

# Optimal policy search for multi agent simulation

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# Introduction

## Optimal policy search

- ▶ Many computational sustainability systems can be represented with multi agent systems.
- ▶ Management decisions need to be optimised with respect to some objective function
- ▶ Computationally expensive to find optimal decision at every timepoint
- ▶ Goal is to find fixed policy optimal over distribution of simulations

# What are we searching for?

## How do we search over policies?

- ▶ Define a policy as a function  $\psi$  that maps state to decisions
- ▶ Uncountably infinite number of possible functions
- ▶ Restrict our search space to looking for decision trees



# Searching for decision trees



## What is a decision tree?

- ▶ Each node is a proposition
- ▶ Branch on answer
- ▶ Leaves are labels

# Methods of search

## Two possible search techniques

### Complete Search

- ▶ Fix the size of the tree
- ▶ For each node have variables representing
  - ▶ Operator
  - ▶ Label
  - ▶ Threshold

### Local Search

- ▶ Start with a random tree
- ▶ Make small changes to improve the tree
- ▶ Keep improving the tree

# Bottlenecks

## What are the problems?

- ▶ The search space is huge!
- ▶ Evaluating the quality of a tree is expensive
- ▶ For complete search difficulty in bounding quality until a complete tree is built
- ▶ How can we reuse experimentation data



# Possible solutions

## Huge search space

- ▶ Use techniques from reinforcement learning to learn where in the search space to move to improve quality

## Expensive simulation

- ▶ Ideas from Approximate dynamic programming allow shifting agent state space to a lower dimension so that it can be solved optimally

## Evaluating quality of a tree

- ▶ Confidence interval calculations from statistics allow termination of experimentation early if new tree is worse than previous best

# Example uses

## MAP Optimisation

- ▶ Cows are agents
- ▶ Policy to cull cows
- ▶ Optimise income





# Questions?



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