HMI
HUMAN MACHINE INTERACTION LABORATORY

ĐẠI HỌC CÔNG NGHỆ

INTRODUCTION TO INTELLIGENT ROBOTS COURSE

Undergraduate course (Spring 2018)

Nguyen Do Van, PhD

Our Introduction

- Student:
  - Name, specialization, what you love?
  - How did you know the course?
  - What do you think about the course?
  - What do you expect?

Course Objective

- Know what it takes to make a robust intelligent robot work
- Sense, think, act
- Understand the importance, approaches, research issues and challenges in intelligent robots
- Know how to program an autonomous robot

Need some information

- Pre-course:
  - Python, Ubuntu
  - Robotics??
  - Artificial intelligence,
  - Machine learning,
  - Computer Vision

Course Information

- What is in the course
  - Introduction to Artificial intelligence and Autonomous Robots
  - Robotics Programming
  - Robot perceptron: vision, sound
  - Mobile robots: Robot Localization and Mapping
  - Manipulated robots: Path Planing and Controlling
  - Intelligence robots: Machine learning, Reinforcement learning (advanced)
  - Assigments and Grade systems
  - *Orders and contents may change during the course*

Lecturers

- **Instructors**: Nguyen Do Van, PhD
- **Teaching Assistents**: Kieu Hai Dang
- **Invitted Lecturers:** A.Prof Le Thanh Ha, Dr. Tran Quoc Long
- **Mentor students**: Intelligent robot team members

Website: https://uet-airobots-spring2018.moodlecloud.com

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ARTIFICIAL INTELLIGENT AND ROBOTS

Intelligent Robots

- Mechanical creature which can function autonomously
- Mechanical: built, constructed
- Creature: think of it as an entity with its own motivation, decision making process

Intelligent Robots

- Basic robot primitives: Sense/Learning/Think/Act
- Three Acting Paradigms:
  - Hierarchical: Sensing -> Planning -> Acting
  - Reactive: Sensing -> Acting
  - Hybrid: Planning -> Sensing -> Acting
- Learning to think, learning to act

