Introduction to Modern Artificial Intelligence

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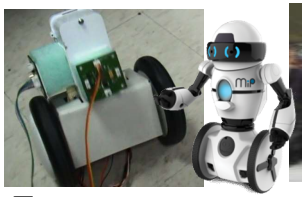
2022/02/22

Outline

- **Introduction to Kuo-Shih**
- What's AI?
- History of AI
- Syllabus
- How to enroll in this course?
- Math and Robotics Lab (Room 213)
- Demonstration
  - Minibot, Bebop

Four legged robots

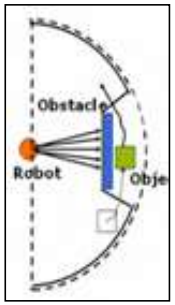
Mobile robots



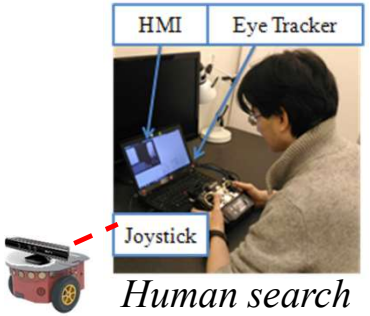
Estimation

Mapping

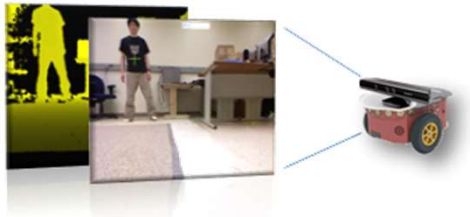
Localization



Tracking



Human search

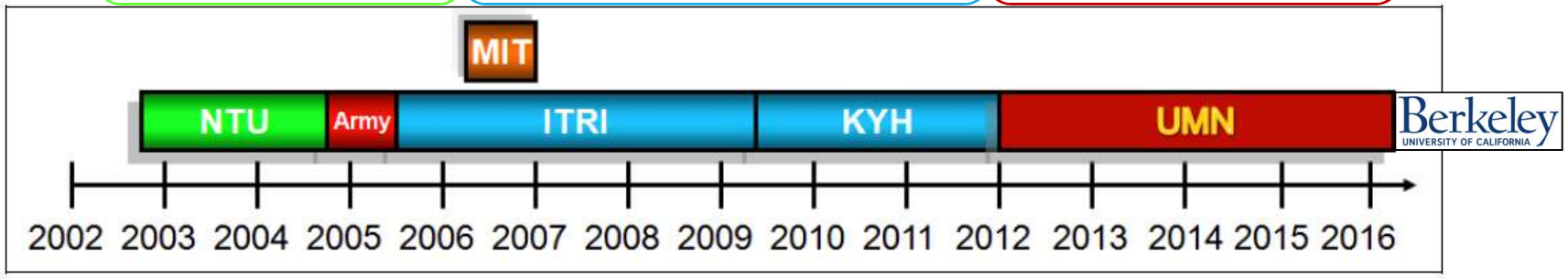


Robot search

Mechatronics (2002~)

Perception (2006~)

Decision making (2012~)



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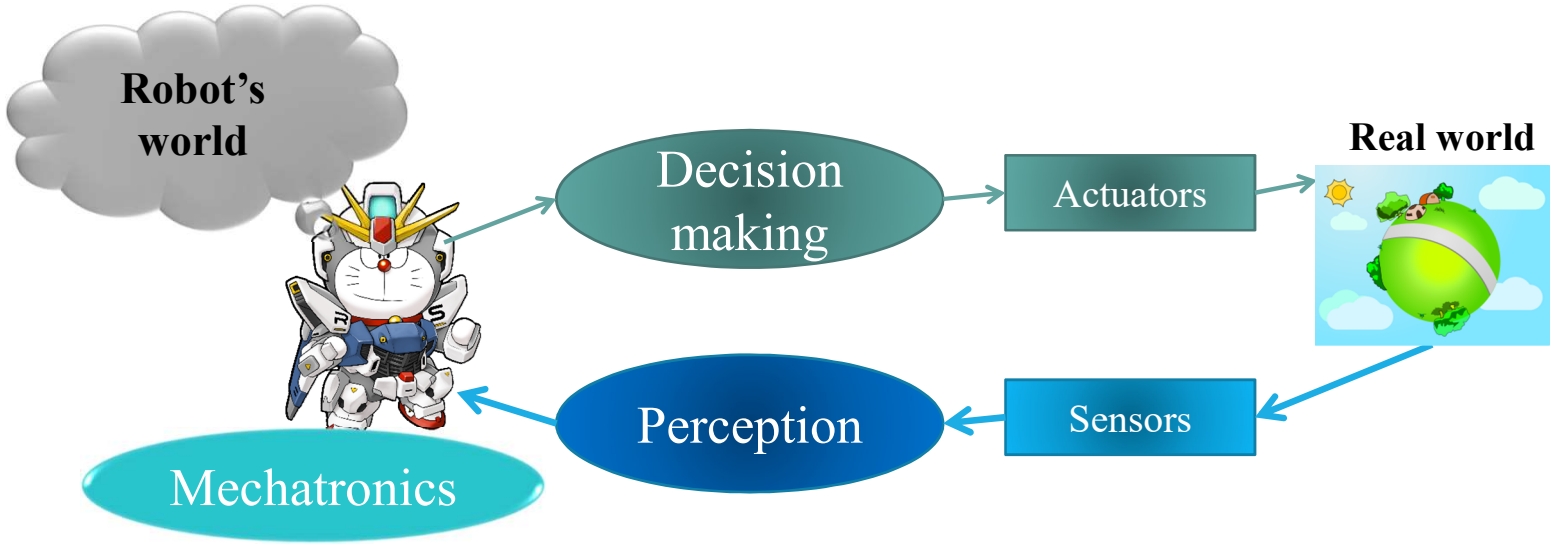
What's AI?

- Definition of AI:
- Any device perceives its environment and takes actions that maximize its chance of successfully achieving its goals. – Poole, Mackworth & Goebel, 1998.
- A machine mimics "cognitive" functions that humans associate with other human minds, such as "learning" and "problem solving". –Russell & Norvig, 2009.
- A system's ability to correctly interpret external data, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation. – Kaplan and Haenlein, 2018.

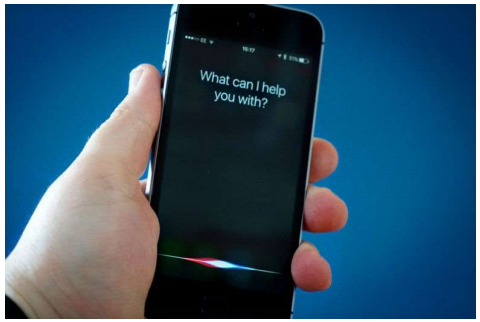
What's AI?



- A machine can interact with the world via perception and decision-making (and improve itself). – Kuo-Shih Tseng, 2019.

What's AI?

ATM



SIRI

Gundam

ASIMO

Roomba

AlphaGo

Which one is AI technology?

What's AI?

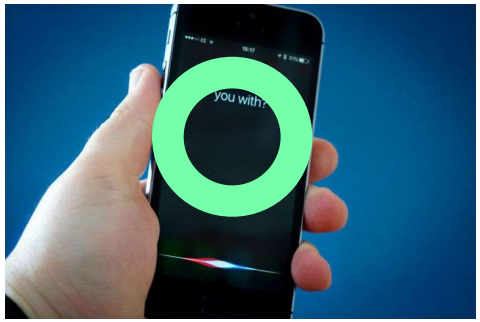
- Weak AI: The machines could act as if they were intelligent
- Strong AI: The machines are actually thinking
- Turing test: A robot interacts with a human via a task. The human cannot distinguish with the task made by a robot or a human. If it's true, this robot passes Turing test, proposed by Alan Turing, 1950.
- Can machines think? "The new form of the problem can be described in terms of a game which we call the imitation game."

  — Alan Turing, 1950.

What's AI?

- **Which one is weak AI technology?**

ATM



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What's AI?

- **Which one is strong AI technology?**

What's AI?

- **Which one can pass Turing test?**

What's AI?

- A machine can interact with the world via perception and decision-making

ATM

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What's AI?

- A machine can interact with the world via perception and decision-making (and improve itself).

