

**How to Spice up *your*  
Planning under Uncertainty  
Research Life**

Scott Sanner

NICTA / ANU

First.Last@nicta.com.au

# Research Happiness Evaluation

- Do you have any of these symptoms:
  - Your uncertain planner seems sluggish?
  - You have feelings of aggression and anger when someone mentions FF-Replan?
  - You think the world may be better off without specialized uncertain planning techniques?

# A Suggested Remedy

- If any of the previous apply...

you might want to spice up your planning under uncertainty research life!

- As a Dr., I recommend VIAGRA

# Summary in Brief

“VIAGRA ... may help expand  
[your] planning research.”

*-Anonymous Reviewer*

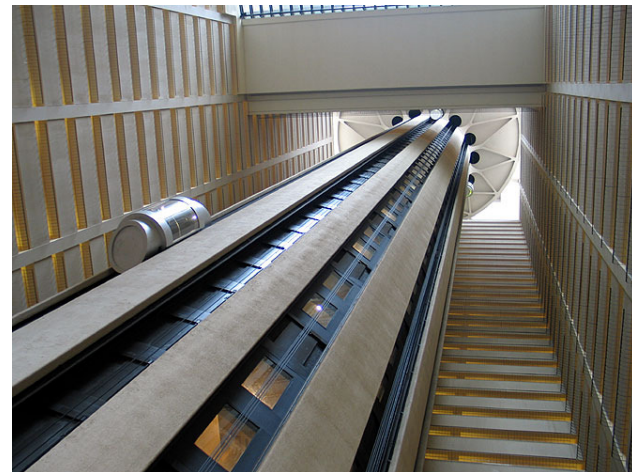
# Why VIAGRA?

- The planning competition is a great idea, but...
  - Misconception that these are only interesting problems
  - And thus replanning is ideal for uncertain planning
- VIAGRA aims to spice up uncertain planning:
  - Ele**V**ators,
  - Cont**I**nuous state and actions,
  - Multiple **A**gents,
  - No **G**oals,
  - **R**eal problems,
  - Exogenous **A**ctions and events

# EleVators

Never underestimate the planning excitement possible with elevators

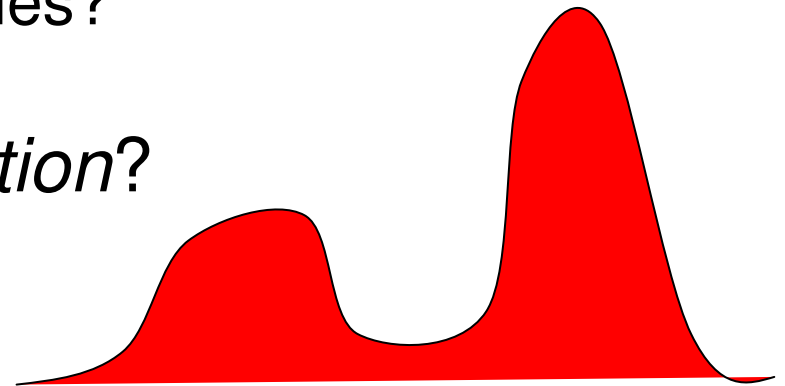
- Key property: *concurrency*
  - Each elevator: up/down/stay
  - 6 elevators:  $3^6$  actions
- Cannot generally search all joint actions / outcomes
  - But any single joint action / outcome may have low probability
- Better to reason in *expectation*?



# Continuous State & Action Spaces

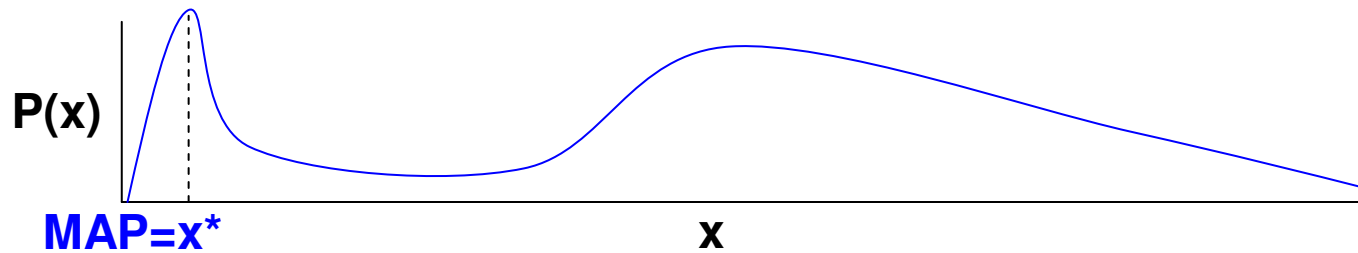
It can be useful to go outside your comfort zone

- The world is not always discrete!
  - E.g., continuous resources (Mars Rover)
  - Encounter curse of dimensionality if discretize
- Can these domains be determined?
  - Which actions, which outcomes?
- Better to reason in *expectation*?
  - For multi-modal distributions
  - And/or high-risk settings?

