Introduction

Wednesday, 11 August 2021 11:15 AM

About the Instructor: Kuldeep S. Meel

- Email: meel+teaching@comp.nus.edu.sg
- Presidential Young Professor (March 2021 – Present)
  - Sung Kah Kay Assistant Professor (July 2018 – June 2021)
- Research Areas: Artificial Intelligence and Formal Methods
  - 2020 IEEE AI's 10 to Watch; 2019 NRF Fellowship for AI
- 2021 Faculty Teaching Excellence Award
- B.Tech. (08/08-05/12) IIT Bombay
- M.S. (01/13 – 05/14); Rice University
  - 2014 Vienna Center of Logic and Algorithms International Thesis Award
- PhD (05/14-09/17); Rice University
  - 2018 Ralph Budd Award

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Teaching Resources: LumiNUS

http://luminus.nus.edu.sg/

- Lesson Plan
- Lectures, Tutorials, Supplementary Materials, Homework
- Discussion forum
  - Any questions related to the course should be raised on this forum
  - Forums are anonymous.
  - Emails will typically have the longest latency.
  - **Emails to teaching staff should be sent only for private matters; other emails will not be answered as a policy to ensure fairness.**
  - Email address: **cs3243private@googlegroups.com**
- Announcements

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Additional Resources

- Instructor's Lecture Notes.
  - https://cs3243-notes.github.io/
  - In addition to PDF, we would like to also have notes in easily accessible format.
  - Your contributions are welcome. Checkout Github repo for instructions.
- Textbook (Optional and Not Recommended):
  - Russell and Norvig (2010). Artificial Intelligence: A Modern Approach (3rd Edition)

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Tentative Syllabus

1. Introduction to Artificial Intelligence
2. Uninformed Search
3. Informed Search
4. Local Search and Optimization Problems
5. Constraint Satisfaction Problem
6. Stochastic Environment
7. Reinforcement Learning
8. Games: Adversarial Search
9. Bayesian Networks
10. Knowledge Representation

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Assessment Overview

What	Grade Percentage
Midterm Exam (during lecture, NO make-up)	25%
Final Exam	35%
Class Projects	30%
Tutorials (Best 6 out of 9)	10%

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Prerequisites

WE WILL ASSUME THAT YOU HAVE THOROUGH UNDERSTANDING OF YOUR PRE-REQUISITES.

STRONG DESIRE TO LEARN

THIS IS A 4 CREDIT MODULE; SO THE COURSE LOAD WOULD REQUIRE YOU TO SPEND **TEN** HOURS PER WEEK.

IF YOU ARE NOT STRUGGLING, YOU ARE NOT LEARNING. YOU WILL HAVE TO PUT TIME AFTER THE LECTURE TO UNDERSTAND THE LECTURE.

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My Teaching Philosophy

- 3000+ level modules need to teach you a way to think not merely the techniques. My goal is to **teach you how to learn** concepts in Artificial Intelligence.
  - "Answers" have no value if you don't know to derive them from first principles
  - I am not going to ask you to do "busy work" or remember "facts".
- I trust students when they tell me what they do or do not know.
- **BUT** it is the job of instructor (i.e., me) to figure out what and how to teach.
  - A child may want to eat candies the whole day but it's the job of parents to decide how many candies to give.
- Be ruthless in your pursuit of knowledge. Your only concern should be to make sure you learn what I am teaching. It is **my** job to figure out when to answer your question or how to pace the class. You should not worry about my job. Ask question all the times....
  - "The only stupid question is the one you didn't ask"

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Academic Integrity

- I take academic integrity **very seriously**.
- There is strict honor code for all the graded components: You are allowed to discuss with anyone in the class but the submitted work must be your own work. ("your own" == "your group" for group projects).
- Ask if there is doubt.
- Any minor violation will be reported to the highest levels at the university and **I will ask for maximum punishment including but not limited to F for the entire course and letter of reprimand.**
- Global pandemic does not mean you can comprise with your internal moral and ethical values.

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Academic Integrity Quiz #1

- Which of the following can be classified under "your own work"?
  - A. Solutions found on the internet after lot of googling
  - B. Solutions from past iterations of the course (after lot of effort in trying to locate it)
  - C. Solutions prepared by your genius friend
  - D. None of the above

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Academic Integrity Quiz#2

- For which of the first-time offences, the instructor will report to SoC and NUS, and argue for F grade and letter of reprimand ?