ATM

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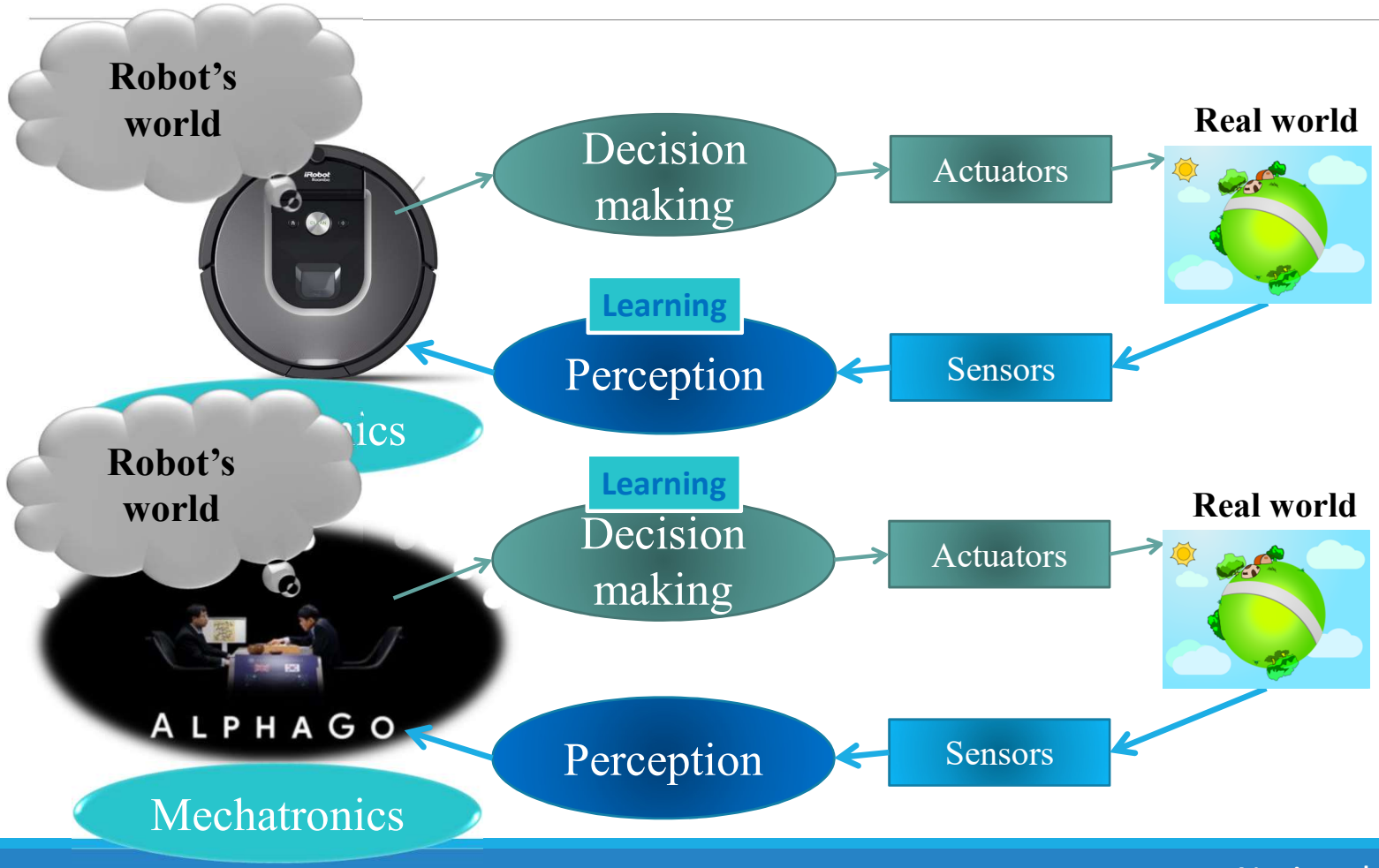
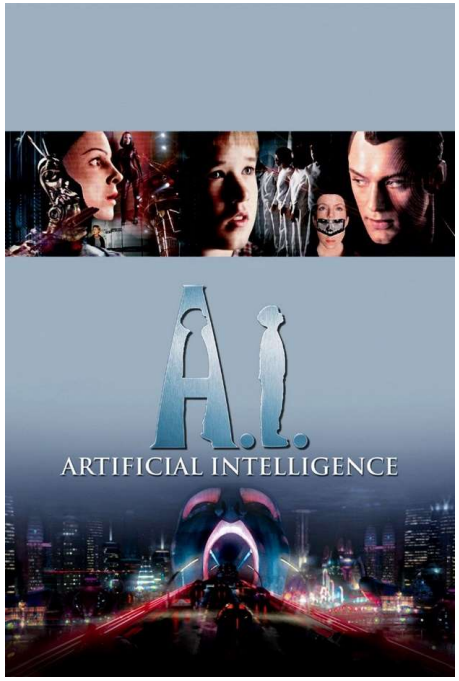
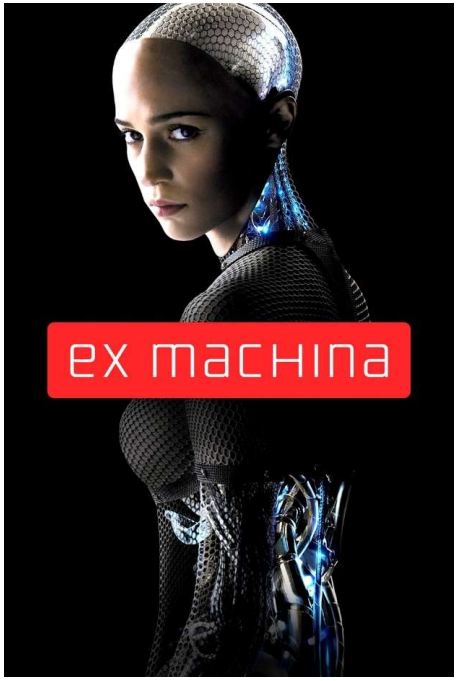
What's AI?


Robot's world
Decision making
Actuators
Real world
Learning
Perception
Sensors
ics
Robot's world
Learning
Decision making
Actuators
Real world
ALPHAGO
Perception
Sensors
Mechatronics

What's AI?

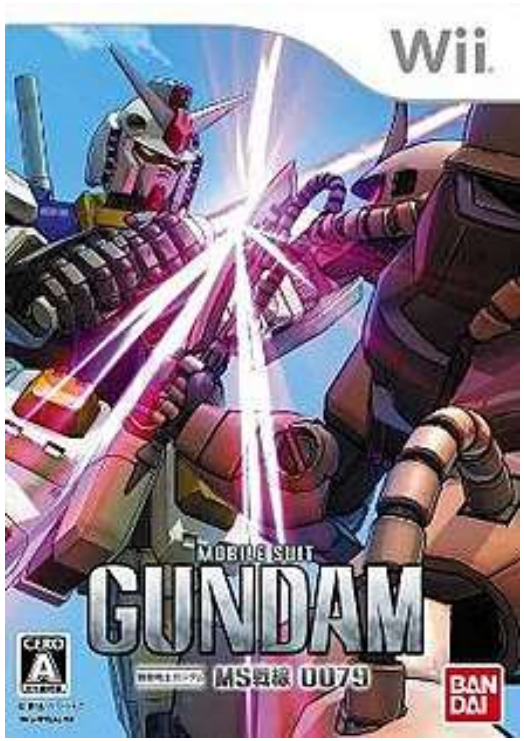
- Watching these movies will learn more about AI.





What's AI?

- Playing these games will NOT learn more about AI.



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- **History of AI**
- Syllabus
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History of AI

- For AI researchers, AI is to "***think how to think***."
- AI methodologies can be divided into two kinds of approaches.
- Symbolicism/logicism/psychologism/computerism:
  - AI is built based on symbolic logic (e.g, 1st order logic).
- Connectionism/bionicsism/physiologism:
  - AI is built based on Biomimetics (e.g., Neural networks).

https://neurovenge.antonomase.fr/

History of AI

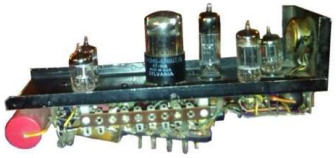
1943

Warren McCulloch and Walter Pitts defined AI as:
1. Knowledge of basic physiology
2. Function of neurons in the brain
3. Formal analysis of proportional logic

1950~1954

Neural Network

Marvin Minsky and Dean Edmonds build SNARC (40 neuros).
This is mathematics?
Von Neumann:
"**If it isn't now, It will be someday**"

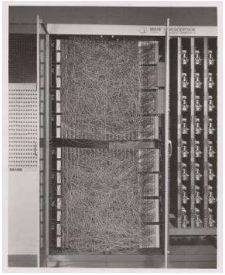


1957 1958

Logic

John McCarthy defined the high-level language – LISP.

Frank Rosenblatt invented "Perceptron"



1969

Expert systems could be applied to other areas of human expertise

(2nd AI depression)

Marvin Minsky wrote a book, "perceptrons."

(1st AI depression)

1988 1995

Probabilistic reasoning

Judea Pearl proposed "Probabilistic reasoning in intelligent systems"

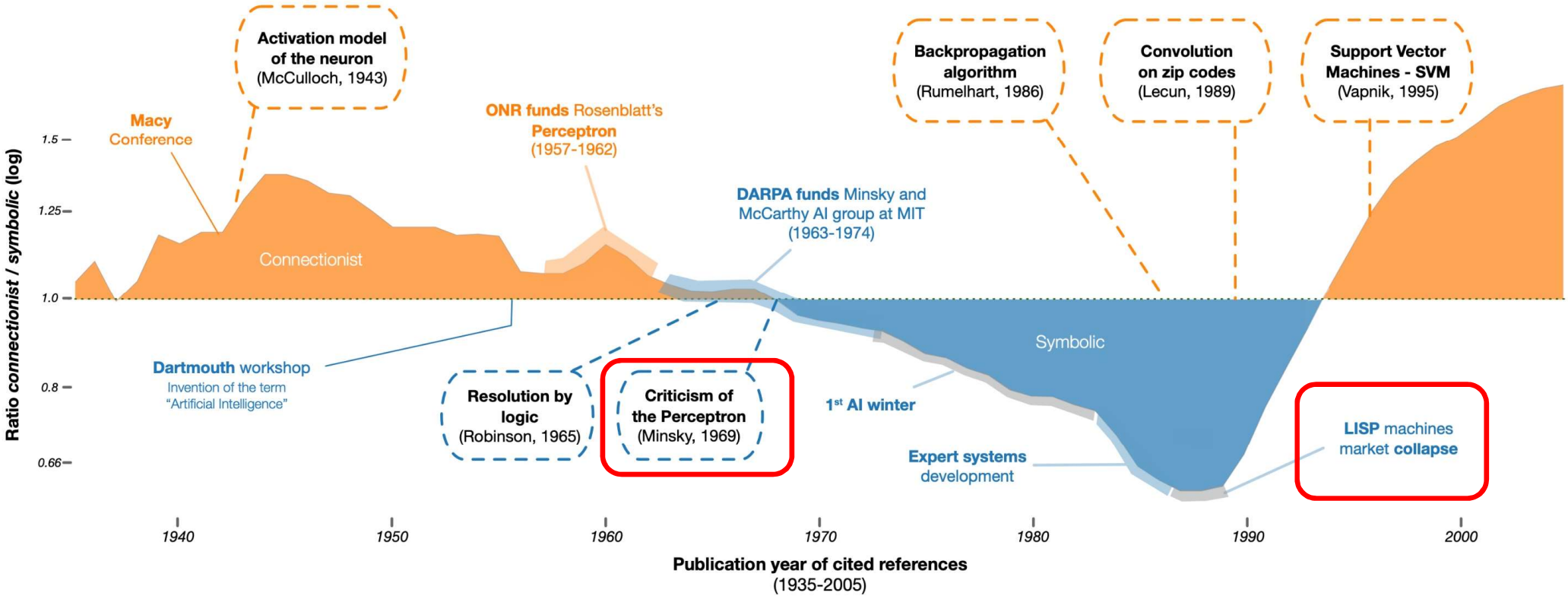
SVM

Vladimir Vapnik proposed "Support Vector Machine"

