Introduction: Problem Environments & Intelligent Agents

CS3243: Introduction to Artificial Intelligence – Lecture 1

10 January 2022

Contents

Administrative Matters

Teaching Staff

- Lecturer
  - Daren Ler : dler@comp.nus.edu.sg
  - https://www.comp.nus.edu.sg/cs/bio/dler/
- Tutors
  - Bryan Wang : e0540007@u.nus.edu
  - Eric Han : dcshlwe@nus.edu.sg
  - Gidijala Rahul : e0425591@u.nus.edu
  - May Lim : dcslmlm@nus.edu.sg
  - Sagar Sureka : e0426366@u.nus.edu
  - Teo Jia Wei : e0415724@u.nus.edu

Topics

1. Introduction: Problem Environments and Intelligence Agents
2. Uninformed Search: Problem-solving Agents and Path Planning
3. Informed Search: Incorporating Domain Knowledge
4. Local Search: Goal Versus Path Search
5. Constraint Satisfaction Problems: Generalising Goal Search
6. Adversarial Search: Playing Games
7. Logical Agents: Knowledge Representation
8. Bayesian Networks: Representations within Uncertainty

Weekly Schedule

- Lectures
  - *Mondays, 1000-1200 hrs*
- Diagnostic Quizzes
  - Release: *After lectures*
  - Deadlines: *Fridays, 2359 hrs*
- Tutorials
  - Begin *Week 3*
  - Release: *After lecture*
  - Deadlines: *Sunday 2359 hrs*

Note:
Week 1 deadlines
pushed to Week 2

Detailed Schedule: LumiNUS > CS3243 > Module Details > Description > Schedule

General Schedule

- Projects
  - Project 1: released *Week 3*; due *Week 6*
  - Project 2: released *Week 6*; due *Week 9*
  - Project 3: released *Week 9*; due *Week 12*
- Midterm Quiz
  - *28 February, 1010-1140 hrs* (Week 7 Lecture Slot)
- Final Examination
  - *25 April, 1700-1900 hrs*

Detailed Schedule: LumiNUS > CS3243 > Module Details > Description > Schedule

Consultations & Other Academic Support

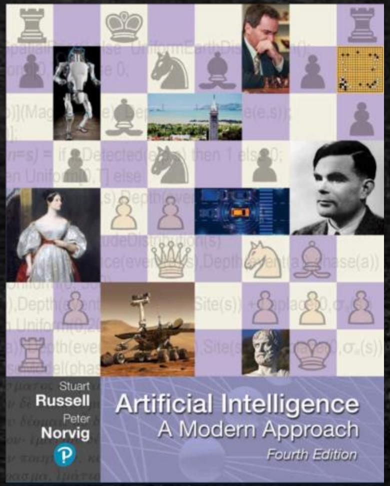
- Consultations
  - By appointment only
  - Exhaust other channels first
- LumiNUS forums
  - Post questions in relevant forums
  - Answer in reasonable time
  - Do ***not*** post solutions
- Telegram groups
  - One Telegram group per tutorial class
  - Managed by your tutor

Assessments

- Diagnostic Quizzes (12)
  - Total 10%
  - LumiNUS Quiz (1 Attempt)
  - 1.25% for Best 8
- Tutorial Assignments (10)
  - Total 10%
  - LumiNUS File Submission
  - 1% each
- Projects (3)
  - Total 30%
  - Individual
  - Each project 10% (2% competitive)
- Midterm Quiz (1)
  - Total 20%
  - Closed Book + Cheat Sheet
  - Online + LumiNUS Quiz
  - Zoom + Screen Recording
  - NO MAKEUP
- Final Examination (1)
  - Total 30%
  - Closed Book + Cheat Sheet
  - Online + LumiNUS Quiz
  - Zoom + Screen Recording

Resources & Textbook

- LumiNUS for all course material
  - https://luminus.nus.edu.sg/modules/e9958908-6911-453c-8e22-547be8653fc6
  - Includes link to library-archived Past Exam Papers (bottom of menu)
- Textbook
  - Artificial Intelligence: A Modern Approach (4th Edition)
  - IBSN 9780134610993
  - Library: https://linc.nus.edu.sg/search/i=9780134610993



Plagiarism & Copyright

- Plagiarism
  - F Grade in module if caught
  - New update this week?
- Copyrights

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NUS Course Materials: Ethical Behaviour and Respecting Copyright

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Examples of Disallowed Things

No Posting on any websites (except for the materials explicitly allowed by your lecturer in the respective module)

No selling of material

No sharing of questions/answers which could lead to cheating/plagiarism

Lecture Protocol

- Periodic pauses to take questions
  - Unmute and ask verbally
  - Type in Zoom chat
- Archipelago
  - Use Voting Board
  - Checked before Zoom chat
- Priority
  - Verbal > Archipelago > Zoom Chat
- Lecture recordings
  - LumiNUS > CS324 > Conferencing > Previous
  - LumiNUS > CS3243 > Multimedia

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Questions on Administrative Matters?

