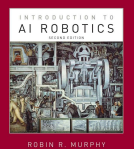
1 What are Intelligent Robots?



What is a robot?

Where do robots work?

Why do we have (or want) robots?

How are they intelligent?

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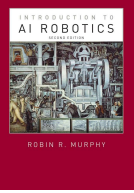
1 Organization of this Lecture

Objectives
Definition
-History
-Components
Why
-Replace
-Project
-Assist
-Amuse
Where
-Ground
-Aerial
-Marine
How
- Intelligence
- AI areas
Summary

- Objectives
- Definition of Robot
  - Historical evolution (linguistic)
  - Components (tangible)
- Why
  - 4 reasons: replace, project, assist, amuse
- Where
  - Land, sea, air
- How
  - What is natural intelligence (linguistic)
  - How AI is studied (tangible)
- Summary



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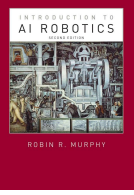
1 Specific Learning Objectives

Objectives
Definition
Why
Where
How
Summary

- Define Intelligent Robot
- List the five components common to all intelligent robots
- Give four different motivations for intelligent robots
- List the three modalities of autonomous (unmanned) vehicles
- List the seven areas of Artificial Intelligence and describe how they contribute to an intelligent robot



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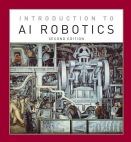
Objectives
Definition
-History
-Components
Why
Where
How
Summary

WHAT ARE ROBOTS?



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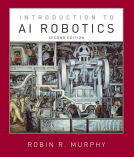
1

What are Robots?

Objectives
Definition
-History
-Components
Why
Where
How
Summary

- **Physically situated agent**
  - In artificial intelligence, an agent is an entity, a "something," that can sense its surroundings and take actions that change the environment.



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1

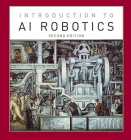
What are AI Robots?

Objectives
Definition
-History
-Components
Why
Where
How
Summary

- **Physically situated *intelligent agent***

Intelligent agent
is a system that perceives its environment and takes actions which maximize its chances of success. ***(Russell & Norvig 2003)***

Asimo.honda.com/gallery



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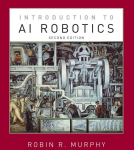
All Have 5 Common Components

Objectives
Definition
-History
-Components
Why
Where
How
Summary

- **Effectors: *legs, arms, neck, wrists***
  - Effectors enable a robot to act on the environment
  - Effectors enable navigational mobility or manipulation
- **Perception: *eyes, ears, nose, smell, touch***
  - Sensors *and sensing*
- **Control: *central nervous system***
  - Inner loop and outer loop; layers of the brain
  - Allow an intelligent robot to maximize its chances of success
- **Communications: *voice, gestures, hearing***
  - **How** does it communicate (I/O, wireless, expressions)
  - **What** does it say?
- **Power: *food and digestive system***



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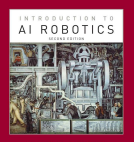
Objectives
Definition
Why
-Replace
-Project
-Assist
-Amuse
Where
How
Summary

WHY DO WE HAVE (OR WANT) ROBOTS?



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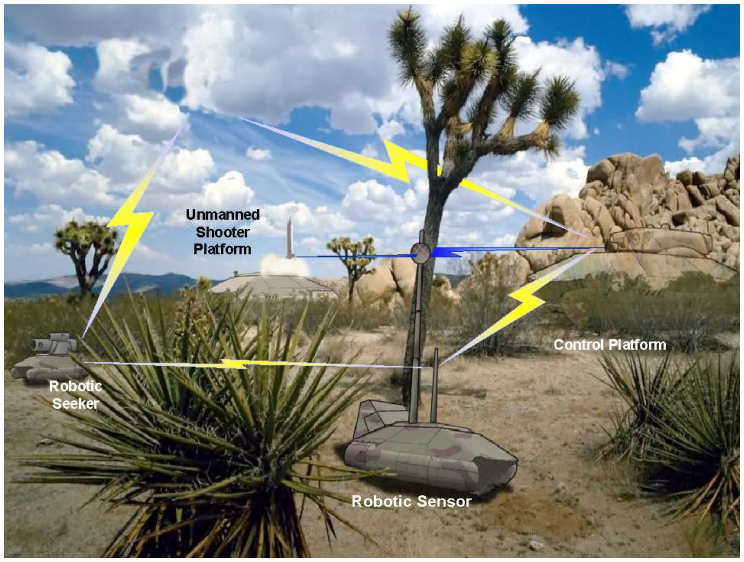
1