  A. Cheating on even one question of a Tutorial assignment
  B. Copying of lecture notes
  C. Cheating on even one question of exams
  D. Copying of even one function in any of the projects
  E. All of the above (and more)

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Pre-requisites Quiz

1. Note your name and student ID.
2. The quiz is available in the LumiNUS folder: “Quiz -> Question paper”
3. The quiz will help you (and us) determine if you have adequate background.

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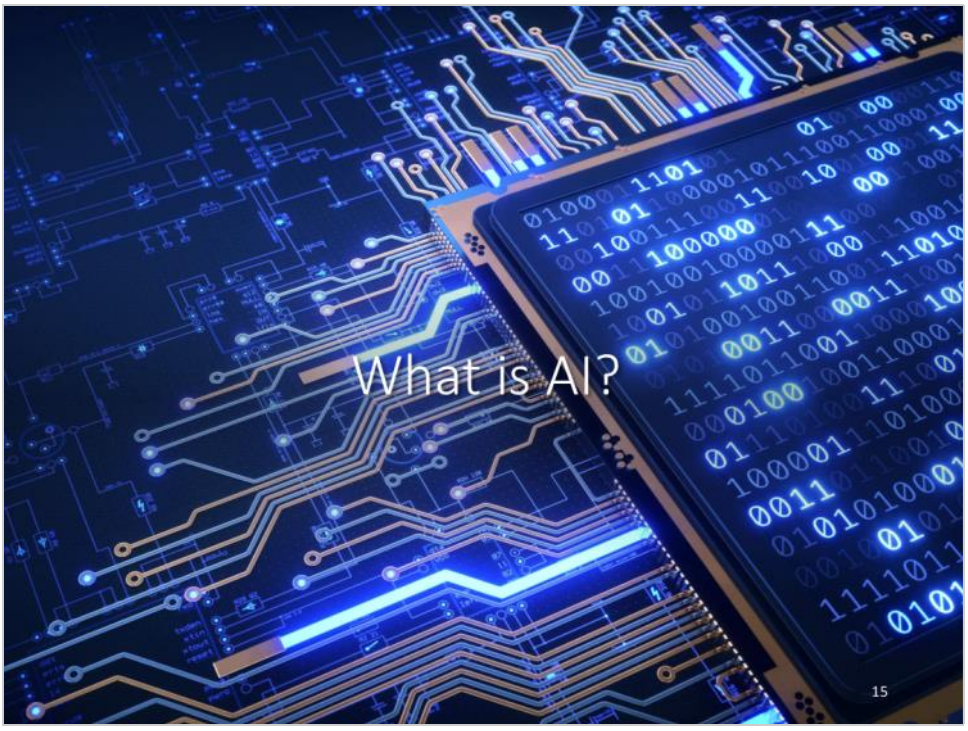

AI: Artificial Intelligence

"Natural": Biological

What does it mean to be Intelligent?

- Are feelings intelligent ?
  - Perhaps not, "Love is blind" after all.
- Apply reason: Rational Behavior

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KPI for AI

- Turing Test (1950)
  - An object is intelligent if a bird could not tell whether it is a bird or not.
  - Did not want to make it look like humans, so communication channel was clearly defined.
  - Very subjective, so results are likely to be debatable.

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The Era of Many Tests

- Vision: Image Net
- International Planning Competition
- Satisfiability and CSP competitions
- Robotics Challenges

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Actions: possible actions available to an agent

Transition model:

RESULT (STATE, ACTION) = Resulting STATE

Rational Agents

- What should AI exactly aim to do?
  - Design Rational Agents
- The module could have been titled:

Intro to Rational Agents Design (RAD)

- RAD (Urban dictionary): "Uber cool"

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What is Agent?

- Anything that can be viewed as perceiving its environment through sensors; acting upon that environment through actuators
- **Human agent:** eyes, ears, skin etc. are sensors; hands, legs, mouth, and other body parts are actuators
- **Robotic agent:** cameras and laser range finders for sensors; various motors for actuators

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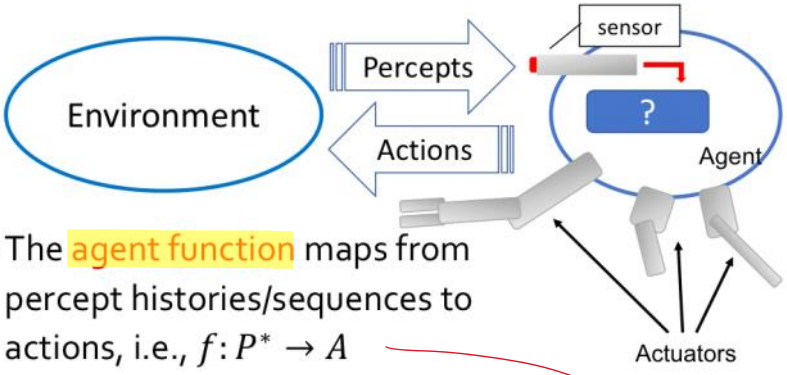
What is Agent?