Heuristic planning to learning

Warehouse Robots

Kiva at Amazon

Fetch

Entertainment Robots

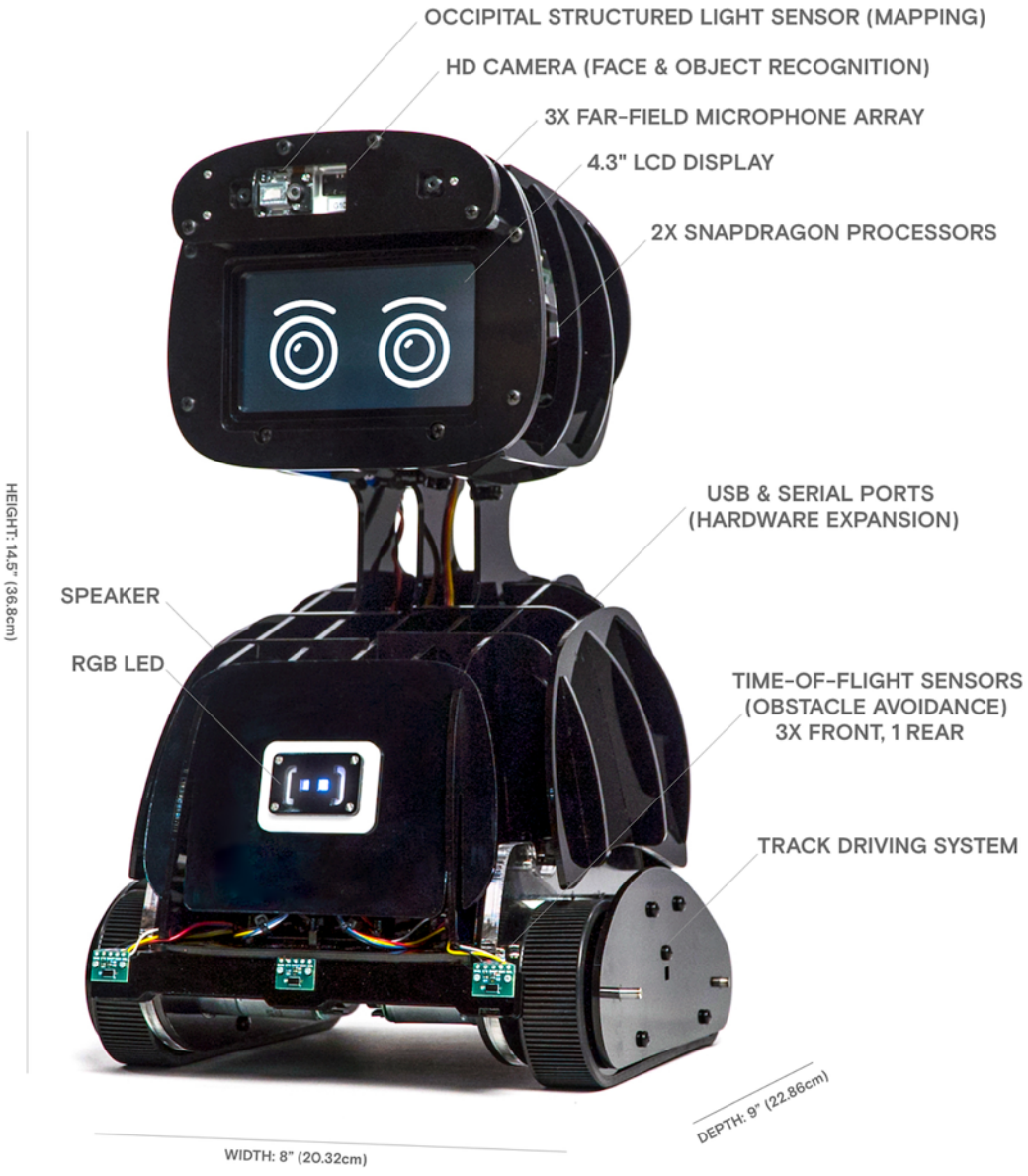









Home Assistant Robots



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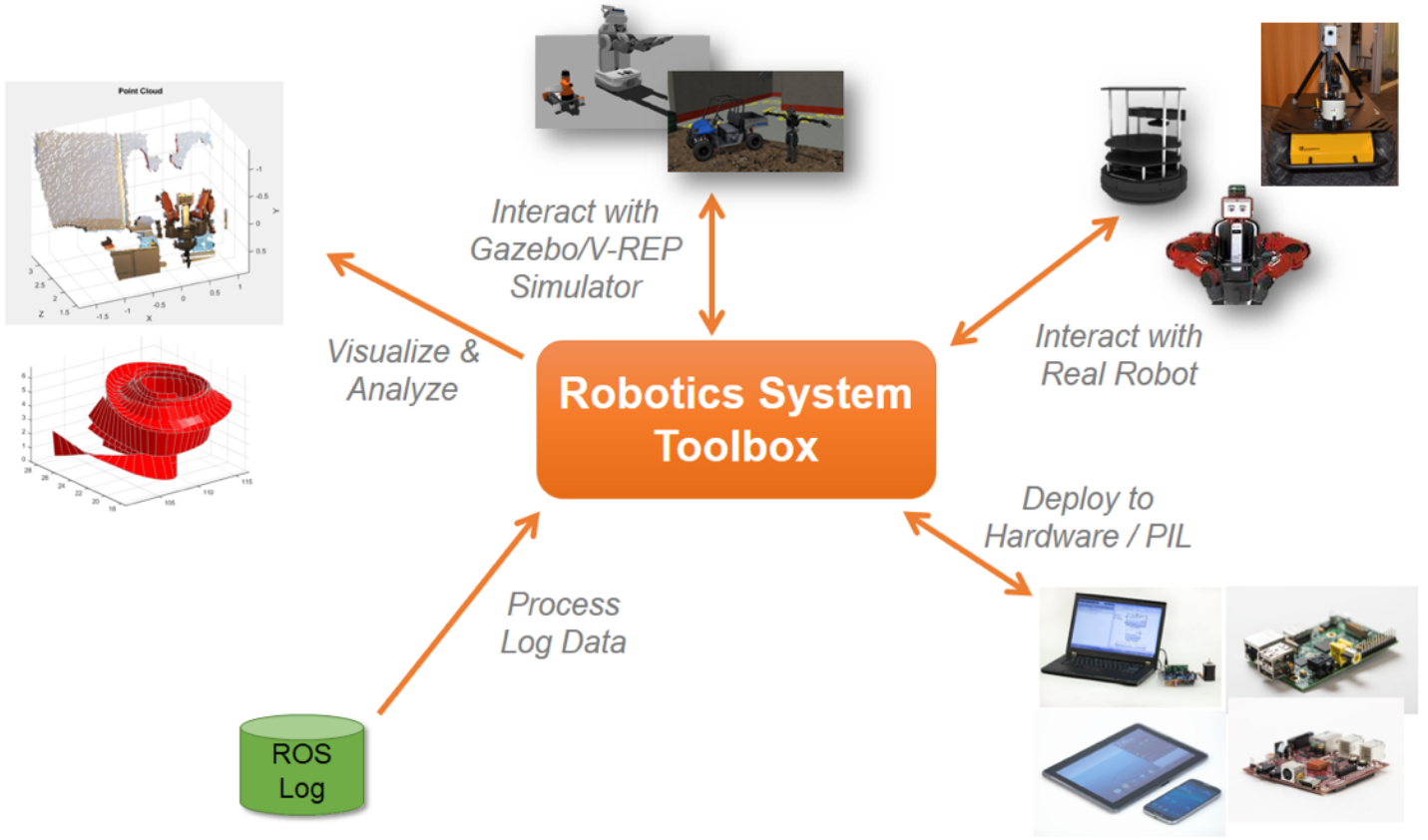
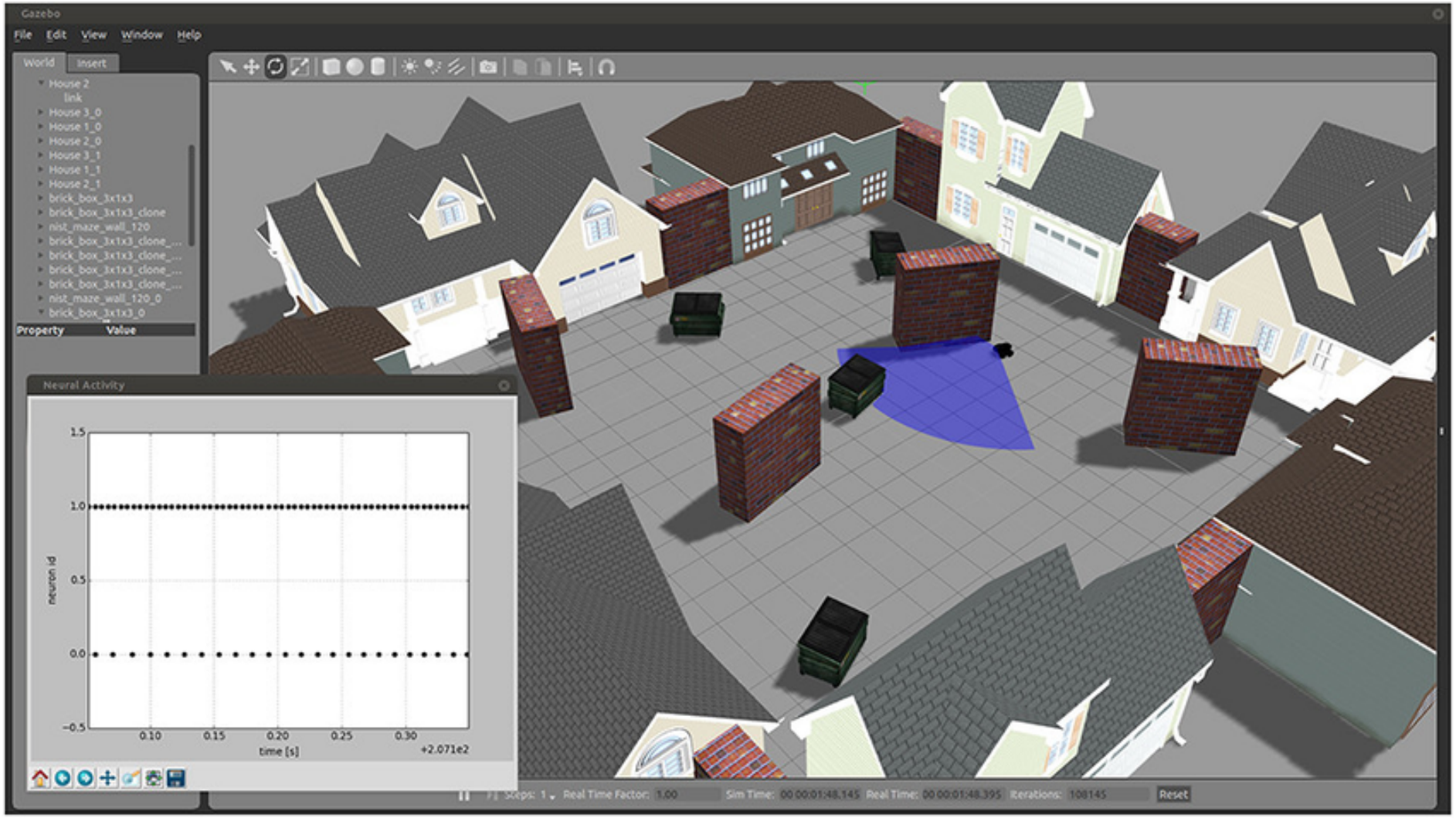
WHAT IN THE COURSE