Reinforcement learning

Chris Watkin proposed "Q-learning"

History of AI



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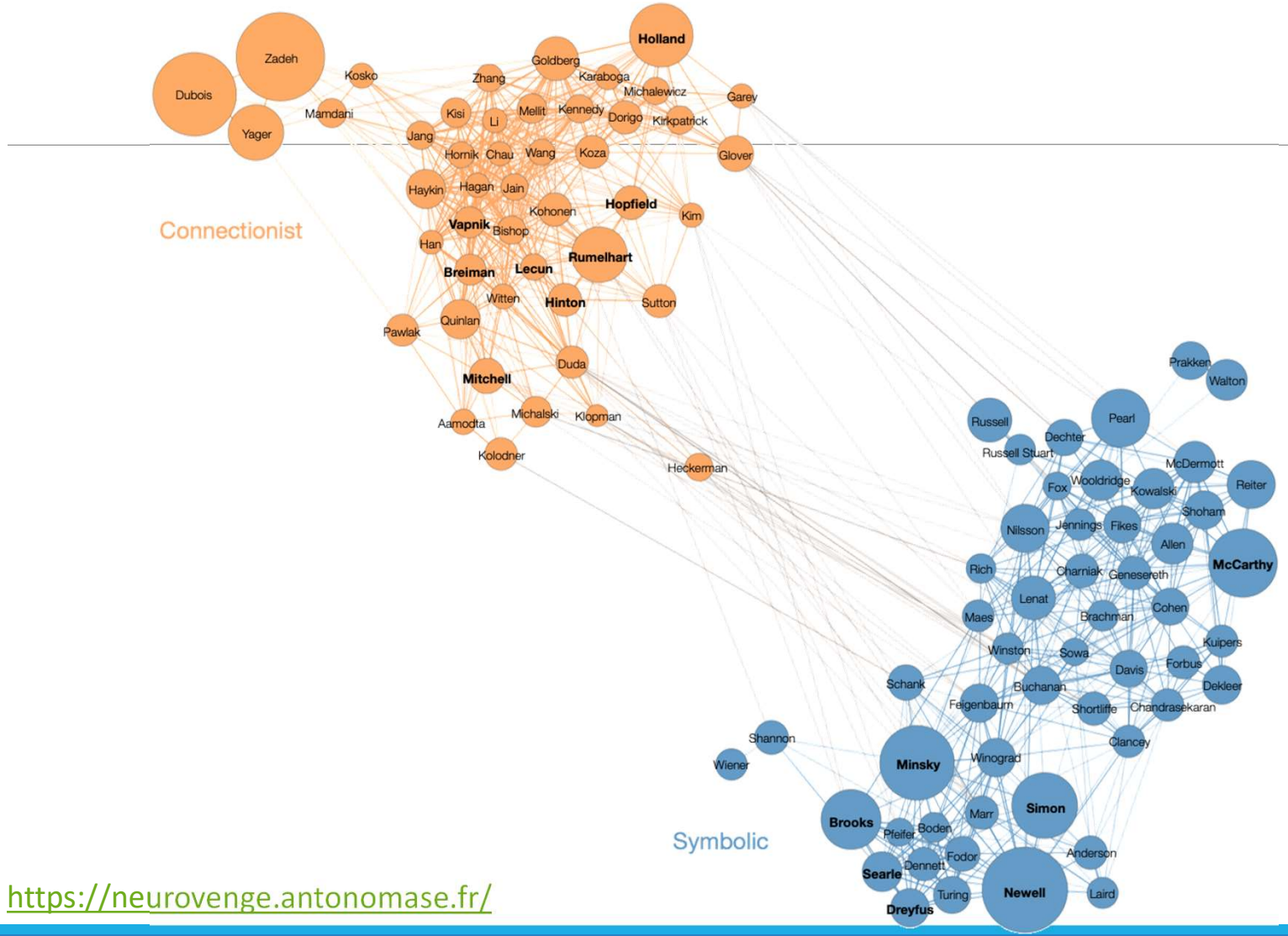

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History of AI

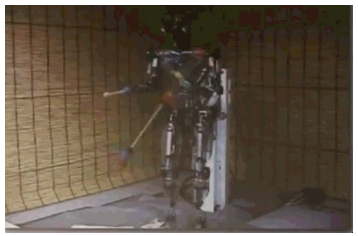
Reinforcement Learning

Deep Learning

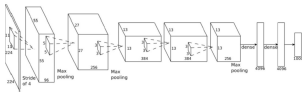
Deep Reinforcement Learning

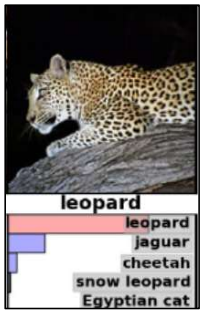
1989 — Chris Watkin proposed Q-learning

2006 — Robots can learn some skills like humans



2012 — AlexNet competed in the ImageNet Challenge





2015 — Computers can play Atari games

2016 — AlphaGo beats human players in GO

https://www.youtube.com/watch?v=V1eYniJ0Rnk

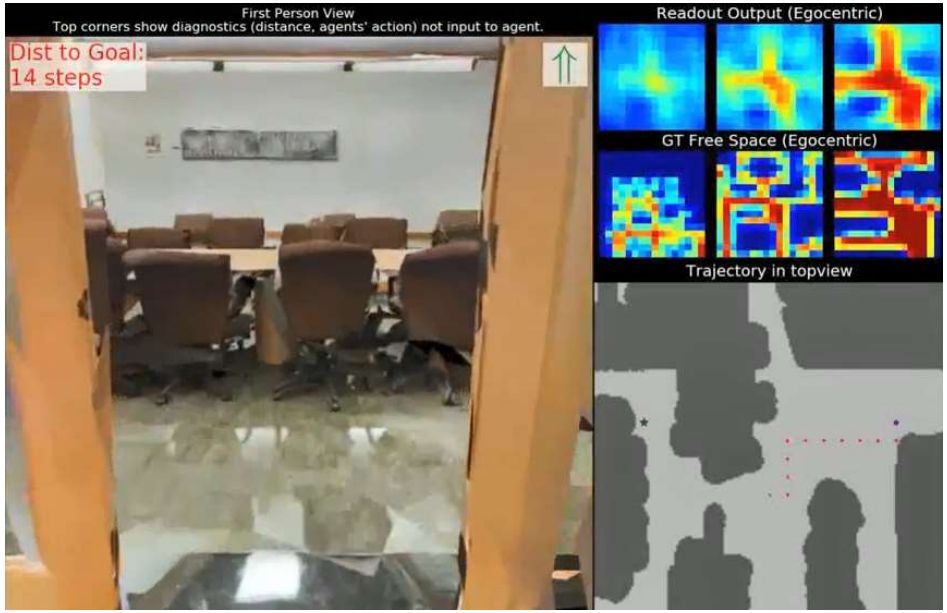
History of AI

- What's state of the art AI?

https://www.youtube.com/watch?v=gn4nRCC9TwQ

History of AI

- What's state of the art AI?

