, it was developed using deterministic knowledge about the game state. Such rules include deciding a player is a spy only when we know with one hundred percent certainty that a player is a spy. number of betrayals is equal to the number of agents on a mission.

In addition to the normal simultaneous game play simplistic rules for cooperation between spies have been built which can be switched on an off. These rules allow the spies to lower exposure by minimising the betrayals where multiple spies are on a single mission by having a pre-configured understanding about who will betray missions an under which circumstances.

We have status for Confirmed and Burnt spies. A confirmed spy is one that the agent knows to be a spy but cannot prove is a spy to others. A burnt spy is one that has shown themselves to be a spy to all players by being on a mission where all agents betray the mission. Confirmed spies we deal with by voting against them. Burnt spies we use to determine whether anyone else votes for them or selects them on a team after burning which should confirm they are a spy rather than just an inept resistance member.

##NOTE##

It is thought that significantly more time could be put into the assessment of spies and the modelling around risk. This said, the gains made by the resistance could likely then be factored into further collusion by spies.

## Validation of Agent Performance

Bernoulli Trials and Hypothesis Testing

## Bibliography

Young, H.Peyton (2007) ‘The Possible and Impossible in Multi-Agent Learning’, Artifical Intelligence (AIJ), Vol 171, pp. 429-433