



Introduction



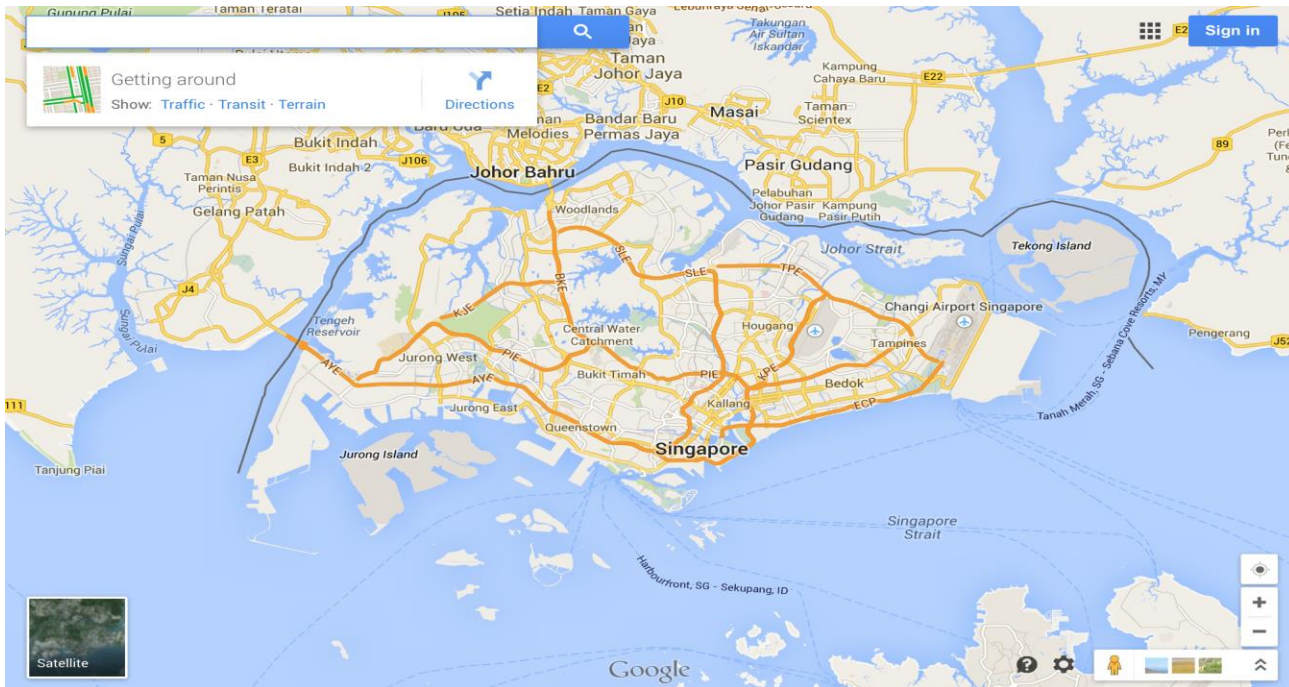
Please join:

pollev.com/anarayan

CS4246/CS5446

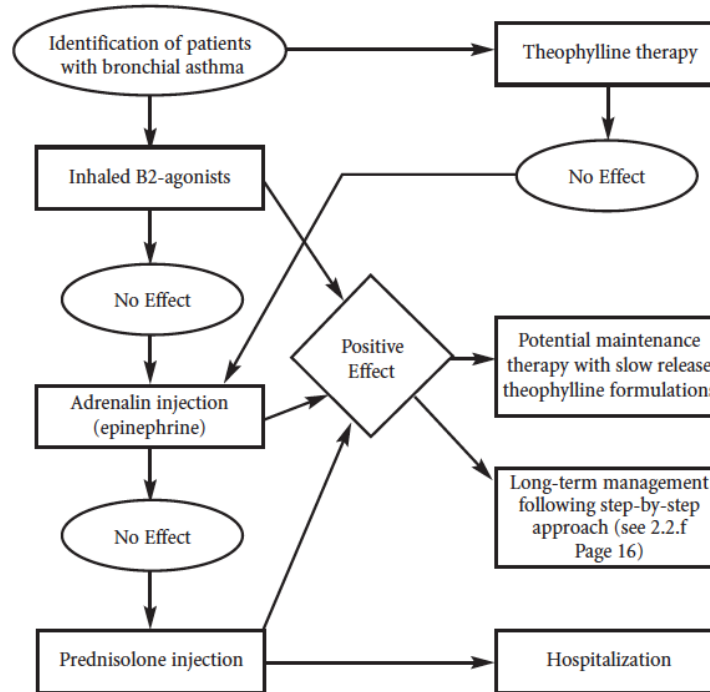
AI Planning and Decision Making

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

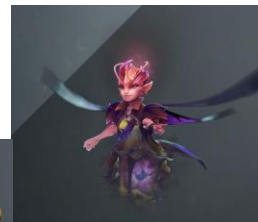
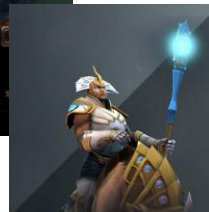
Source: <https://aiwarriorswebsite.github.io/AIWarriors/>