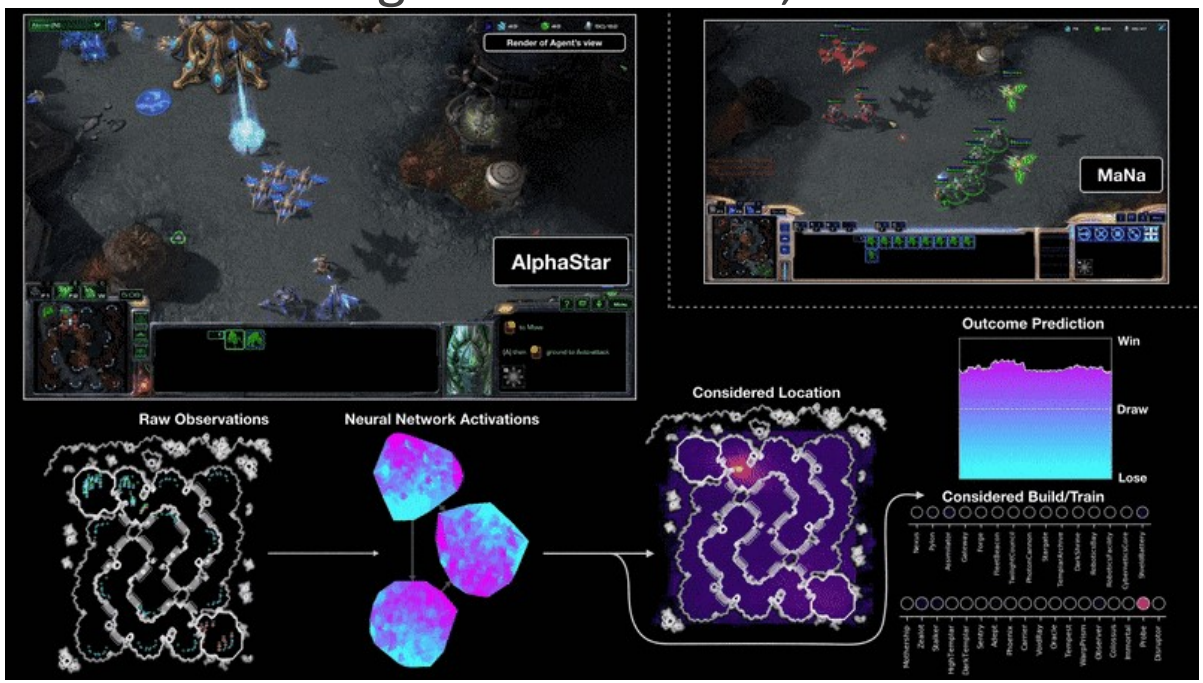


Cognitive Mapping and Planning for Visual Navigation

CAD2RL

History of AI

- The Challenge of StarCraft II, 2019



https://deepmind.com/blog/alphastar-mastering-real-time-strategy-game-starcraft-ii/?fbclid=IwAR0oUtPE9az5V1kKXlSNJOncd1Ys-VP1r3PVICOV5gb0mI39uMowI6SURl8
https://www.youtube.com/watch?v=cUTMhmVh1qs

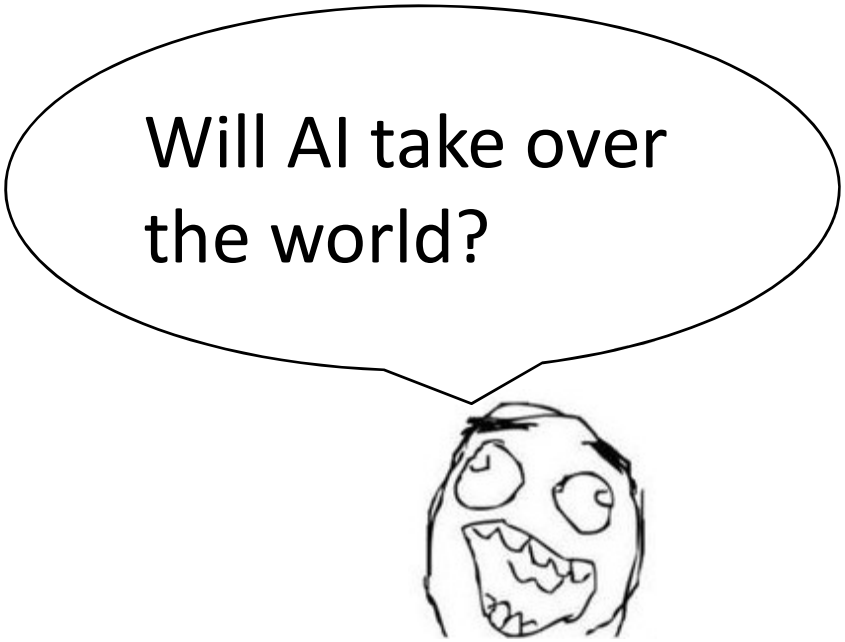
History of AI

- Deep reinforcement learning could be the future of AI. But, it cannot solve all problems currently. You can find these successful examples are based on observable information or simulators.
- There are still a lot of challenging problems in AI.
- We need more researchers involved in AI. That's the reason why you are here!

- We are doing something like movies (Matrix – learning kung fu)
- https://www.youtube.com/watch?v=6vMO3XmNXe4

History of AI

"They don't appear to want to take over. They just want to dance."



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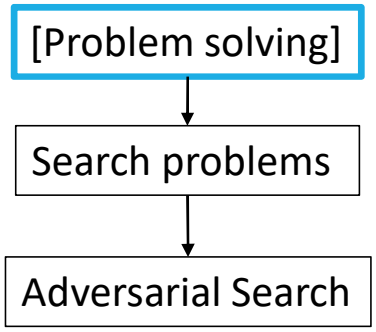
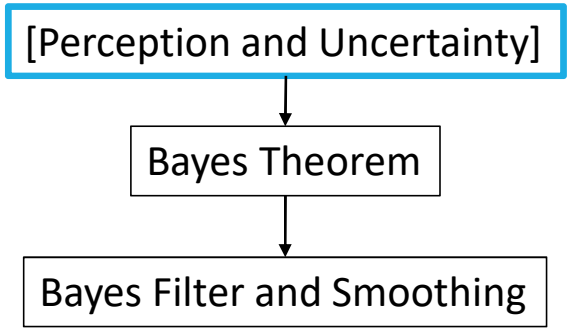
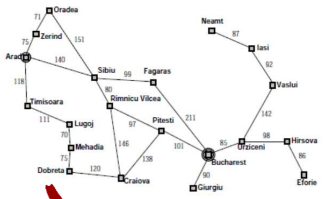
Syllabus

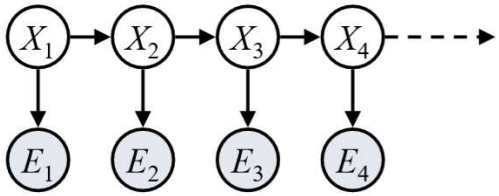
- L1: Introduction
- L2: Search
- L3: Search
- L4: Adversarial search

- L5: Bayes theorem
- L6: Bayes theorem over time



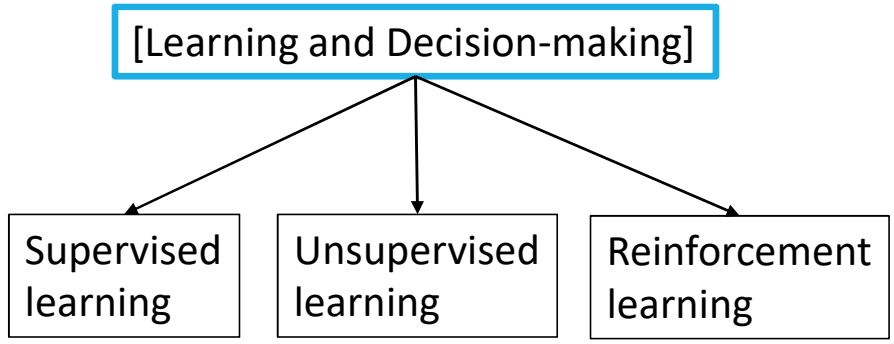


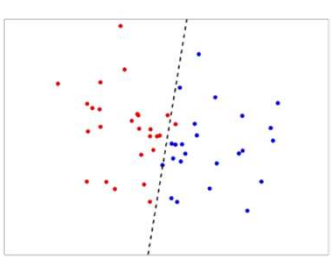


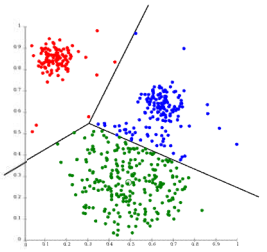


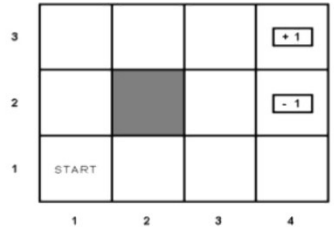
Syllabus

- L7: MDP
- L8: POMDP
- L9: Reinforcement learning
- Midterm
- L10: GP and LWPR



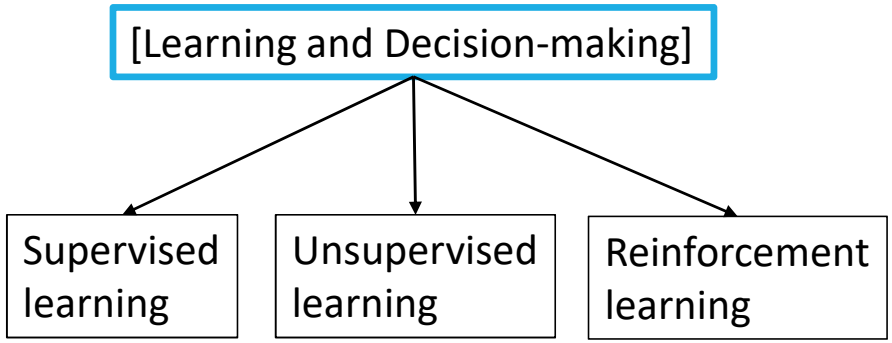


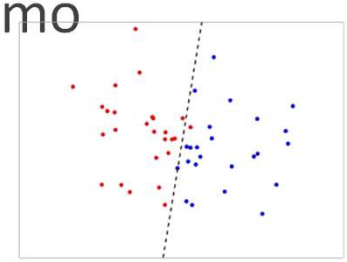


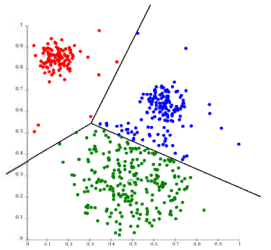


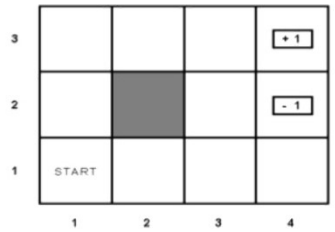
Syllabus

- L11: Naïve Bayes and Perceptron
- L12: Adaboost
- L13: Deep learning and DRL
- L14: K-Means and EM
- ROS Tutorial (2 lectures)
- Final Project Presentation and Demo

