

# Introduction: Problem Environments & Intelligent Agents

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CS3243: Introduction to Artificial Intelligence – Lecture 1

10 January 2022

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# Administrative Matters

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# Teaching Staff

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- Lecturer
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# Topics

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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

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- 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

# General Schedule

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- 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*

# Consultations & Other Academic Support

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- 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



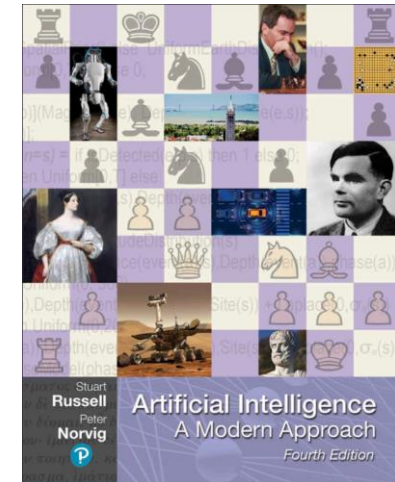
# Assessments

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- 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 (4<sup>th</sup> Edition)
  - ISBN 9780134610993
  - Library: <https://linc.nus.edu.sg/search/i=9780134610993>



# Plagiarism & Copyright

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



## NUS Course Materials: Ethical Behaviour and Respecting Copyright

All course participants (including permitted guest students) who have access to the course materials on LumiNUS or any approved platforms by NUS for delivery of NUS modules are not allowed to re-distribute the contents in any forms to third parties without the explicit consent from the module instructors or authorized NUS officials



## 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

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- 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



OR <https://archipelago.rocks/app/resend-invite/16959622599>

# Questions on Administrative Matters?

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- Was anything unclear?
- Do you need to clarify anything?
- Channels
  - Verbally on Zoom
  - On Archipelago
  - Via Zoom Chat



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# What is Artificial Intelligence (AI)?

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# Artificial Intelligence (in a Nutshell)

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- 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

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- 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 ...*