Robot Operating System (ROS)

- Standardized package manager
- Runs on Ubuntu
- Standardizes message-protocols for:
  - Pose estimation
  - Localization
  - Navigation
  - Computer vision
- Incorporates the latest contributions from academia

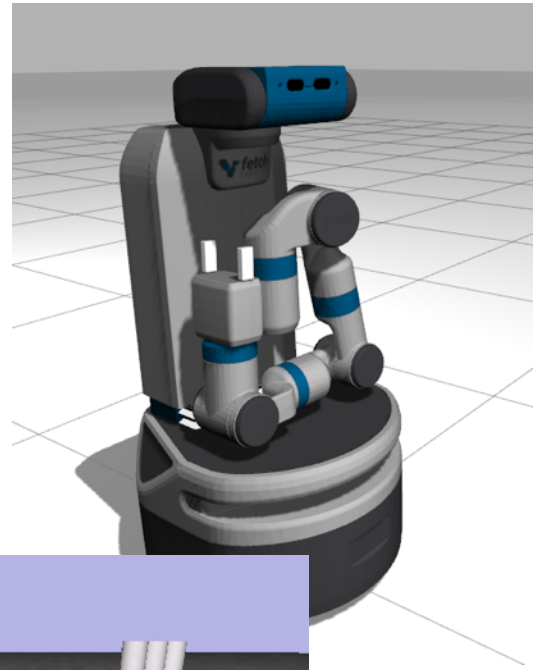


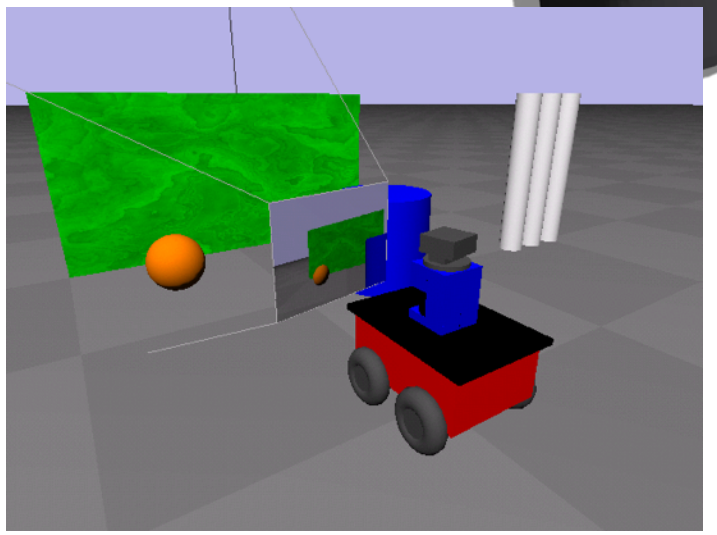
Simulation


Gazebo
File Edit View Window Help
World Insert
House 2
link
House 3_0
House 1_0
House 2_0
House 3_1
House 1_1
House 2_1
brick_box_3x1x3
brick_box_3x1x3_clone
nist_maze_wall_120
nist_maze_wall_120_0
brick_box_3x1x3_0
Property Value
Neural Activity
1.5
1.0
0.5
0.0
−0.5
neuron id
0.10
0.15
0.20
0.25
0.30
time [s]
+2.071e2
Real Time Factor: 1.00
Sim Time:
Real Time:
Iterations:
Reset

Simulation: Gazebo

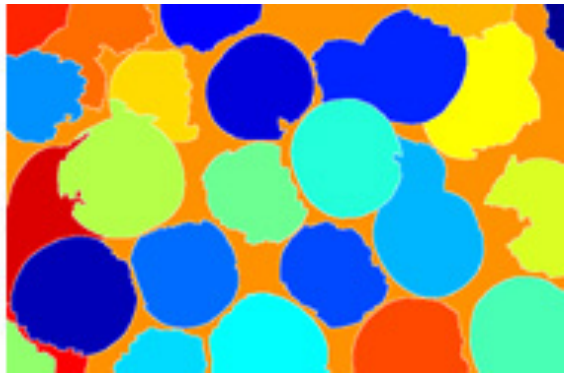
- What
  - Mimic the real world, to a certain extent
- When
  - Always!!
- Why
  - Save time and your sanity
  - Experimentation much less destructive
  - Use hardware you don't have
  - Create really cool videos
- How
  - Someone has probably already done it, so use it





Perceptron - Computer Vision

- Computer vision is the task of understanding the images captured by a camera
- Vision tasks that are simple for humans to do, can be very difficult for a computer
  - For example, color each fruit a different color

