NUS National University of Singapore | Computing

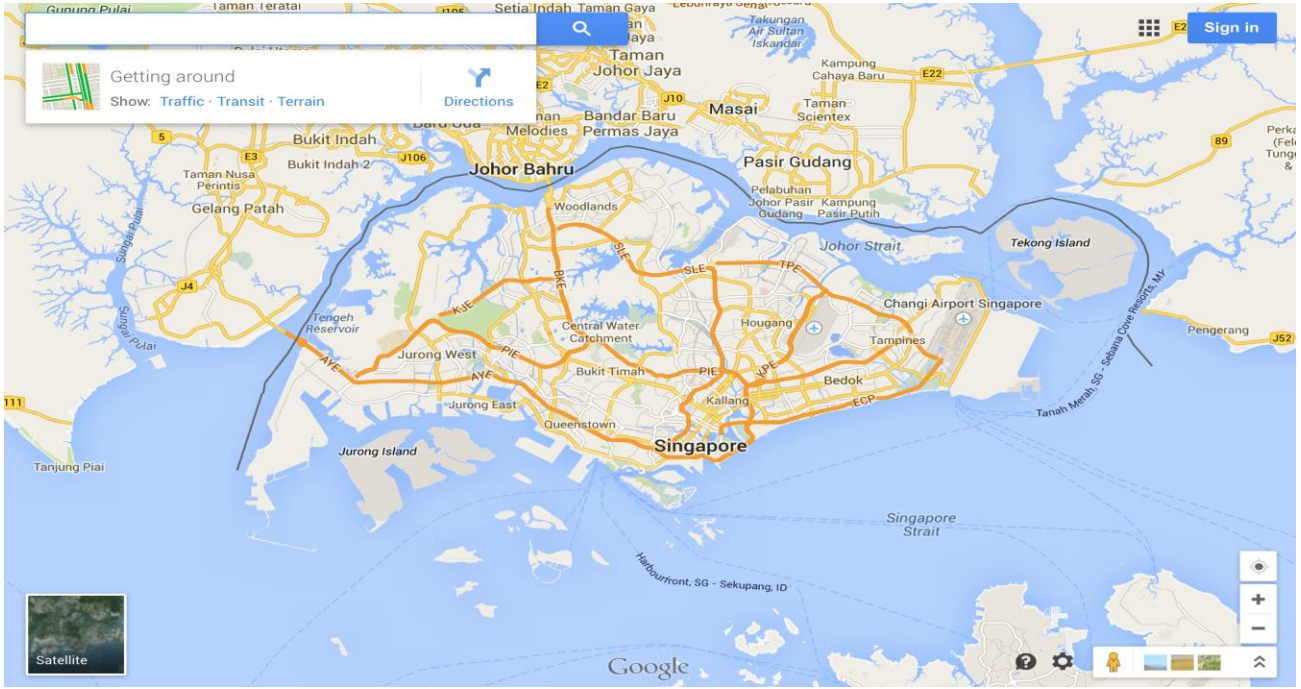
Introduction

Please join:
pollev.com/anarayan

CS4246/CS5446

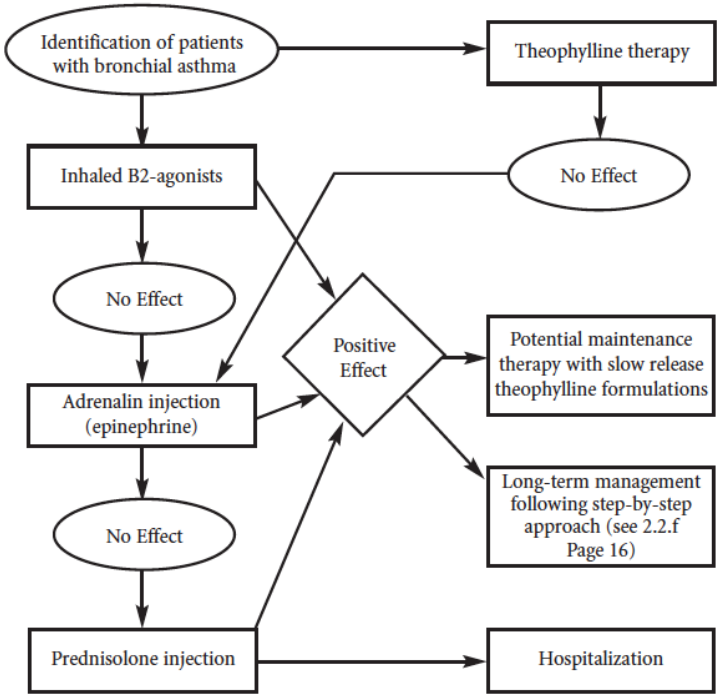
AI Planning and Decision Making

Example: Parcel Delivery



Source: maps.google.com.sg

Example: Asthma Management



Source: AIHA 2006

Source: American International Health Alliance. BRONCHIAL ASTHMA- Clinical Practice Guideline for General Practitioners. 2006.