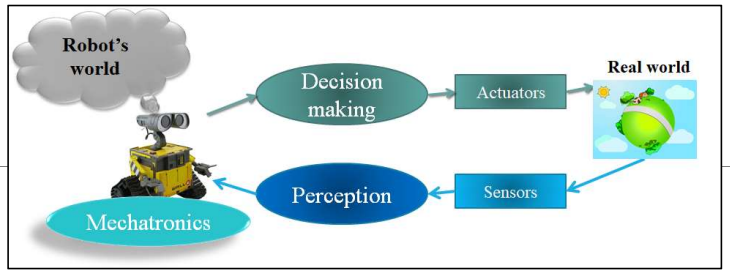








Syllabus



[Problem solving]

Search problems

Adversarial Search

[Perception and Uncertainty]

Bayes Theorem

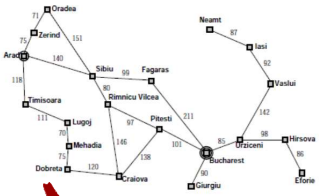
Bayes Filter and Smoothing

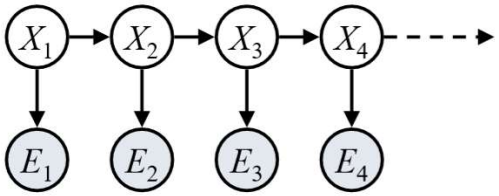
[Learning and Decision-making]

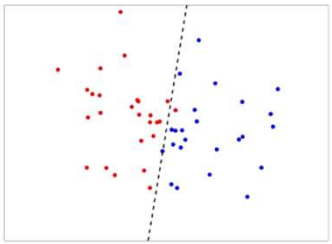
Supervised learning

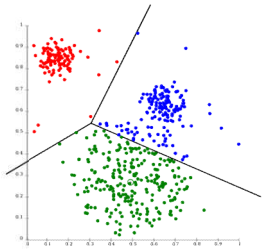
Unsupervised learning

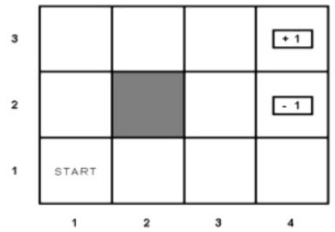
Reinforcement learning











Syllabus

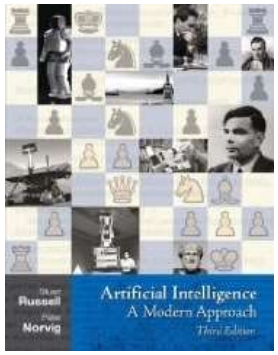
- The grade for this course will consist of the following components:
  - Homework (X3) 30%
  - Midterm Exam 30%
  - Project Proposal (1-2 page) 10%
  - Project Presentation and Demonstration 10%
  - Project Report (4-8 pages) 20%
  - Attendance 0%
- In the final project, students need to propose interesting applications of AI, formulate the problem, implement algorithms on a real robot (e.g., Minibot or Bebop).
  - A group should include **no more** than 2 students. If your project is large enough, you can have 3 group members.

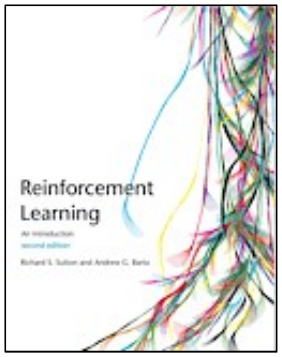
Syllabus

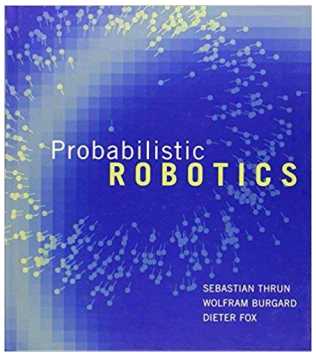
- Textbook: Prof. Tseng's notes
- Office hours: Wed 23 @ 407 room
- The lecture materials are based on 10 AI-related courses I took. I extract these topics which changed or are changing the world.
  - I encourage you to attend each lecture since you cannot find the same materials anywhere.
- Optional textbook:
  - Stuart Russell and Peter Norvig, "Artificial intelligence: a modern approach," Pearson Education, 3rd edition, 2010.

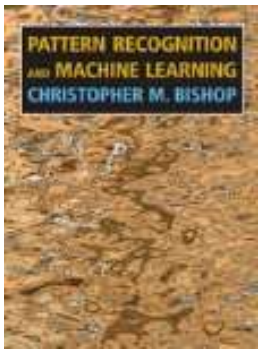
Syllabus

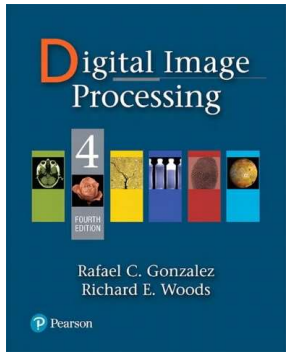
- **Reference books**

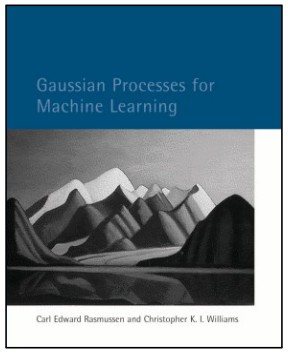








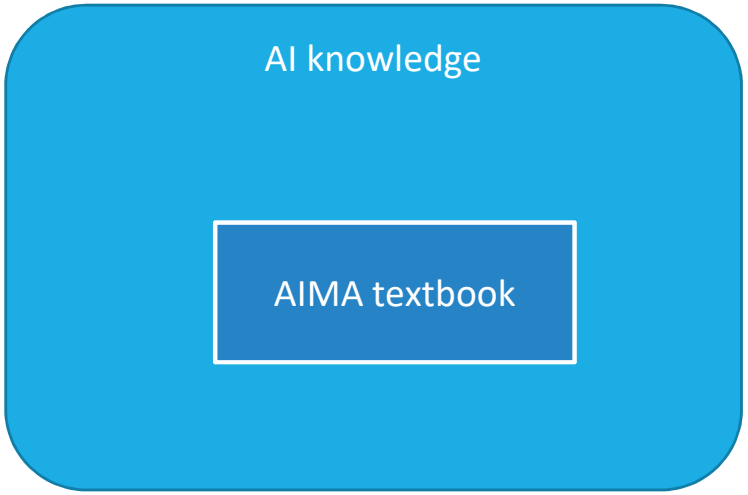


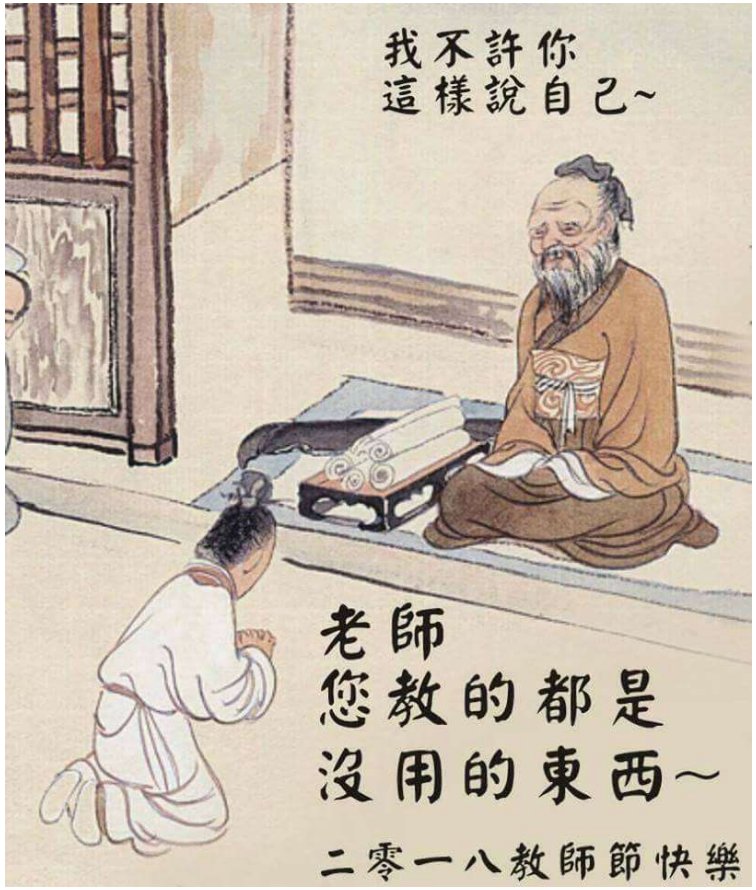


[1] Stuart Russell and Peter Norvig, “Artificial intelligence: a modern approach,” Pearson Education, 3rd edition, 2010.
[2] Richard S. Sutton and Andrew G. Barto, "Reinforcement Learning: An Introduction," MIT Press, 2nd edition, 2018.
http://incompleteideas.net/book/the-book.html
[3] Sebastian Thrun, Wolfram Burgard and Dieter Fox, “Probabilistic Robotics,” MIT Press, 2006.
[4] Christopher M. Bishop, "Pattern Recognition and Machine Learning," Springer,2013.
[5] Rafael C. Gonzalez and Richard E. Woods, “Digital Image Processing," Pearson, 4th edition, 2018.
[6] Carl Edward Rasmussen and Christopher K. I. Williams, " Gaussian Processes for Machine Learning," MIT Press, 2006.
[7] Aurélien Géron, "Hands-On Machine Learning with Scikit-Learn and TensorFlow," O'Reilly Media, 2017.