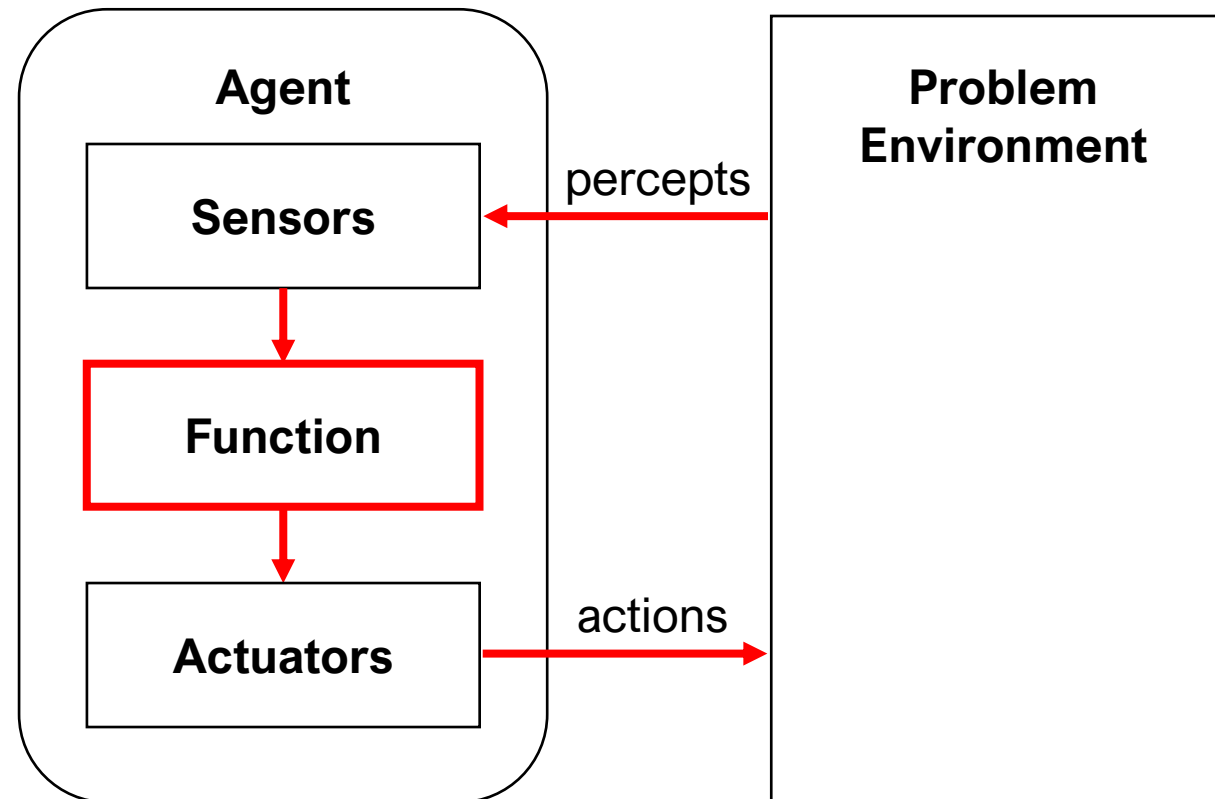


# Intelligent Agents

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# Agent Framework

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# Agent Components

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- Sensors and actuators
  - Sensors: what can/should be captured about the environment?
    - Percept data at time step  $t$ ,  $p_t$
    - Percept sequence,  $\mathbf{P} = \{p_1, \dots, p_t\}$
  - Actuators: how will the agent affect change in the environment?
    - Set of actions,  $\mathbf{A}$
- Focus is on the agent function
  - Specify a function  $f$
  - Such that  $f: \mathbf{P} \rightarrow a_t$
  - Where  $a_t \in \mathbf{A}$  is the selected action given  $\mathbf{P}$

CS3243 focuses on

- Representations for  $\mathbf{P}$  and  $\mathbf{A}$
- 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  $\rightarrow$  determine agent function  $f$ 
  - $f: P \rightarrow a$
  - $a \in A$

- Key idea  $\rightarrow$  AI as graph search

- Each percept corresponds to a state in the problem (state  $\rightarrow$  vertex)
- Define the desired states  $\rightarrow$  goals
- After each action, we arrive at a new state (action  $\rightarrow$  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

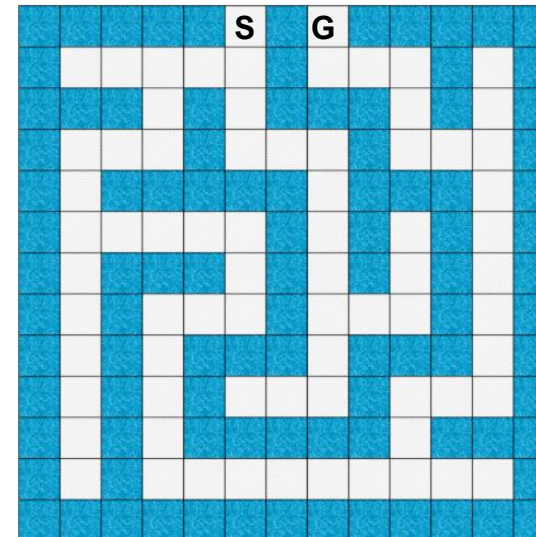
(1) Define performance measure and search space

(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)
  - $A$  :  $\{ \leftarrow, \uparrow, \rightarrow, \downarrow \}$
- 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

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# Environment Properties

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- Fully observable versus partially observable
  - Agent cannot access all information as some cannot be sensed
  - Requires handling uncertainty
- Deterministic versus stochastic
  - Stochastic  $\rightarrow$  intermediate state cannot be determined based on action taken at a given state
  - Handling uncertainty typically required
- Stochastic  $\rightarrow$  partially observable?
  - May be fully observable (sense all) but still have randomness with action

# Environment Properties

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- 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

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- 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

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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

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# Types of Agents

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- 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

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- 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

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Property	CS3243	Notes
Reflex Agents	Yes	
Model-Based Reflex Agents	Yes	<ul style="list-style-type: none"><li>• Logical Agents</li><li>• Bayesian Networks</li></ul>
Goal-Based and Utility-Based Agents	Yes	<ul style="list-style-type: none"><li>• Uninformed / Informed Search</li><li>• Local Search</li><li>• Constraint Satisfaction Problems</li><li>• Adversarial Search</li></ul>
Learning Agents	No	



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