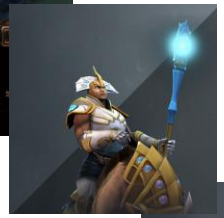
http://www.aiha.com/en/ResourceLibrary/Products/Curricula/pdf/CPG%20Asthma%20EN.pdf[Accessed 6 Aug 2010]

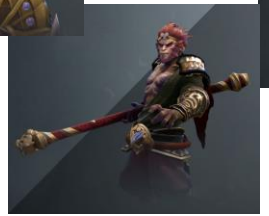
Example: Characters in Games

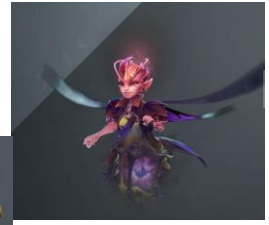
Source: https://aiwarriorswebsite.github.io/AIWarriors/

Source: www.battle.net/wow

Source: stardewvalley.net

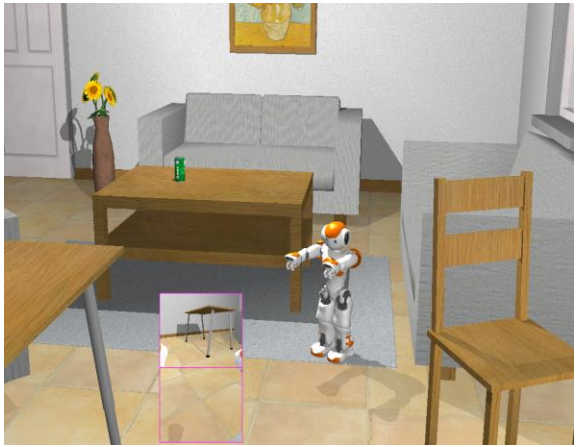






Source: dota2.com

Example: Assistive Robots

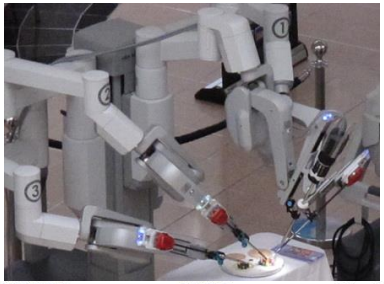


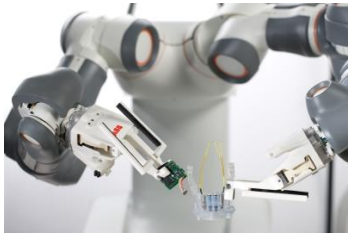
Source: www.cyberbotics.com

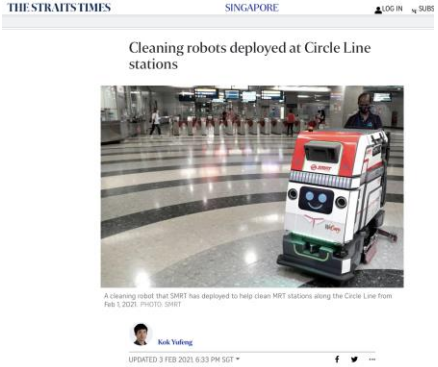
Source: Aldebaran

Source: Romibo

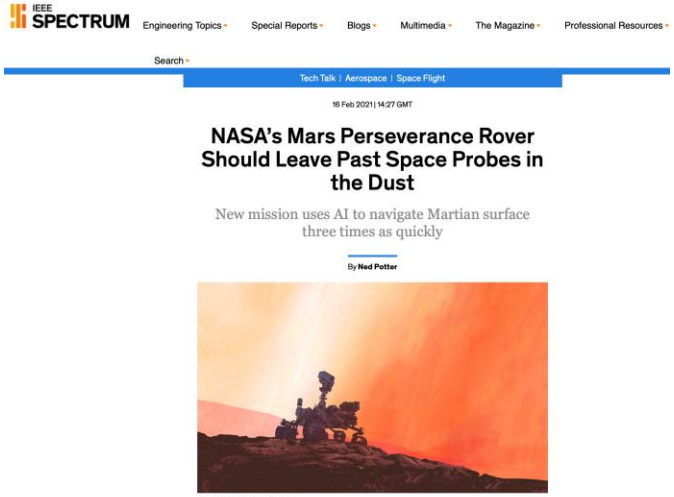
Example: Scientific and Industry Robots





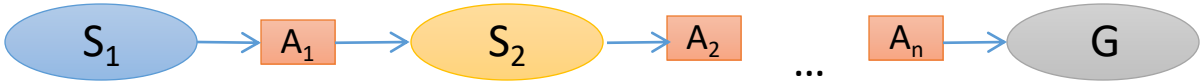


Source: IMDA



AI for Good!

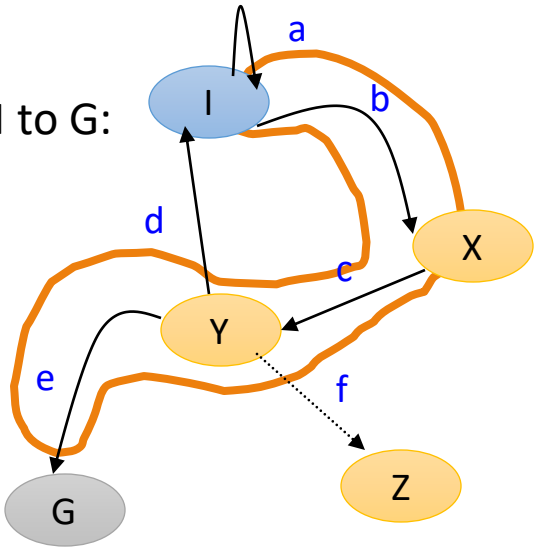
A Planning Problem



- Assumption:
  - Agent in task Environment
- Definition:
  - States in an environment, with Initial State
  - Actions available in a state
  - Effects of applying an action
  - Goal test to see if objective is met
- Solution:
  - Start from Initial State, find action sequence whose effects (resulting states) lead to the goal state

Example:

Plan from I to G:
b → c → e



Solving Planning Problems

- Planning Problem or Model
  - Appropriate abstraction of states, actions, effects, and goals (and costs and values)
- Planning Algorithm
  - Input: a problem
  - Output: a solution in the form of an action sequence (a plan)
- Planning Solution
  - A plan or path from the initial state(s) to the goal state(s)
    - Any path; OR
    - An optimal path wrt to costs or values
  - A goal state that satisfies certain properties

Planning Problem Types

Human Factors!

Problem Feature	Simple	Complex
States	Fully observable	Partially observable
Actions	Discrete	Continuous
Effects	Deterministic	Non-deterministic or Uncertain
Goals	Deterministic	Ordered or graded
Environment	Static	Dynamic
Agent	Single	Multiple

Toy Problems!

Real-Life Problems!

Costs, preferences, horizon, changes, etc.

Source: (GNT) Chapter 2, Ghallab, M., D. Nau, and P. Traverso, *Automated planning: Theory and practice.* 2004: Morgan Kaufmann

AI Planning and Decision Making

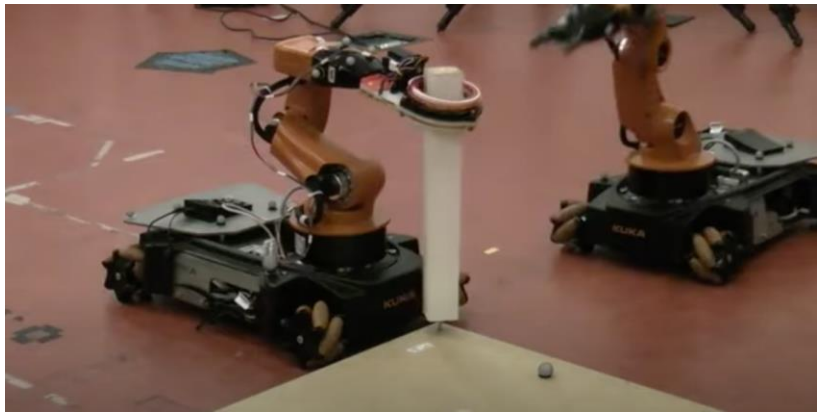
- Classical planning
- Decision theory
- Probabilistic planning
- Reinforcement learning (Planning + Learning)
- Game theory and multi-agent decision making
- And other new trends ..