- Was anything unclear?
- Do you need to clarify anything?

- Channels
  - Verbally on Zoom
  - On Archipelago
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What is Artificial Intelligence (AI)?

Artificial Intelligence (in a Nutshell)

- Solving problems to help humans
  - Programs relating to human actions / thinking
  - More dynamic solutions → able to deal with many cases
    - Example
      - Google DeepMind's AlphaGo, AlphaZero, and MuZero
        https://deepmind.com/research/case-studies/alphago-the-story-so-far (with movies)
  - Generality of the solution is the key

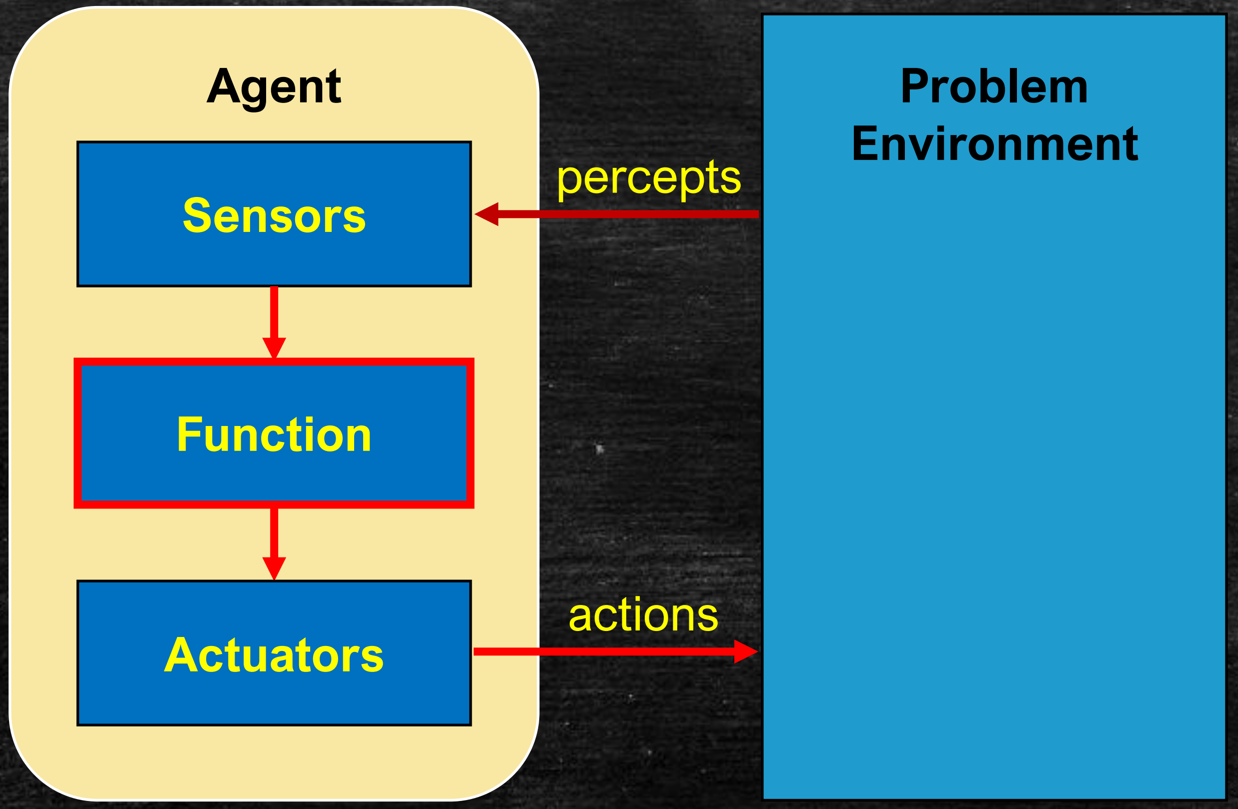
- Building intelligent mechanisms
  - Perform at least as well as humans
  - Not necessarily in the same way as humans (nature)
    - Need not follow the example we know of – e.g., birds versus planes

Kinds of AI

- Strong AI
  - *General* problem-solver
  - Very dynamic programs → solves many problems
- Weak / Narrow AI
  - Less dynamic programs → solves fewer problems (typically just 1)
  - Corresponds to most AI work
- Usually focused on Narrow AI
  - Easier to formalise
  - *More on this later …*

Intelligent Agents

Agent Framework



Agent Components

- Sensors and actuators
  - Sensors: what can/should be captured about the environment?
    - Percept data at time step t, p_t
    - Percept sequence, $P = \{ p_1, \ldots, p_t \}$
  - Actuators: how will the agent affect change in the environment?
    - Set of actions, A

- Focus is on the agent function
  - Specify a function f
  - Such that $f : P \rightarrow a_t$
  - Where $a_t \in A$ is the selected action given P

CS3243 focuses on

- Representations for ***P*** and ***A***
- Algorithms that determine f

Rationality & Performance

- Desire a program that works well
  - At least better than humans; ideally optimal
  - Implies a quantifiable objective → performance measure
    - Are the objectives and performance measure aligned?