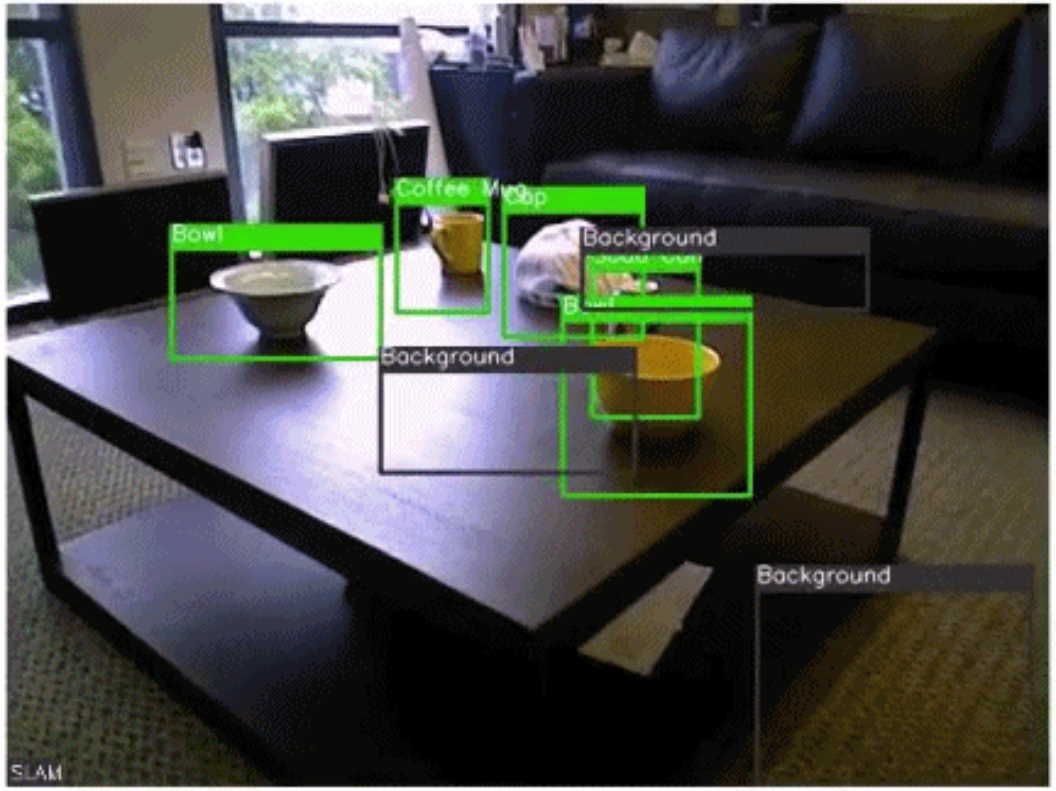


What we see

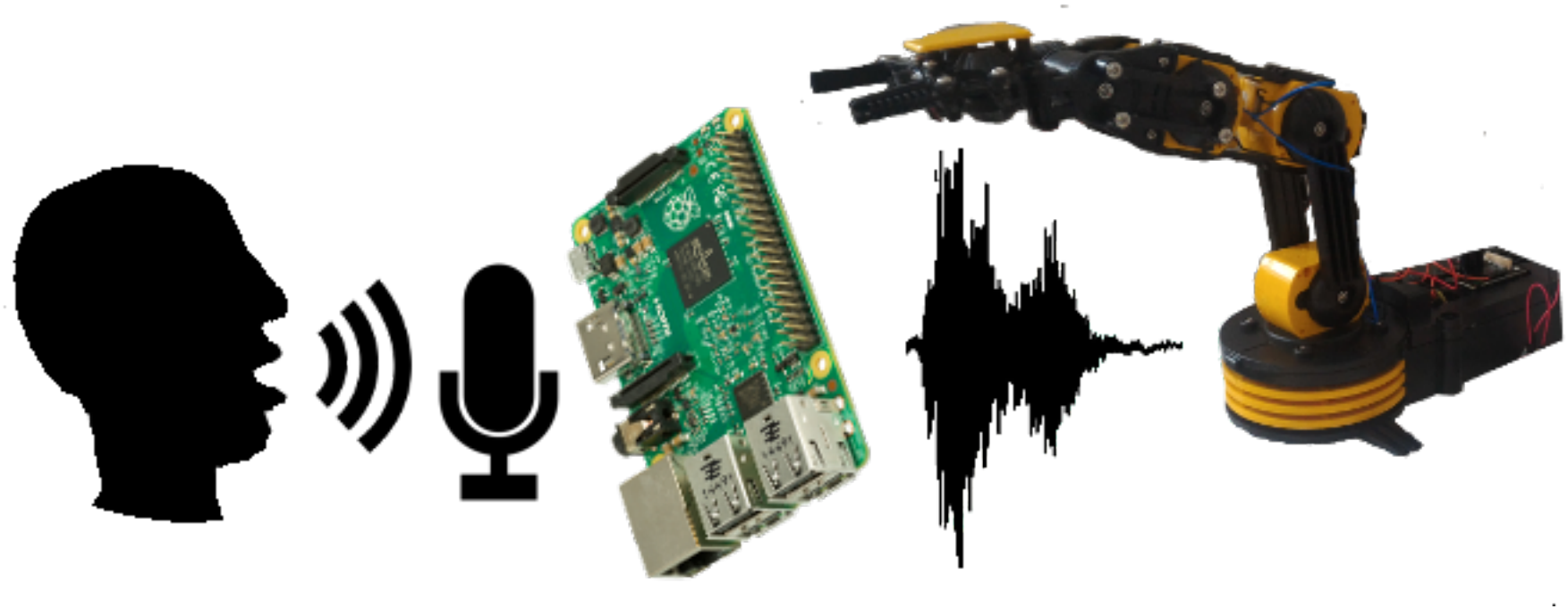
What a computer sees

Vision for Robotics

- Objects Recognition and Object Tracking

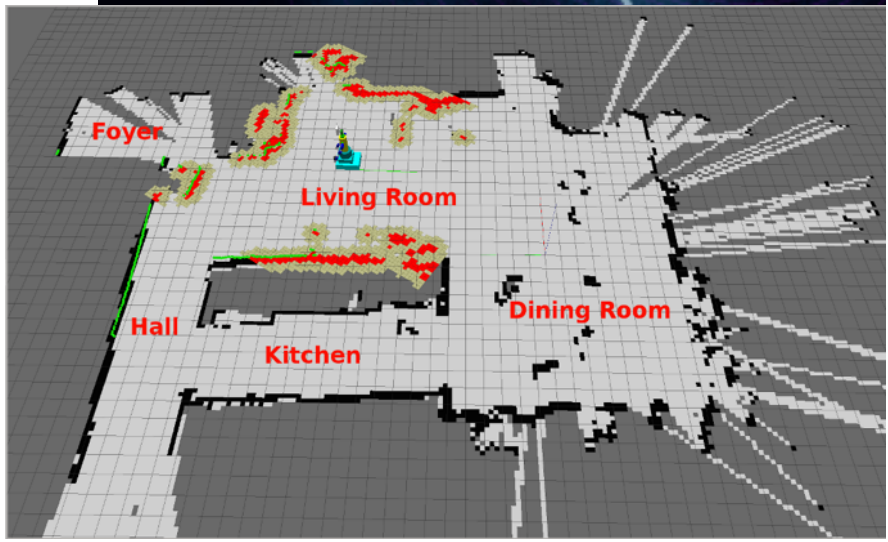


Sound Recognition



Localization and Mapping

- Localization is the task of determining a robot position
- Mapping is the task of building an accurate map of the environment
- Simultaneous Localization and Mapping (SLAM)
  - A process of dynamically building a map of the world around a robot while estimating the position of the robot within this map
- Application
  - Precision driving
  - Room to room navigation



Planning and Controlling

- Robots must make decisions that consider their entire environment
- Robots would be ineffective if they only consider their immediate sensor measurements
- Planning is the procedure of devising a strategy for achieving a goal based on a global perspective of the world.

Robot Arms

- Robot arms are used to grasp and move items.
- Planning algorithms are used to define how the robot arm should move.

Navigation

- One of the most important applications of planning is for navigation
- Navigation typically involves two levels of planning:
  - global plans
  - local plans

Machine learning ⊆ artificial intelligence