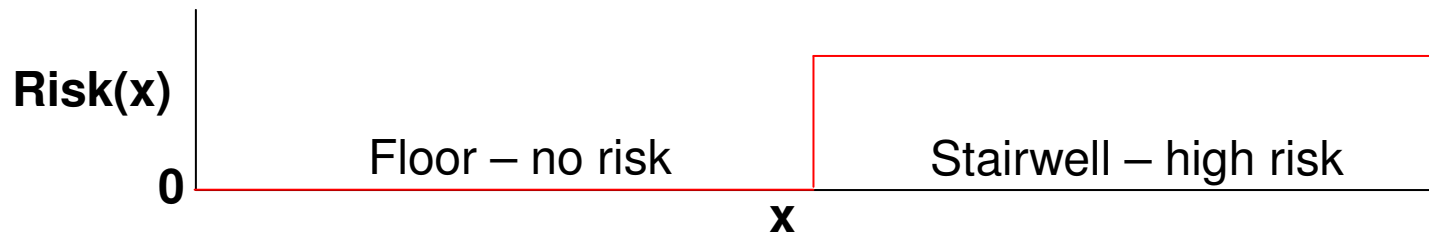


# Multi-modal Distributions

- Robot has belief  $P(x)$  over position after action



- Associate  $\text{Risk}(x)$  w\ position  $x$  (e.g., stairs!)



- MAP Risk =  $\text{Risk}(x^*) = 0$
- Expected Risk =  $\int_x \text{Risk}(x)p(x|D) > 0$

- Which risk estimate would you use?

Practical robotics did not come of age until probabilistic methods introduced.



# Multiple Agents

Spice up your planning life with more than one agent

- May be adversarial
  - Unlike Elevators (cooperative)
- Often need stochastic strategies
  - $\infty$  number of strategies
  - E.g., rock-paper-scissors
- Reduce to deterministic search?
  - Or do we need game-theoretic treatment?



# No Goals

Its not always a good idea to have a clearly defined goal of what you expect to achieve

- Planning competition is goal-oriented
  - Interesting problems with *avoidable dead-ends*
- But this is just the tip of the iceberg
  - Problems with *avoidable low-expected value states*
- General reward,  $\infty$ -horizon
  - Need to reason in expectation?

# Real Problems

Real problems are more exciting than toys

- Autonomous mobile robotics
  - Extremely complex task, requires expertise in vision, sensors, real-time operating systems
  - Full model unknown & partially observable!



# Exogenous **A**ctions and Events

Planning can get more interesting when unexpected events happen

- Most planning problems make a strong frame assumption
- But what about
  - Mail or network packet delivery?
  - System administration?
- Planning must be robust to external events
  - Many low probability possibilities
  - High likelihood one will occur

# Exogenous Events in PPDDL

## SysAdmin variant in PPDDL

(requires *forall-probabilistic* combination)

```
(:action reboot
:parameters (?x - comp)
:effect (and (decrease (reward) 1)
            (probabilistic 0.9 (up ?x))
            (forall (?d - comp)
              (probabilistic
                0.2 (when (exists (?c - comp) (and (conn ?c ?d)
                                                    (not (up ?c))
                                                    (not (= ?x ?d))))
                  (not (up ?d) )
                )
            )
))))
```

# Recap: A Common Fallacy

- The planning competition is a great idea, but...
  - Misconception that these are only interesting problems
  - And thus replanning is ideal for uncertain planning
- VIAGRA aims to spice up uncertain planning:
  - Ele**V**ators (*concurrent actions*),
  - Cont**I**nuous state (*resources*) and actions,
  - Multiple **A**gents (*adversarial, stochastic policies*),
  - No **G**oals (*general reward,  $\infty$ -horizon*)
  - **R**eal problems (*unknown models, partial observability*),
  - Exogenous **A**ctions and events (*dense transitions*)

# Conclusion

If your planning under uncertainty research life seems lackluster or dull...

**consider VIAGRA**

It's guaranteed to spice up your research life!