Syllabus

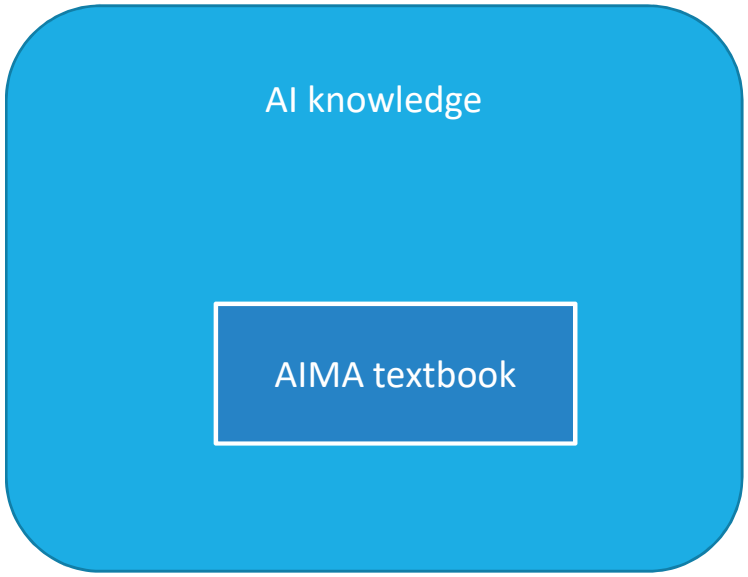
- The authors of AIMA textbook: The subtitle of this book is “A Modern Approach.” The intended meaning of this rather empty phrase is that we have tried to synthesize what is now known into a common framework, rather than trying to explain each subfield of AI in its own historical context. We **apologize** to those whose subfields are, as a result, less recognizable.

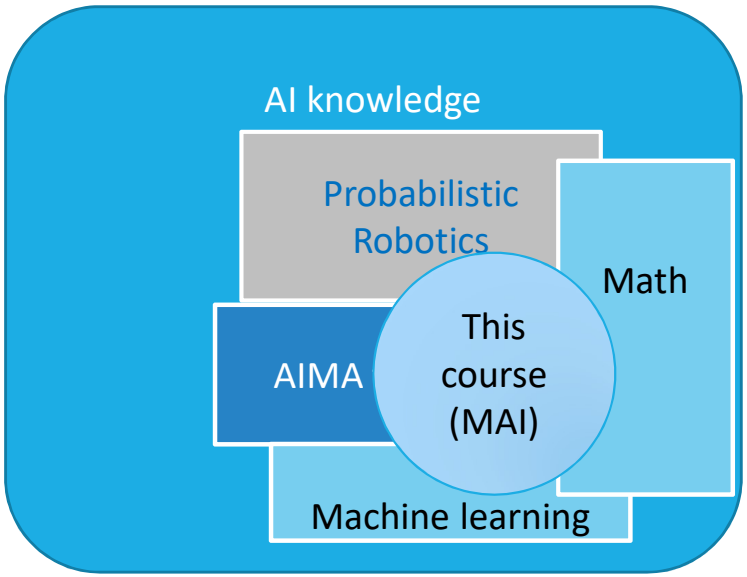



我不許你
這樣說自己~
老師
您教的都是
沒用的東西~
二零一八教師節快樂

Syllabus

- Why is it called “Modern” Artificial Intelligence
  - It also includes probabilistic robotics, machine learning and mathematics.
  - These topics changed or are changing the world
  - You will write code on a real robot and then it will learn something!





Syllabus

- Homework (30%):
  - 50% theory problems
  - 50% programming assignments (Matlab)
- Midterm (30%):
  - You have to solve a real AI problem within 2~3 hours.
  - You can take an A4 cheating sheet, which notes everything you want.
- Final project (40%):
  - You can propose an interesting AI application. Then, you can utilize what you learned from the lectures and homework to work on your project.
  - The project proposal and reports should be in IEEE conference format. You can edit it using LATEX or Word.
  - Slogan: ***Demo or Down!***

Syllabus

- Programming skill requirements:
- Most of HW can be done in MATLAB. The HW problems are toy problems.
- In final projects, you need to use C++ or Python since the robots only understand C++ and Python. We will build our code on ROS.
- The difference between HW and final project is that you have to **build almost everything** by yourself in your final project. Anything not your work should be **cited**. You will learn how to use ROS to speed up your code development.

Syllabus

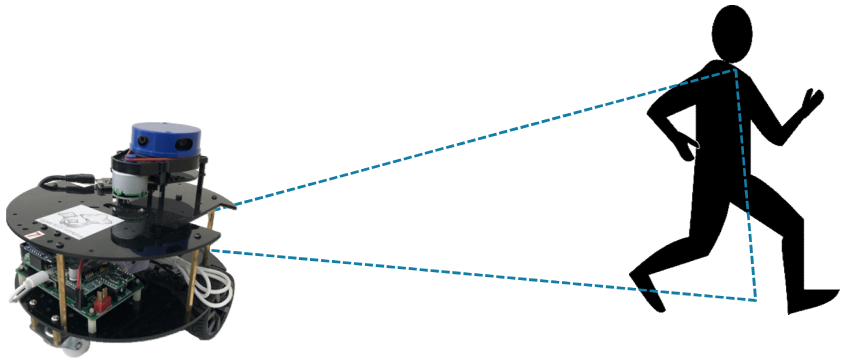
- BAD final project examples:
  - Any things similar to the lecture examples
  - Any things easier than the lecture materials
- Basic ideas of final project:
  - The robot can improve itself by past experience → Learning.
- You can discuss your project with Prof. Tseng during office hour. He will give you some suggestions:
  - What you could do
  - What you should not do

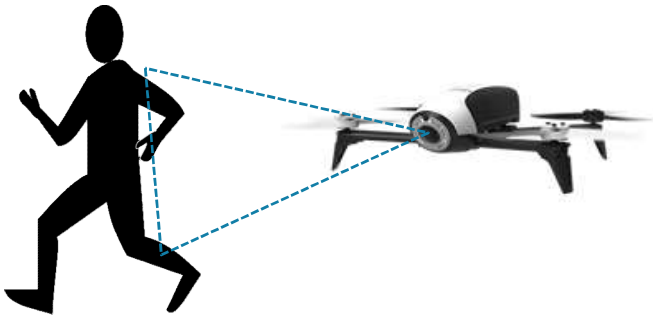
Syllabus

- Final project example 1:
  - Learning how to fly in Math department

Syllabus

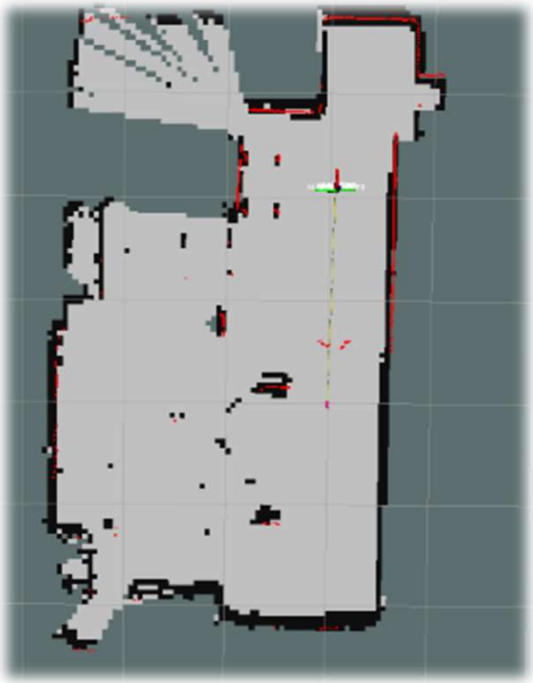
- Final project example 2:
  - Learning how to follow a person.

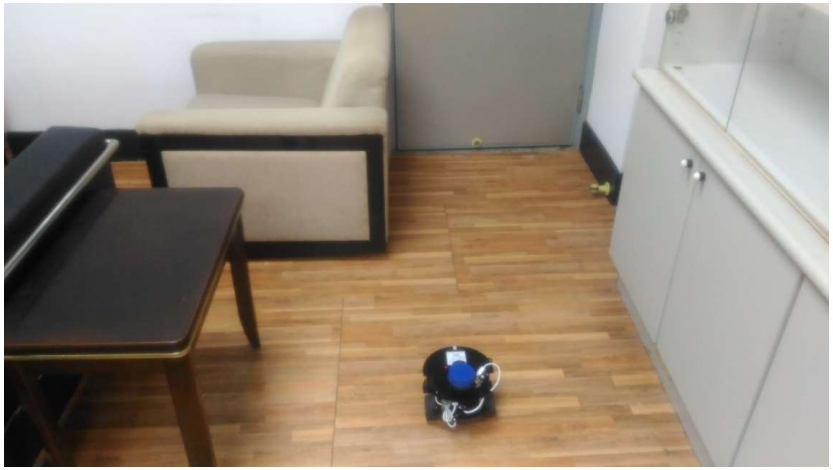




Syllabus

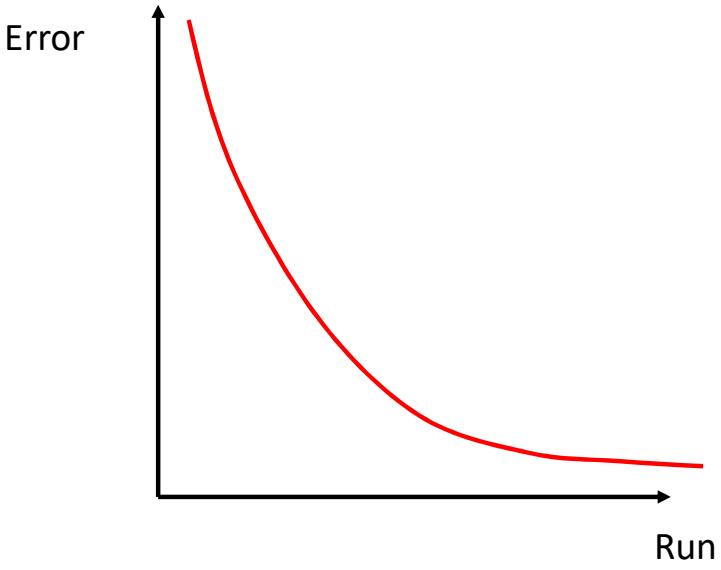
- Final project example 3:
  - Learning how to avoid obstacles