- Rational agent (function), $f : P \rightarrow a$
  - Given
    - Percept sequence
    - Prior knowledge
    - Set of actions
    - Performance measure

    } available data
  - Rational agent optimises performance measure

Note:
do ***not*** assume
agent is omniscient

Why more Narrow AI?
Easier to define the performance measure and thus a rational agent to solve that problem

AI as Search: A First Look

- Goal in AI → determine agent function f
  - $f : P \rightarrow a$
  - $a \in A$

- Key idea → AI as graph search
  - Each percept corresponds to a state in the problem (state → vertex)
  - Define the desired states → goals
  - After each action, we arrive at a new state (action → edge)
  - Construct a search space (graph)
  - Design and apply a graph search algorithm

Recall the agent framework
- Agent gets percepts
- Agent function determines action
- Agent enacts action
- Repeat

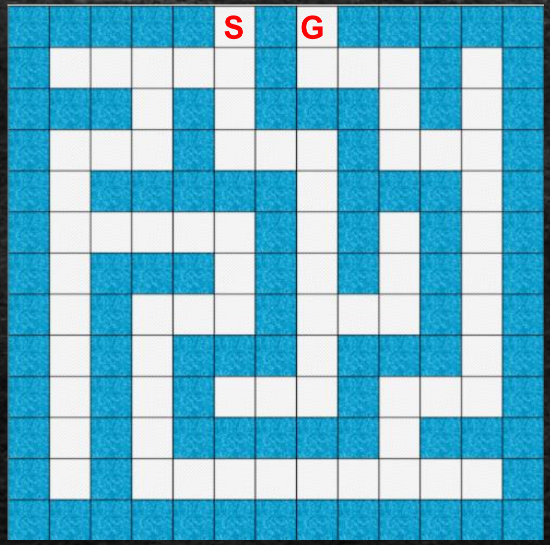
(1) Define performance measure and search space

(2) Design search algorithm

First problem we will look at in CS3243 (next week)
– *other topics will expand on this idea*

An Example Agent

- Problem environment
  - 2-dimensional maze navigation agent
  - P_i : (row, column)
  - A : { ←,↑,→,↓ }



- Agent function f ?
  - Assume map always the same
    - Function: series of if statements
  - Assume map is different each time but remains static during game
    - Function: determined by path planning algorithm (e.g., Dijkstra's)
  - What other possible assumptions?
    - We review this in the next part of the lecture

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Problem Environments

Environment Properties

- Fully observable versus partially observable
  - Agent cannot access all information as some cannot be sensed
  - Requires handling uncertainty

- Deterministic verses stochastic
  - Stochastic → intermediate state cannot be determined based on action taken at a given state
  - Handling uncertainty typically required

- Stochastic → partially observable?
  - May be fully observable (sense all) but still have randomness with action

Environment Properties

- Episodic versus sequential
  - Episodic → actions only impact the current state (not those beyond)
  - Sequential → an action may impact all future decisions
  - *Note that it is possible to model an episodic environment into a sequential search space (more on this next week)*

- Discrete versus continuous
  - Refers to state information, time, percepts, actions

Environment Properties

- Single vs multi-agent
  - Do other entities exist in within the environment that are themselves agents whose actions directly influence the performance of this agent?
    - Chess → opponent is a competitive agent
    - Automated vehicles → other vehicles are cooperating agents

- Known versus unknown
  - Refers to knowledge of the agent/designer (not environment itself)
  - Includes performance measure

- Static versus dynamic
  - Will the environment change while the agent is deciding an action?

Environment Properties

Property	**CS3243**	**Notes**
Fully / Partially Observable	Both	Latter in Bayesian Networks
Deterministic / Stochastic	Both	
Episodic / Sequential	Both	
Discrete / Continuous	Both	Mostly discrete
Single / Multi-agent	Both	Latter in Adversarial Search
Known / Unknown	Known	
Static / Dynamic	Static	

Taxonomy of Agents

Types of Agents

- Reflex agent
  - Uses rules in the form of if-statements to make decisions
  - Direct mapping of percepts to actions
  - Mostly domain specific
  - Impractical with large search spaces

- Model-based reflex agent
  - Makes decisions based on an internalised model

Types of Agents

- Goal-based and utility-based agents
  - Given
    - State and action representations
    - Definition of goals or utility
  - Determines
    - Sequence of actions necessary to reach goals or maximise utility
    - Or state that satisfies goal conditions or maximises utility

- Learning agents
  - Agents that learn how to optimise performance

Environment Properties

Property	CS3243	Notes
Reflex Agents	Yes	
Model-Based Reflex Agents	Yes	• Logical Agents • Bayesian Networks
Goal-Based and Utility-Based Agents	Yes	• Uninformed / Informed Search • Local Search • Constraint Satisfaction Problems • Adversarial Search
Learning Agents	No	

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