Poll

Poll result

IkeaBot – Assembling an IKEA table

- Planning problem specified in PDDL, a classical planning specification that we will learn in this module
  - https://www.youtube.com/watch?v=B9sYogRVF8Q



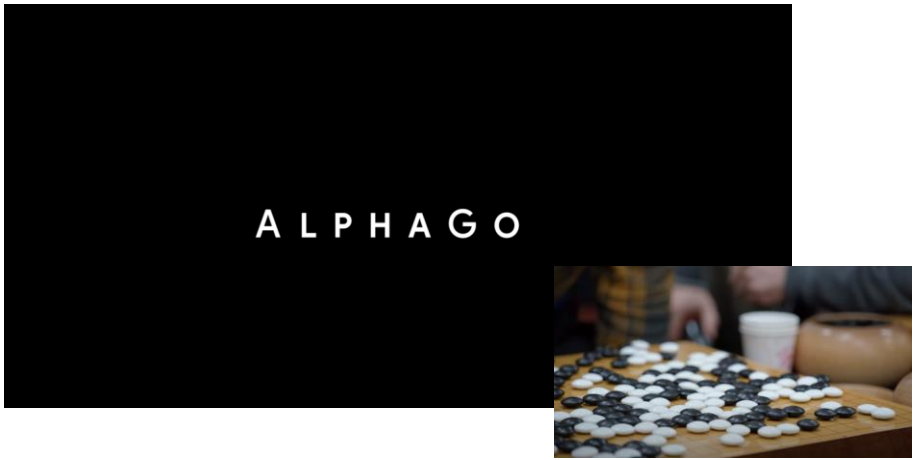
Paper: https://rpal.cs.cornell.edu/docs/KneEtal_ICRA_2013.pdf

Autonomous driving in NUS UTown

- Problem formulated as Partially Observable Markov Decision Process (POMDP), which we will learn in this module
  - https://www.youtube.com/watch?v=y_9VMD_sQhw

Defeating the World Champion in Go

- AlphaGo uses learning and Monte Carlo Tree Search (which we will cover in this module!) to defeat world champion Lee Sedol
  - https://www.youtube.com/watch?v=8tq1C8spV_g



Playing Atari games using RL

- Agent learns to play Atari games by “looking” at the screen using Reinforcement Learning (you will work on an RL problem in this module)
  - https://www.youtube.com/watch?v=V1eYniJ0Rnk

Dr Strangelove - Doomsday Machine

- Use game theory to analyze situations like those seen in the video, and recommend a right course of actions to avoid war
  - https://www.youtube.com/watch?v=2yfXgu37iyI

Beyond Technical Challenges

- Domain challenges
  - Involving deep domain knowledge and operational issues
  - Interacting conditions, processes, and goals
- User challenges
  - Different skill levels and preferences
  - Varying usage patterns and cognitive biases
- Economic challenges
  - High implementation costs
  - Unclear market viability and scalability
- System challenges
  - Uncertain and changing information, processes, environments
  - Evolving IT and communication systems

Responsible AI Planning and Decision Making

- Toward Human-Aware AI Systems
  - AI working for, working with, and working alongside Humans
  - Human-AI collaboration
- Toward Trustworthy AI Systems
  - Natural interaction and effective collaboration
  - Fairness, accountability, and transparency
  - Robustness, resilience, privacy and security
  - Social, ethical, governance and regulatory considerations

References

- Main reference/textbook:
  - (RN) Russell, S. and P. Norvig, Artificial intelligence: A modern approach. 4th ed. 2020: Pearson.
- Other references:
  - (GNT) Ghallab, M., D. Nau, and P. Traverso, Automated planning and Acting. 2016: Cambridge University Press.
    [Book website: http://projects.laas.fr/planning/]
    [e-Book for personal use: http://projects.laas.fr/planning/book.pdf]
  - (SB) Sutton, R. S. and A. G. Barto. Reinforcement Learning: An introduction. 2nd ed. 2018: MIT Press.
    [Book website: http://incompleteideas.net/book/the-book.html]
    [e-Book for personal use: http://incompleteideas.net/book/RLbook2020.pdf]
  - (FN) Fenton, N. and M. Neil, Risk Assessment and Decision Analysis with Bayesian Networks. 2nd ed. 2019: CRC Press, Inc.
  - (SLB) Shoham, Y. and K. Leyton-Brown. Multiagent systems: Algorithmic, game-theoretic, and logical foundations. Cambridge University Press, 2009. [Ebook download: http://www.masfoundations.org/index.html]