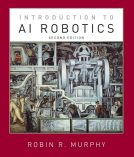
Replace Humans

Objectives
Definition
Why
-Replace
-Project
-Assist
-Amuse
Where
How
Summary

- Future Combat Systems
- Factory robots
- Roomba/scooba, other cleaning robots
- EOD, bomb-squad robots
- Sewer and pipe inspection robots
- Nuclear clean up

Dirty,
Dangerous,
Dull (3Ds) Tasks





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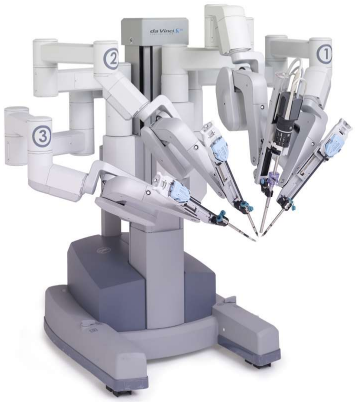
Project Humans

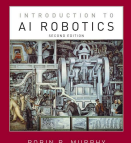
Allowing humans to project themselves into a remote environment in order to provide a remote presence

Objectives
Definition
Why
-Replace
-Project
-Assist
-Amuse
Where
How
Summary

- Robots for fire rescue, law enforcement, and hazardous materials handling can enter dangerous areas and allow experts to rapidly assess, and mitigate, disasters without risking human exposure

- Military drones allow soldiers to see and shoot around the world
- Robotic surgical system, such as the DaVinci system, allows surgeons to project themselves into the smaller scale of the human body and work with precision





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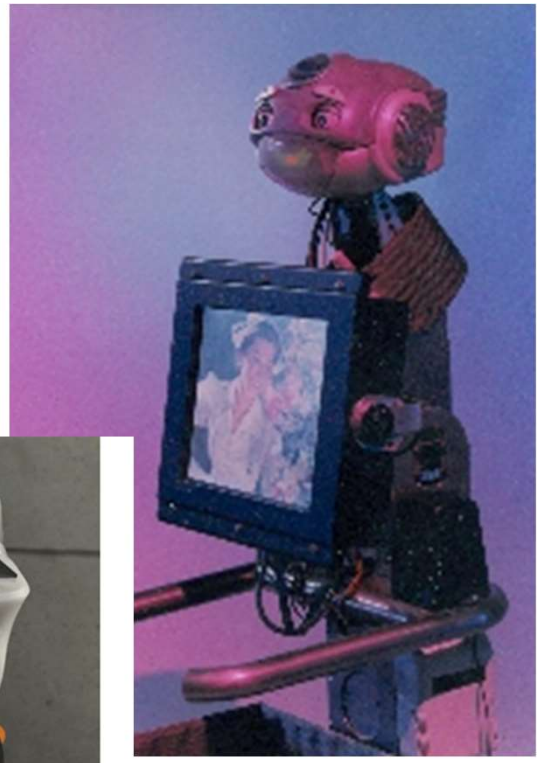
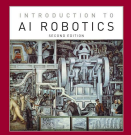
Assist Humans

Objectives
Definition
Why
-Replace
-Project
-Assist
-Amuse
Where
How
Summary

- Assistive Robots for
  - Eldercare, nursing
  - Rehabilitation and physical therapy





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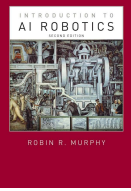
Amuse Humans

Objectives
Definition
Why
-Replace
-Project
-Assist
-Amuse
Where
How
Summary

- Entertaining robots
- Toys
- Educational toys
- Special effects (being replaced by graphics)

Furby Snowball



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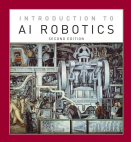
1

Objectives
Definition
Why
Where
-Ground
-Aerial
-Marine
How
Summary

WHERE DO ROBOTS WORK?