Source: stardewvalley.net



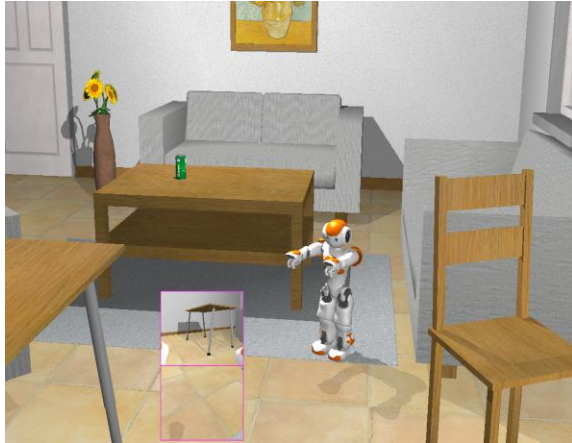
Source: www.battle.net/wow



Source: dota2.com



Example: Assistive Robots



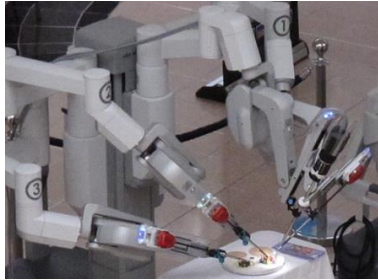
Source: www.cyberbotics.com

Source: Aldebaran



Source: Romibo

Example: Scientific and Industry Robots



THE STRAITS TIMES SINGAPORE

Cleaning robots deployed at Circle Line stations

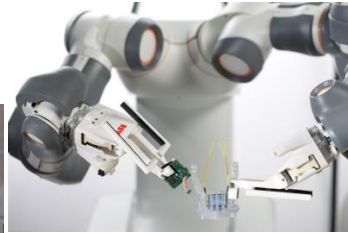


A cleaning robot that SMRT has deployed to help clean MRT stations along the Circle Line from Feb 1, 2021. PHOTO: SMRT



Kok Yifeng

UPDATED 3 FEB 2021 6:33 PM SGT



Source: IMDA

Search

Tech Talk | Aerospace | Space Flight

16 Feb 2021 | 14:27 GMT

NASA's Mars Perseverance Rover Should Leave Past Space Probes in the Dust

New mission uses AI to navigate Martian surface three times as quickly

By Ned Potter



AI for Good!

nature communications

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Perspective | Open Access | Published: 13 January 2020

The role of artificial intelligence in achieving the Sustainable Development Goals

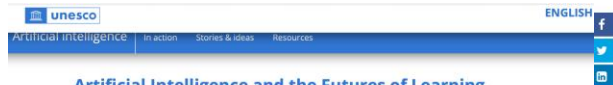
Ricardo Vinuesa , Hossein Azizpour, Iolanda Leite, Madeline Balaam, Virginia Dignum, Sami Domisch, Anna Felländer, Simone Daniela Langhans, Max Tegmark & Francesco Fusco Nerini 

Nature Communications **11**, Article number: 233 (2020) | [Cite this article](#)

84k Accesses | **83** Citations | **439** Altmetric | [Metrics](#)

Abstract

The emergence of artificial intelligence (AI) and its progressively wider impact on many sectors requires an assessment of its effect on the achievement of the Sustainable



Artificial Intelligence and the Futures of Learning



The Artificial Intelligence and the Futures of Learning project builds on the Recommendation on the Ethics of Artificial Intelligence to be adopted at the 41st session of the UNESCO General Conference and will follow up on the recommendations of the upcoming UNESCO global report *Reimagining our futures together: A new social contract for*

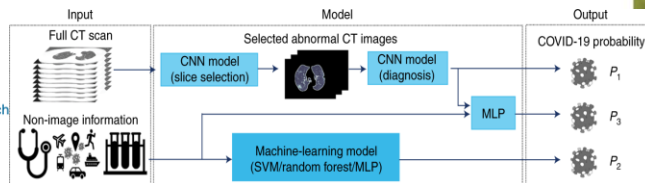


Letter | Published: 19 May 2020

Artificial intelligence-enabled rapid diagnosis of patients with COVID-19

Xueyan Mei, Hao-Chih Lee, [...] Yang Yang 

Nature Medicine (2020) | [Cite this article](#)



COLLEGES & CAMPUS NEWS

Where Artificial Intelligence Meets Urban Planning

First-year doctoral student is disseminating an AI program capable of changing the world of urban planning.

BY SIMONE ROUSSEAU | OCTOBER 6, 2020



Urban planning is a multi-faceted discipline in which planners collect data points from targeted areas to determine if a store, hospital or other types of buildings are likely needed in that area.