- The agent function maps from percept histories/sequences to actions, i.e., $f: P^* \rightarrow A$
- The agent program runs on the physical architecture to perform f

there are a specific set of valid inputs & possible outputs
→ bound by sensors → how to model the environment
→ bound by physical architecture

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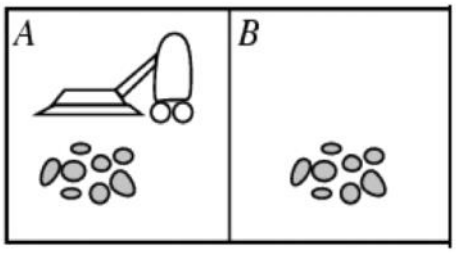
Mop Bot World



Environment: Location of Mopbot, Status of Each Location (Clean or Dirty)

Percept: Current Location and the status of that Location

Actions: Left, Right, Mop, Idle

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Mop Bot Agent Function

Percept Sequence	Action 1
$[A, \text{Clean}]$	Right
$[A, \text{Dirty}]$	Mop
$[B, \text{Clean}]$	Left
$[B, \text{Dirty}]$	Mop
$[A, \text{Clean}], [A, \text{Clean}]$	Right
$[A, \text{Clean}], [A, \text{Dirty}]$	Mop

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Mop Bot Agent Function

Percept Sequence	Action 1	Action 2
$[A, \text{Clean}]$	Right	Mop
$[A, \text{Dirty}]$	Mop	Right
$[B, \text{Clean}]$	Left	Mop
$[B, \text{Dirty}]$	Mop	Left
$[A, \text{Clean}], [A, \text{Clean}]$	Right	Mop
$[A, \text{Clean}], [A, \text{Dirty}]$	Mop	Right

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Acting Rationally: Rational Agent

- Rational behavior: doing the "right thing"
- The right thing to do on Jan 15, 2020
  - Lockdown the entire world for 3 weeks.
- Rationality ≠ omniscience (all-knowing with infinite knowledge)

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Acting Rationally: Rational Agent

- An agent should strive to "do the right thing", based on what it can perceive and the actions it can perform.
- Performance measure: objective criterion for measuring success of an agent's behavior
- Vacuum-cleaner agent:
  - amount of dirt cleaned
  - time taken
  - electricity consumed
  - noise generated

} Perhaps a bit of everything?

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Specifying Task Environment

Performance Measure
- amount of dirt cleaned
- time taken
- electricity consumed
- noise generated

Environment
- Rooms
- Cats
- Food bites

Actuators
- Mop
- Accelerator
- Brake
- Vacuum pump
- Speaker

Sensors
- Cliff
- Dirt
- Speedometer
- Bluetooth

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Properties of Task Environments

Fully observable (vs. partially observable):
- sensors provide access to the complete state of the environment at each point in time.

Deterministic (vs. stochastic)
- The next state of the environment is completely determined by the current state and the action executed by the agent.

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Properties of Task Environments

Static (vs. dynamic)

- The environment is unchanged while an agent is deliberating.

Discrete (vs. continuous)

- A finite number of distinct states, percepts, and actions.

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Properties of Task Environments

Single agent (vs. multi-agent)

- An agent operating by itself in an environment.

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Implementation of Agent Function

Table Driven Agent

Algorithm 1 Table-Driven-Agent(*percept*)

1: Static: *percepts*: a sequence
table: a table of actions, indexed by percept sequences, fully specified.
2: percepts ← precepts ∪ *percept*.
3: *action* ← LOOKUP(*percept*,*table*)
4: **return** *action*

Drawbacks

- Huge table to store
- Take a long time to build the table
- So many entries to get correct

Different Kinds of Agent Programs

Type	Characteristics	Analogy
Simple Reflex	Action depends only on percept	**Infant** • If Hungry then Cry • If Happy then Sleep
Model-based Reflex	Action depends on internal state (based on percept history), model of the world, and percept	**Kid** If Want candy & Didn't Receive candy then Ask for candy
Goal-based	Action depends on current state, percepts, model of the world Action plan to achieve desired goal	**Teenager** Goal: Want to get into NUS Plan: Study and Playing based on the Goal.
Utility-based	Useful for multiple (possible) conflicting goals A weighted combination of goals	**Adult** • α*Job+ β*Partner+ γ*Health

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what to choose depends on the environment model