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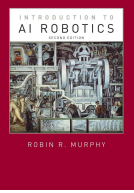
3 Major Modalities

Objectives
Definition
Why
Where
-Ground
-Aerial
-Marine
How
Summary

- **Unmanned Ground Vehicles**
  - since 1967
- **Unmanned Aerial Vehicles**
  - drones since Vietnam: Global Hawk, UCAV
- **Unmanned Marine Vehicles**
  - Autonomous Underwater Vehicles
  - ROVs since 1960s
  - Unmanned surface vehicles



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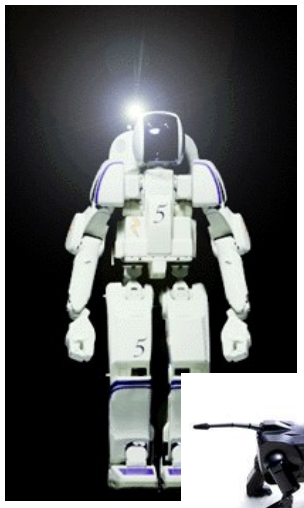
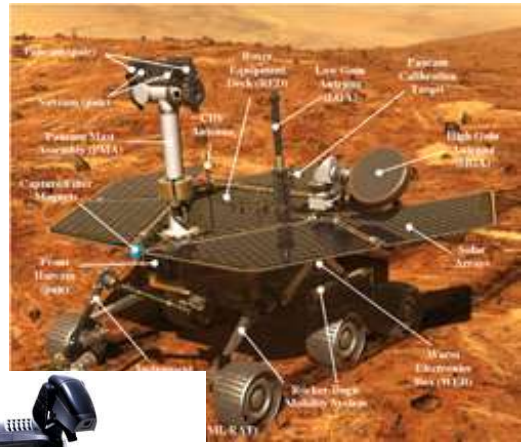
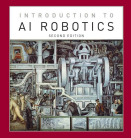
1 Unmanned Ground Vehicles

Objectives
Definition
Why
Where
-Ground
-Aerial
-Marine
How
Summary

- Three categories:
  - Mobile
  - Humanoid/animal
  - Motes
- Famous examples
  - DARPA Grand Challenge
  - NASA Mars Rovers
  - Roomba
  - Honda P3, Sony Asimo
  - Sony Aibo