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How AI can unlock a \$127B opportunity by reducing food waste

Scaling up AI's deep learning technology with a circular-economy vision could revolutionize the way food is grown, designed, purchased, and enjoyed.



By Clairese Magnin



Managing Partner of McKinsey in France. Leads our work in the Consumer Packaged Goods and Retail Practices in Africa, Europe, and the Middle East; the agriculture



LOGIN



Steam and smoke rise from the cooling towers and chimneys of a power plant. Artificial intelligence is being used to prove the case that plants that burn carbon-based fuels aren't profitable.
PHOTOGRAPH BY ROBB KENDRICK, NAT GEO IMAGE COLLECTION

NEWS

How artificial intelligence can tackle climate change

The biggest challenge on the planet might benefit from machine learning to help with solutions. Here are a just a few.

BY JACKIE SNOW



PUBLISHED JULY 18, 2019 • 6 MIN READ

A Planning Problem

- Assumption:

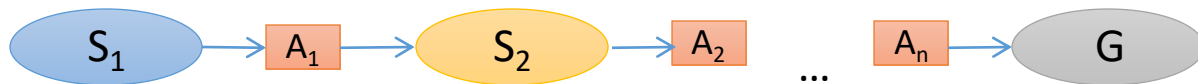
- Agent in task Environment

- 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:

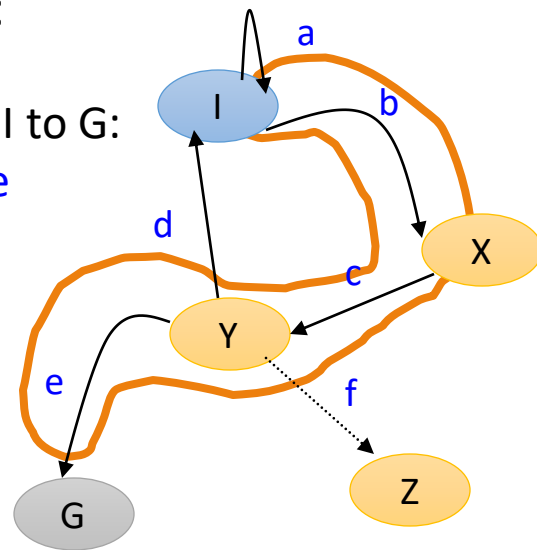
- Start from Initial State, find action sequence whose effects (resulting states) lead to the goal state



Example:

Plan from I to G:

$b \rightarrow c \rightarrow e$



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

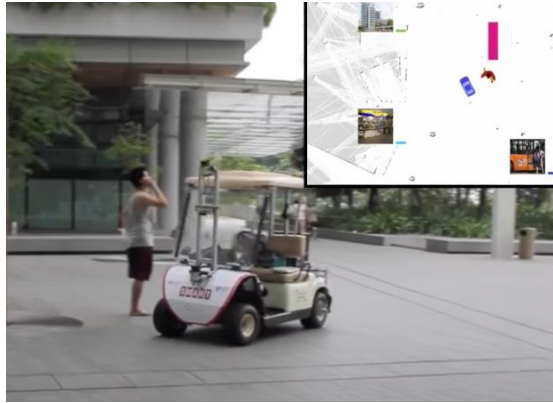
- Planning problem specified in PDDL, a **classical planning** specification that we will learn in this module
 - <https://www.youtube.com/watch?v=B9sYogRVF8Q>



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

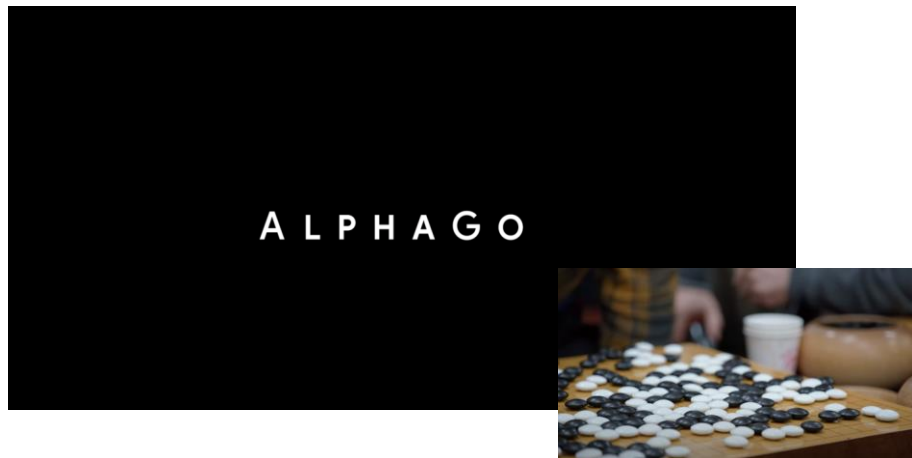
Autonomous driving in NUS UTown

- 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=ozg7gEchjuM>





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>]