ARTIFICIAL INTELLIGENCE

Design an intelligent agent that perceives its environment and makes decisions to maximize chances of achieving its goal.
Subfields: vision, robotics, machine learning, natural language processing, planning, …

MACHINE LEARNING

Gives "computers the ability to learn without being explicitly programmed" (Arthur Samuel, 1959)

SUPERVISED LEARNING

Classification, regression

UNSUPERVISED LEARNING

Clustering, dimensionality reduction, recommendation

REINFORCEMENT LEARNING

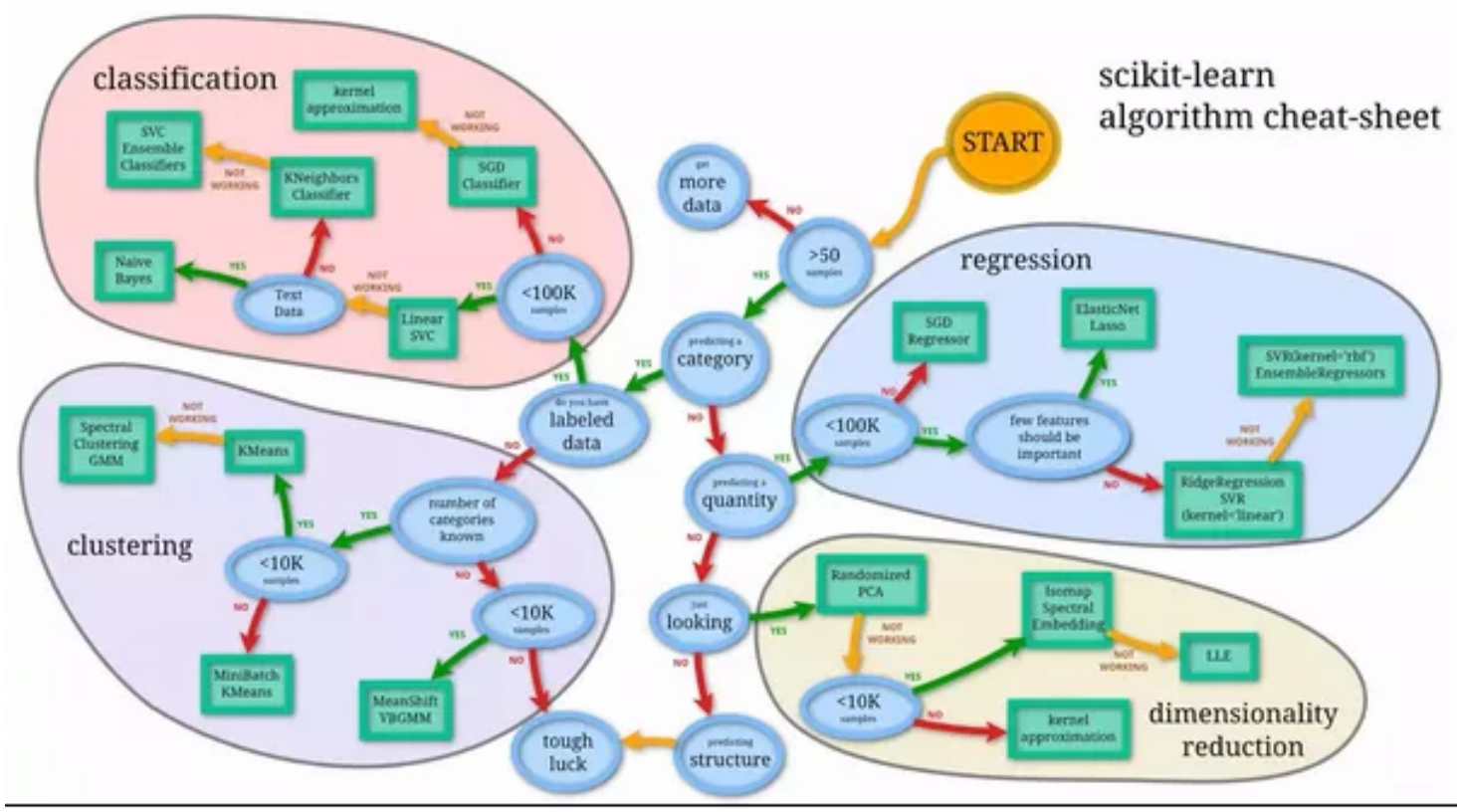
Reward maximization

Features in Machine Learning

- Features are the observations that are used to form predictions
  - For image classification, the pixels are the features
  - For voice recognition, the pitch and volume of the sound samples are the features
  - For autonomous cars, data from the cameras, range sensors, and GPS are features
- Extracting relevant features is important for building a model
  - Time of day is an irrelevant feature when classifying images
  - Time of day is relevant when classifying emails because SPAM often occurs at night
- Common Types of Features in Robotics
  - Pixels (RGB data)
  - Depth data (sonar, laser rangefinders)
  - Movement (encoder values)
  - Orientation or Acceleration (Gyroscope, Accelerometer, Compass)