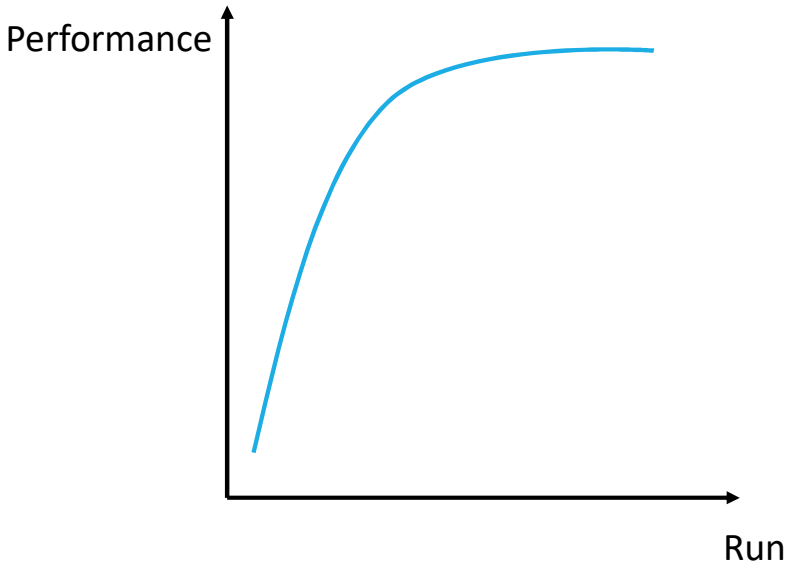




Syllabus

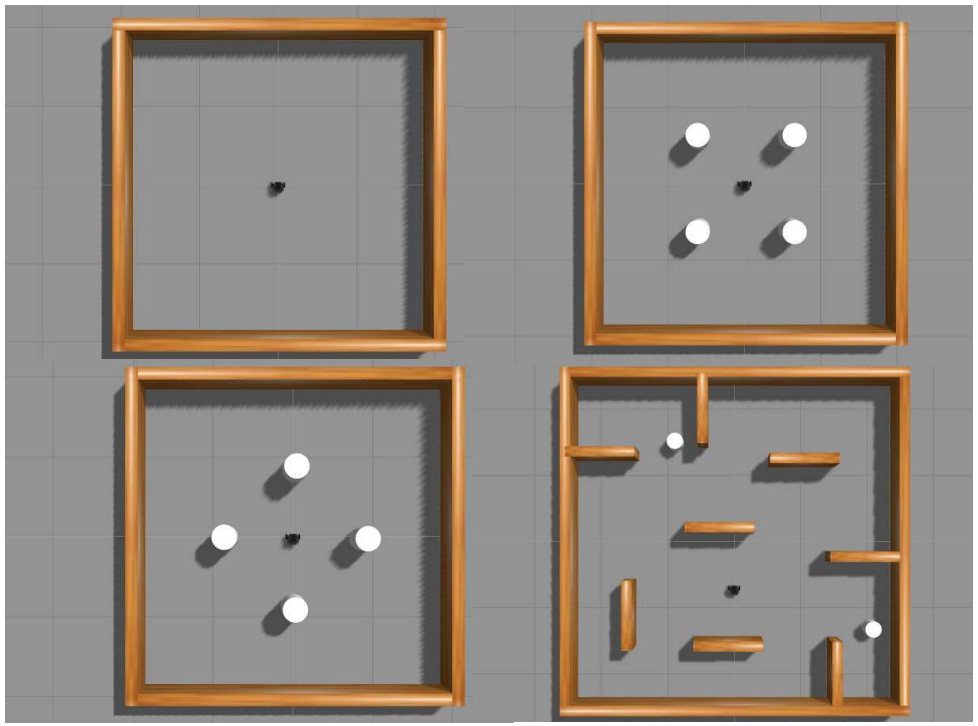
- Basic ideas of final project:
  - The robot can improve itself by past experience → Learning.





Syllabus

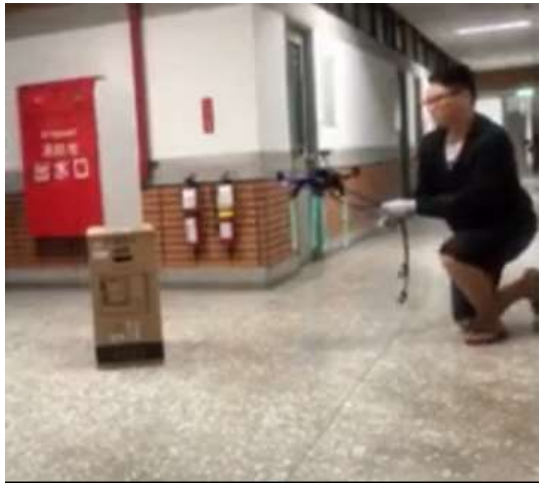
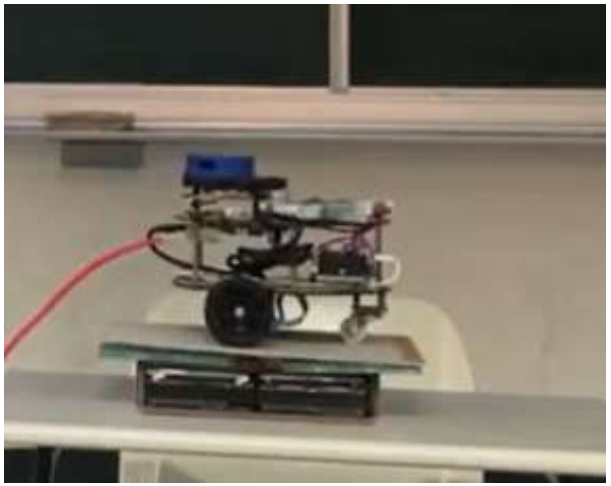
- A good example. We will work on real robots!



https://www.youtube.com/watch?v=5uIZU8PCHT8&feature=youtu.be

Syllabus

- MAI, 2019 Fall.


Modern Artificial Intelligence, final project , 2019 Spring.
https://youtu.be/U6wQOqiuYWM

Syllabus

- What you should know
  - **Programming, probability and linear algebra**
- What you will learn
  - Problem solving (search)
  - Perception (Bayes theorem)
  - Reinforcement learning
  - Unsupervised learning and supervised learning
- What you will NOT learn
  - The principal of sensors
  - The principal of control
  - How to build a robot

Syllabus— Cheating and Plagiarism

- The homework and the programming assignment must NOT be the result of cooperative work. Each student must work **individually** in order to understand the material in depth. You CANNOT copy the homework or the programming assignment of somebody else.
- All work in the projects and the programming assignment must properly **cite** reference. For example, if you quote a source in your project, you must include the quotation in quotation marks and clearly indicate the source of the quotation. If you includes a library in your code for final projects, you also need to **cite** the open source code/library you used.
- Any student caught cheating will receive an "F" as a class grade and the University policies for cheating and plagiarism will be followed.

Syllabus

- You can find information on the course website or LMS
- https://sites.google.com/site/kuoshihtseng/courses/mai
- https://lms.ncu.edu.tw/
- All of homework, slides and reports are in English.
- Due to the **intelligent property** (IP) issues, anyone **CANNOT** record video, photo and audio in this lecture. We will record your final project demonstrations with your permission.

How to enroll in this course?

- If you would like to take this course, please send me (kuoshih@math.ncu.edu.tw) the following documents by 2/26(Fri.):
  - 1-page SOP to explain why you want to take this course
  - Your transcript to demonstrate your ability in program, probability and linear algebra
  - Other supporting documents (e.g., programming competition award)
- If you are qualified, I will give you a password card. Priority:
  - Program + probability + linear algebra + good SOP
  - Program + probability + linear algebra
  - Probability + linear algebra or program
- If you cannot enroll in this course, you still can be an audience
  - You cannot use the robots & I will not grade your HW
  - Cannot attend the exam, project presentation and demo
  - Cannot download files from LMS

How to enroll in this course?

- Programming (one of these courses)
  - MATH: Computer Programming and Application
  - EECS: Introduction to computer I & II
  - EECS: Data structure
  - EECS: Algorithm
- Probability
  - Any probability courses (undergraduate level)
- Linear Algebra
  - Any linear algebra courses (undergraduate level)
- Your major (e.g., Math, CS, ME, EE, or CE) will NOT affect the priority.

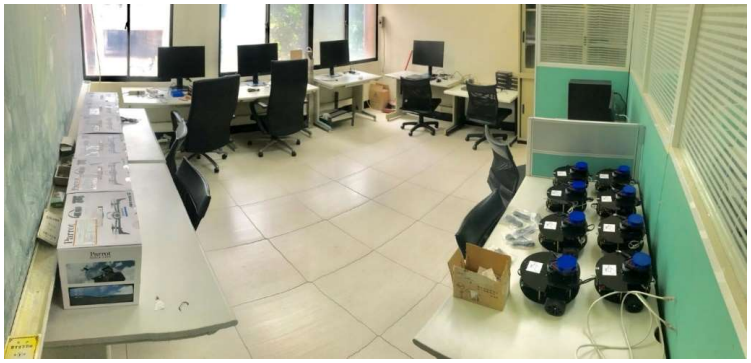
Outline

- Introduction to Kuo-Shih
- What's AI?
- History of AI
- Syllabus
- **Math and Robotics Lab (Room 213)**
- Demonstration
  - Minibot, Bebop

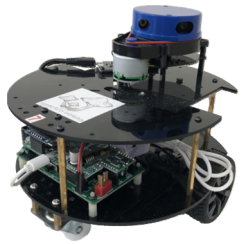
Robotics Lab (Room 213)

數學機器人實驗室
Math and Robotics Lab

- NCU Math got a funding to build a Robotics Lab in Room 213.
- Robotics Lab has
  - Minibot X 10
  - Turtlebot3 X10
  - Bebop2 X8
  - PC X1
  - Notebook X2



- You can swipe your NCU ID card to access to Robotics Lab.
- You will need a Minibot or Bebop for final projects.