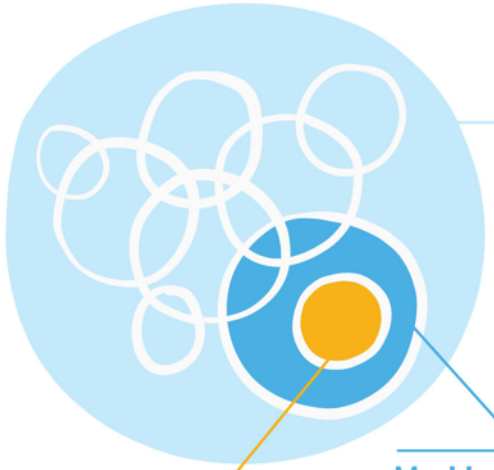
Intelligent Robots (Advanced)

- Machine learning



WHAT IS DEEP LEARNING?

WHAT IT IS



Computer Science
The study of computation and computer technology, hardware, and software.

Machine Learning
Algorithms that can make predictions through pattern recognition.

Deep Learning
A form of machine learning that uses a computing model inspired by the structure of the brain, which requires less human supervision.

> **Deep Learning isn't an application**—it's a technology that makes many applications smarter and more natural through experience.

HOW IT IS DONE

THE "BRAINS" OF AI

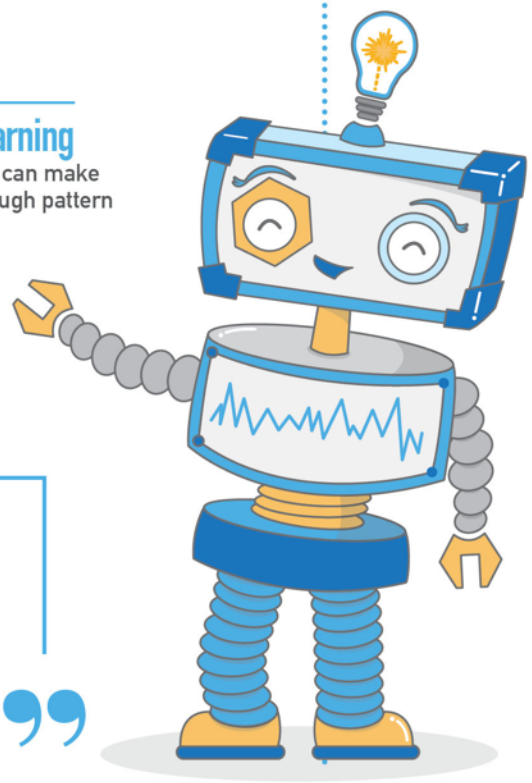
Deep Learning Algorithms ("neural networks")

Open Source Technology

Large Data Sets

Engineering Experts

Specialized Hardware



HOW IT CAN BE USED

Applications that ...

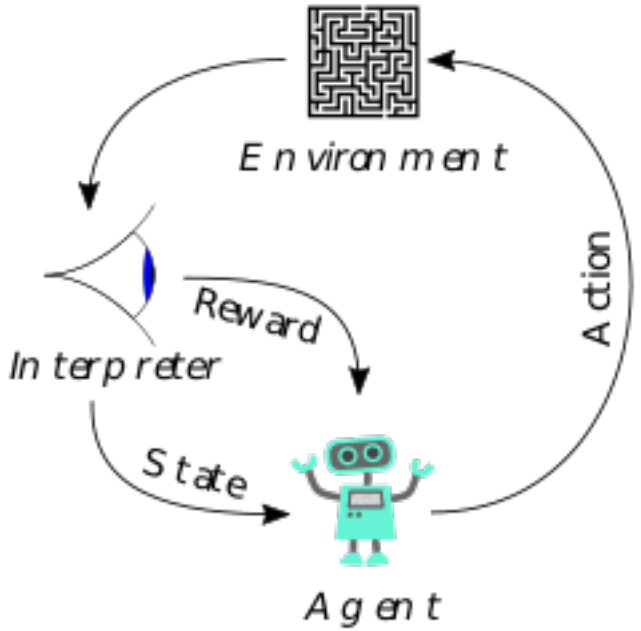
UNDERSTAND SPEECH
- > Personal Assistant
- > Control a Robot

AID VISION
- > Self-Driving Car
- > Image Recognition

IDENTIFY PATTERNS
- > Fraud Detection
- > Predict Behaviors
- > Advertising

Reinforcement learning

- Making good decision to do new task: fundamental challenge in AI, ML
- Learn to make good sequence of decisions
- Intelligent agents learning and acting
  - Learning by trial-and-error, in real time
  - Improve with experience
  - Inspired by psychology:
    - Agents + environment
    - Agents select action to maximize *cumulative* rewards
- What we discuss: Pure RL and Deep Reinforcement learning



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RL Applications

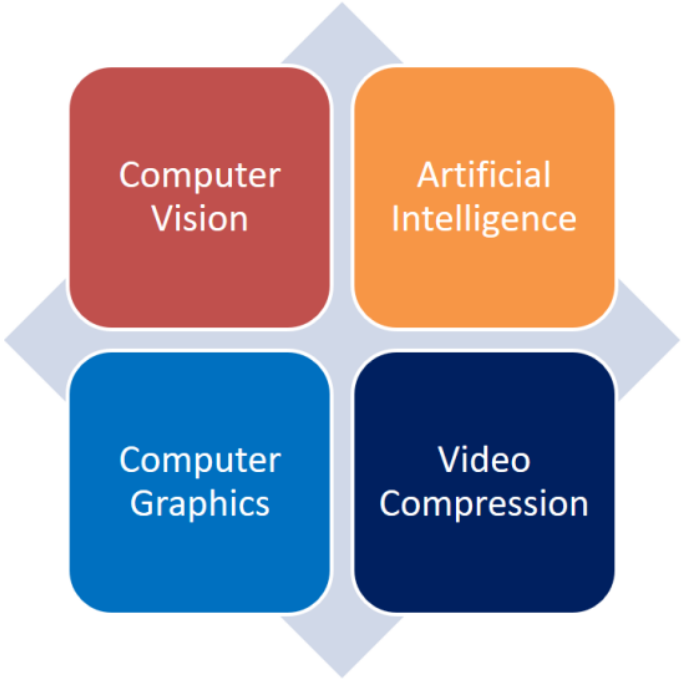
- Multi-disciplinary Conference on Reinforcement Learning and Decision Making (RLDM2017)
  - Robotics
  - Video games
  - Conversational systems
  - Medical intervention
  - Algorithm improvement
  - Improvisational theatre
  - Autonomous driving
  - Prosthetic arm control
  - Financial trading
  - Query completion

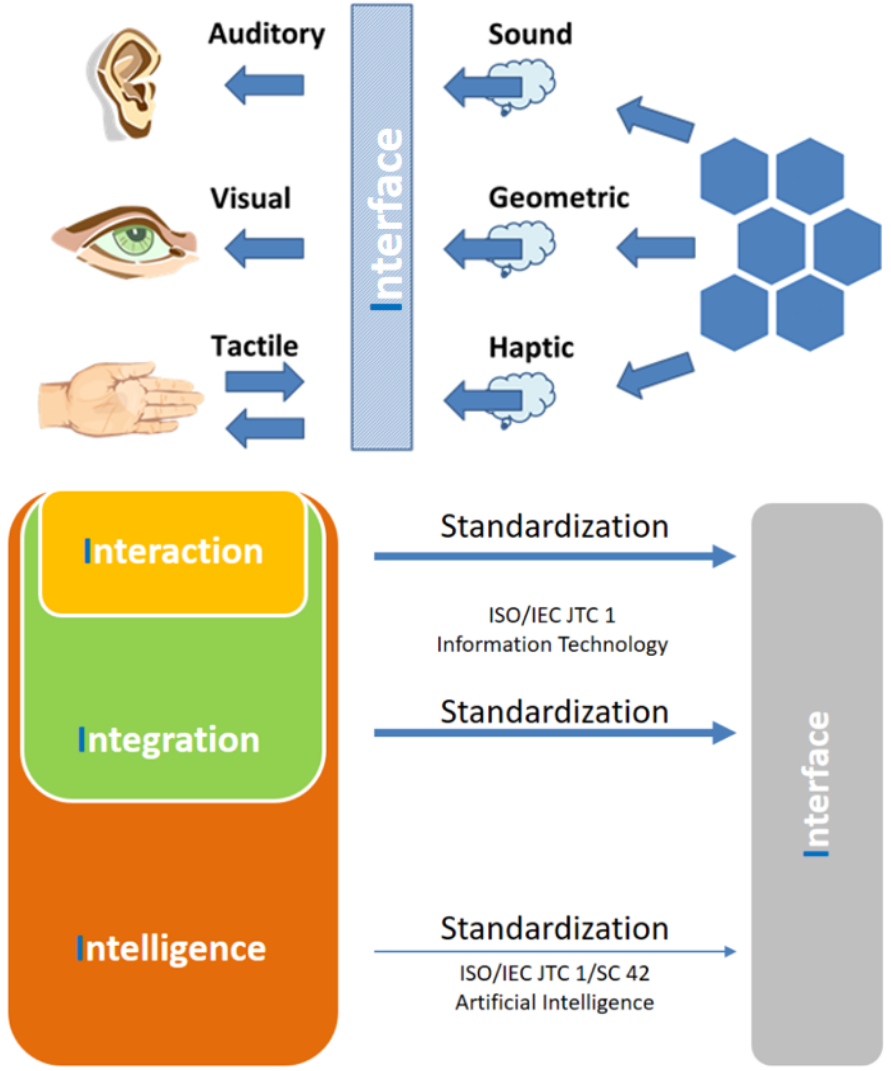
Assignments and Grade

Tasks	Methods	Weight
Assignments	02 group projects	15%
Mid-term test	Written test	10%
Practice	Programming in each lecture	15%
Final test	Oral	60%
Overall		100%

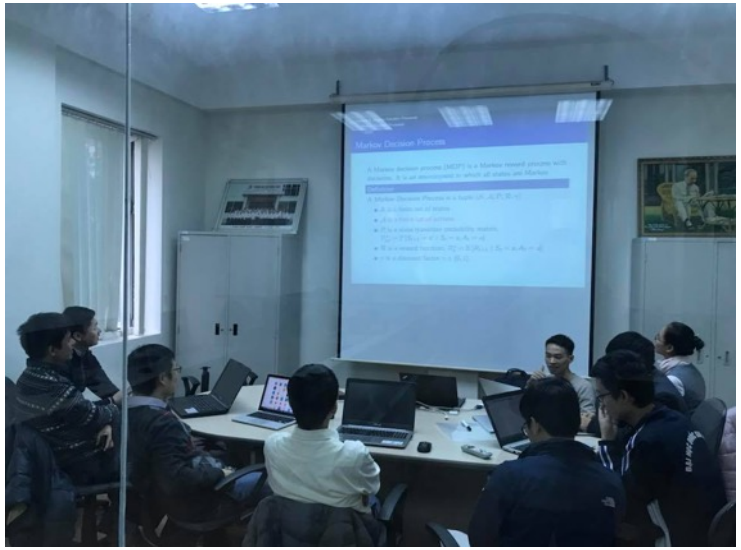
Lab introduction

- HMI Lab:
  - https://hmiuet.wordpress.com
  - https://www.facebook.com/hmiuet/





Artificial Intelligence – Computer Vision Group



Grant/Cooperative Agreement Award

1. AWARD NO.	2. EFFECTIVE DATE	3. PURCHASE REQUEST NO.	4. CFDA NO.	PAGE OF
FA2386-17-1-4053	27 SEP 2017	See Block 16	12.800	1 7

5. ISSUE BY AOARD CODE FA2386	6. AWARDED TO CAGE CODE SCNM3	7. AUTHORITY
ASIAN OFFICE OF AEROSPACE R&D 7-23-17, ROPPONGI, MINATO-KU TOKYO 160-0032 JAPAN FUMIKO KANO 81-425-11-2013 fumiko.kano.jp@us.af.mil	UNIVERSITY OF ENGINEERING AND TECHNOLOGY 144 XUAN THUY STREET,, DICH VONG HAU WARD, E3 BUILDING, HANOI VIETNAM	10 U.S.C. 2358 8. PERIOD OF PERFORMANCE 27 Sep 17 to 26 Sep 19