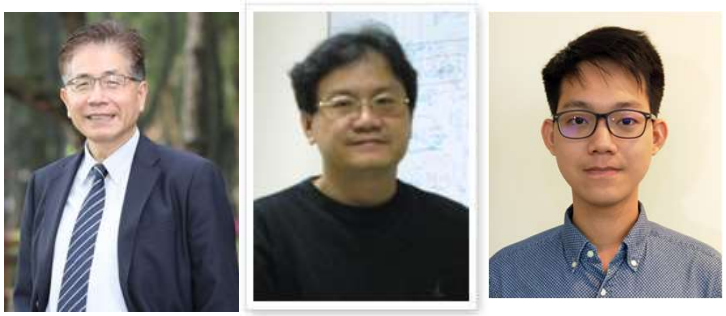




Robotics Lab (Room 213)

- Acknowledgement:

NCU gave Math department a funding to build a robotics Lab for teaching and makers.
We cannot have this space and robots without the following people's support.

- NCU president: 周景揚 校長
- NCU TLDC (教發中心)
- College of Science (理學院)
- Math department chair: 洪盟凱 主任
- Math department staffs:
  - 賈玉珊
  - 呂靜如
  - 呂易青
  - 孫慧麗
- HyphaROS: 林浩銧



Robotics Lab (Room 213)

- Robotics Lab is an AI maker Lab, where students build **AI code** instead of building robots (e.g., gears or circuits).
- It is currently managed by Prof. Kuo-Shih Tseng and his students.

Robotics Lab (Room 213)

- They are NOT TAs of this course. You can ask anything (e.g., hardware and setup) about Robotics Lab. But, DO NOT ask them homework or projects of this course.
- EX: Where is the USB cable of Minibot. (O) ☺
- How to charge Bebop2. (O) ☺
- Could you give me hints of HW2? (X) ☹
- Could you help me build ROS code of my final project ? (X) ☹
- Could you help me in debugging? (X) ☹ ☹ ☹ ☹ ☹ ☹ ☹ ☹ ☹ ☹ ☹

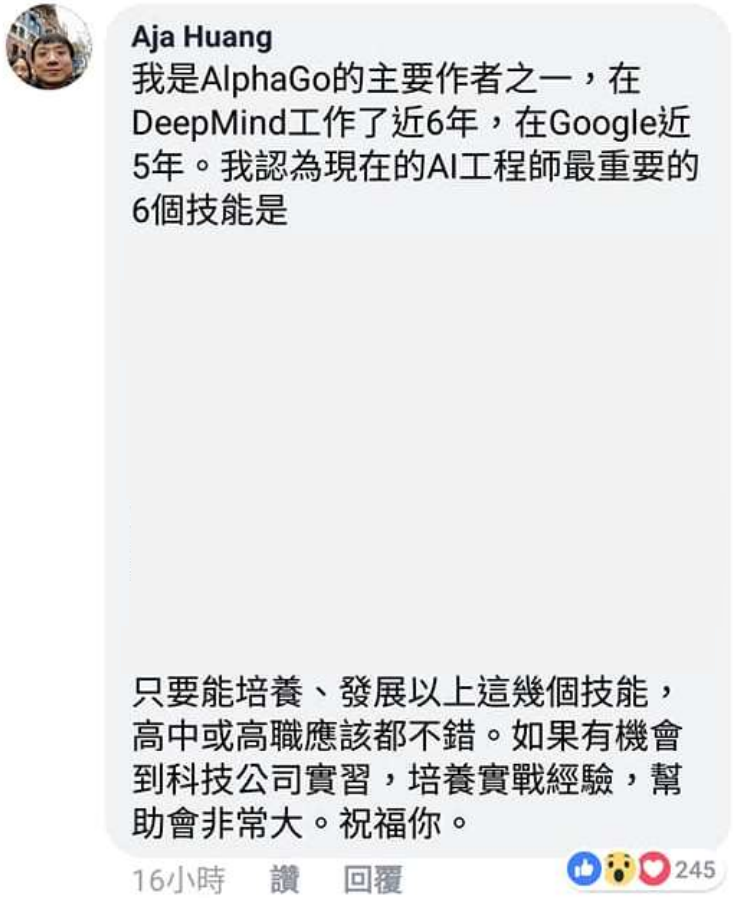
FAQ:

- This is an easy course?
  - No, this is a graduate level (MS or PhD) course. Students should have enough background to avoid a disaster.
- Could I ask Prof. Tseng questions about programming?
  - (X) Compiler error (e.g., linker error or missing function type)→ ask Google
  - (O) Algorithm and mathematical error
- Could Prof. Tseng help me in debugging my code?
  - ☹☹☹☹☹☹☹☹☹☹☹☹☹☹☹☹☹☹☹☹☹☹☹☹☹☹☹☹☹☹☹☹☹☹☹☹
- Could I do the final project by myself?
  - If you are very strong and we have enough robots, the answer is YES!

FAQ:

- I didn't take background courses. Could I take this course?
  - No, I am sorry. You still can be an audience.
- Why don't you buy more robots and take more students?
  - We don't have enough funding this year.
- This course looks interesting. Did you implement all of these experiments of this course?
  - Yes, I implement 90% code of this course. Trust me! I was an engineer!
- It's possible for a Math student to learn robotics? I know nothing about gears or circuits.
  - It's fine if you know math and programming.

FAQ:


Aja Huang
我是AlphaGo的主要作者之一，在DeepMind工作了近6年，在Google近5年。我認為現在的AI工程師最重要的6個技能是
只要能培養、發展以上這幾個技能，高中或高職應該都不錯。如果有機會到科技公司實習，培養實戰經驗，幫助會非常大。祝福你。
16小時 讚 回覆
245

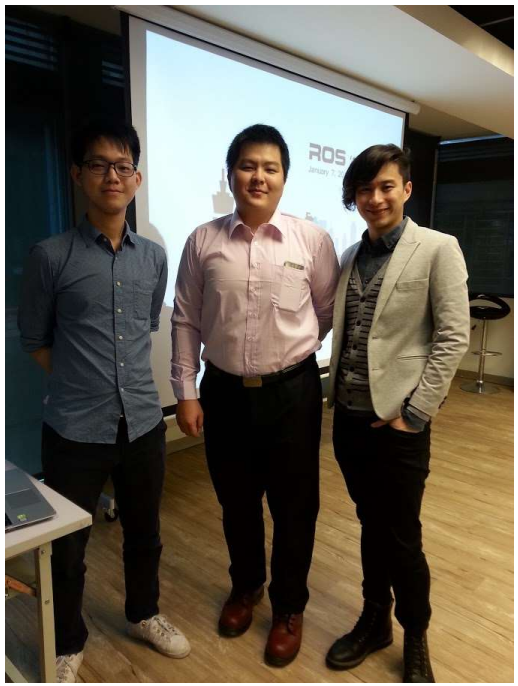
Outline

- Introduction to Kuo-Shih
- What's AI?
- History of AI
- Syllabus
- Math and Robotics Lab (Room 213)
- **Demonstration**
  - Minibot, Bebop

Demonstrations

HYPHA ROS WORKSHOP

- Minibot
  - IMU
  - Laser
  - Encoder



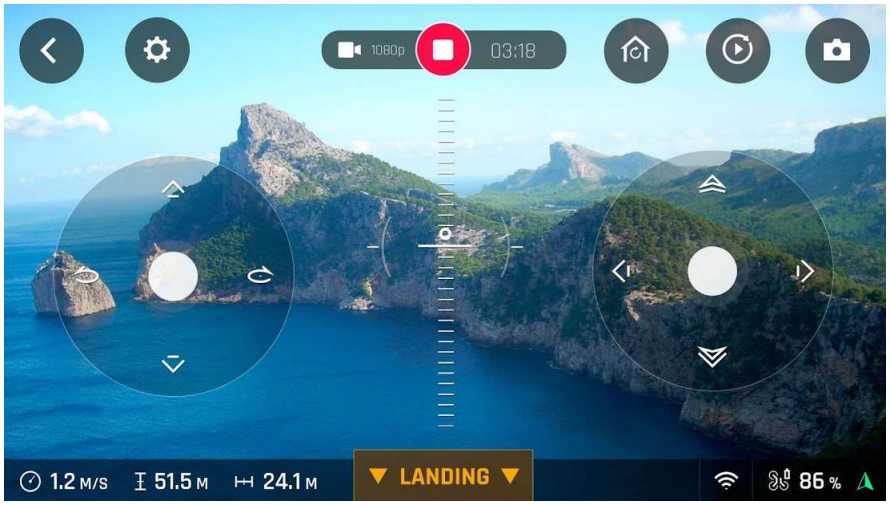
Team memebers:

- Hao-Chih Lin (林浩錡)
- Chien-Linag Chu
- Eric W. Ko

https://hypharosworkshop.wordpress.com/

Demonstrations

- Bebop
  - RGB camera
  - IMU



Q&A