9. SCOPE / AGREEMENT TERMS

Basic Research for AOARD Proposal 17IOA053 "Vision-based Recognition using Deep Reinforcement Learning for Unmanned Systems", dated 04 JUL 2017 (the Grantee's Technical Proposal) is hereby incorporated by reference.
(CONTINUED ON PAGE 2)

TỜ KHAI
ĐĂNG KÝ SÁNG CHẾ

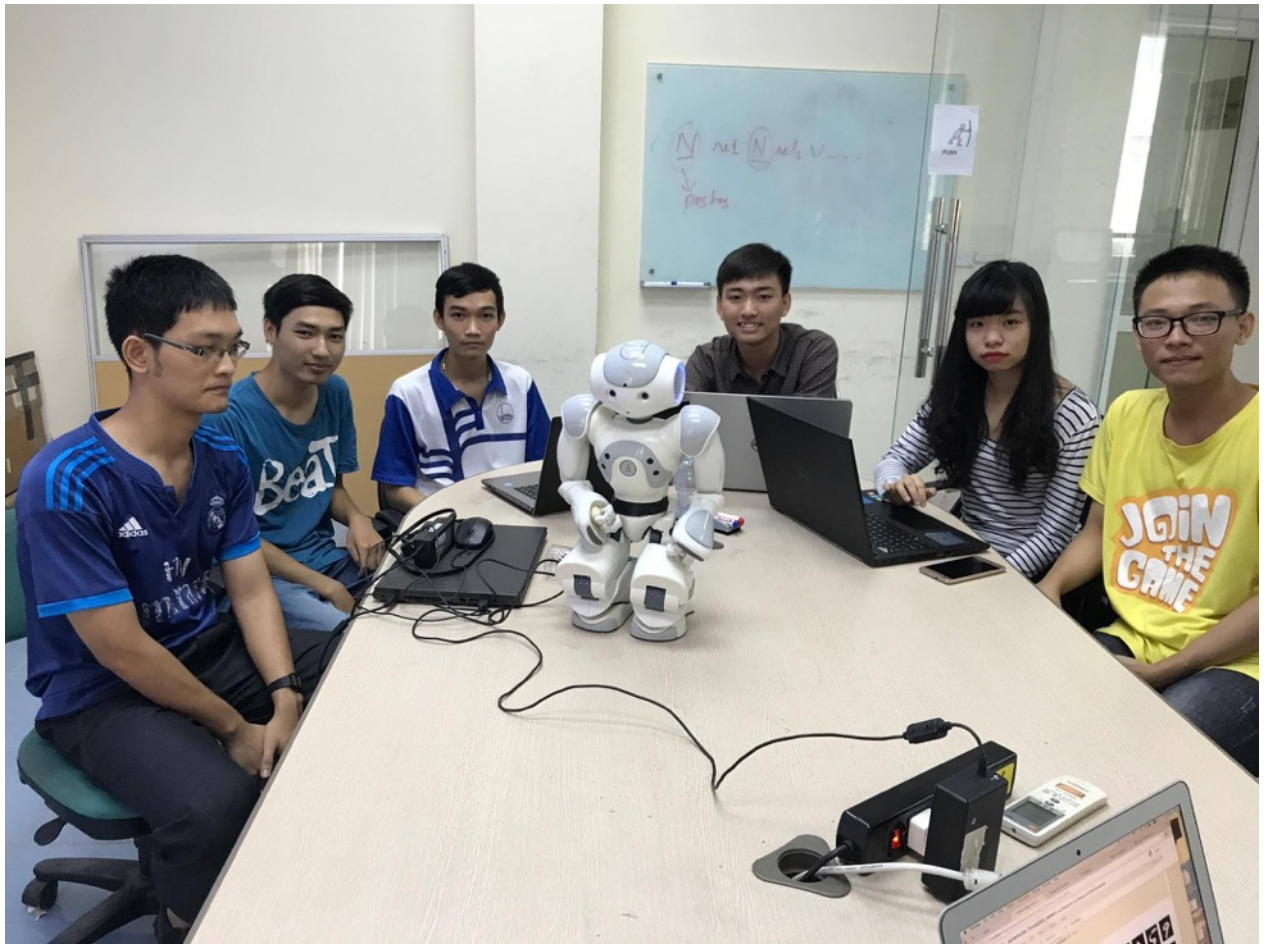
Kính gửi: Cục Sở hữu trí tuệ
386 Nguyễn Trãi, Hà Nội

Chủ đơn dưới đây yêu cầu Cục Sở hữu trí tuệ xem xét đơn và cấp*: ☒ Bằng độc quyền sáng chế
☐ Bằng độc quyền giải pháp hữu ích

ĐẦU NHẬN ĐƠN
CỤC SỞ HỮU TRÍ TUỆ
NATIONAL OFFICE OF INTELLECTUAL PROPERTY
NGÀY DATE 07 -06- 2017
1-2017-02136
SC

Chủ đề
Trích rút thông tin từ chứng minh thư sử dụng kỹ thuật thị giác máy
Bám bắt đối tượng chuyển động trên đường cao tốc
Phát hiện và nhận dạng phương tiện vận tải trên đường cao tốc
Điều khiển Robot Nao thông qua nhận dạng cử chỉ tay
Xây dựng ứng dụng chào hỏi trên robot Nao
Điều khiển robot Fetch trong nhà kho
Nhận diện hàng hóa cho robot Fetch trong nhà kho
Reinforcement learning methods for mobile robot navigation
Semantic segmentation in video sequences
Real-time semantic image segmentation
Real-time face recognition in surveilliance video
Real-time face detection and tracking in surveilliance video
Object recognition in remote sensing images
Semantic segmentation for remote sensing image
Mice sperms counting using computer vision methods
Mice sperms mobility analysis using computer vision methods
Feature extraction for EEG signal to give control commands for electronic devices

Intelligent Robot Team



Recruit:
AI & CV group member
Intelligent Robot Team Member
Seminar: Saturday, 101, G2
Lab: 307, E3

What do **WE** do?

- Instructors, TA: Give lectures
- Students: Comprehend and Do Assignments
- WE: Do together
- Q&A