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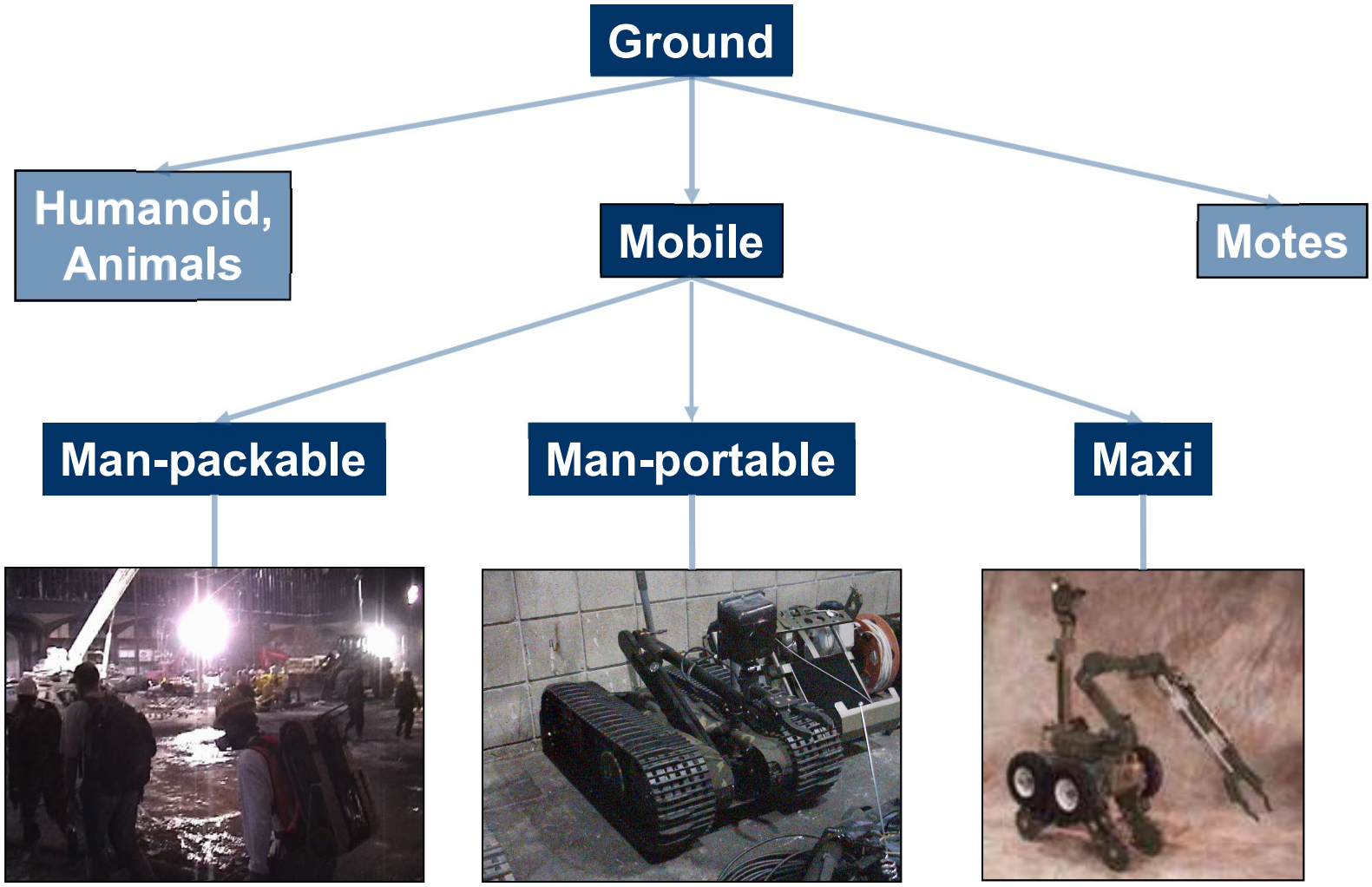
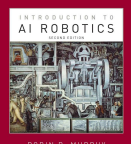
Taxonomy of UGV

Objectives
Definition
Why
Where
-Ground
-Aerial
-Marine
How
Summary





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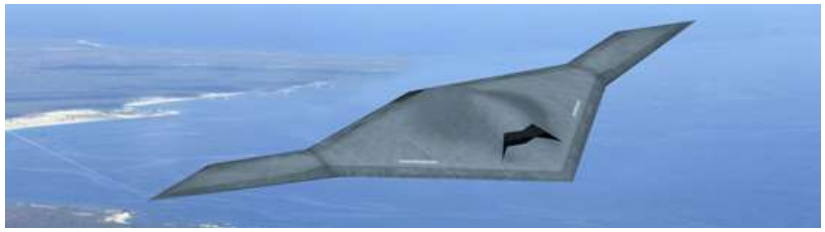
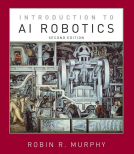
1

Unmanned Aerial Vehicles (or Systems) UAV (or UAS)

Objectives
Definition
Why
Where
-Ground
-Aerial
-Marine
How
Summary

- Three categories:
  - Fixed wing aircraft
  - Rotor-craft, or vertical take-off and landing platforms (VTOL)
  - Small or Micro aerial vehicle (MAV), which can be either fixed wing or VTOL
- Famous examples
  - DOD Global Hawk
  - DOD Predator
  - Yamaha RMAX





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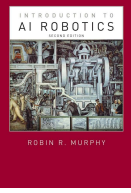
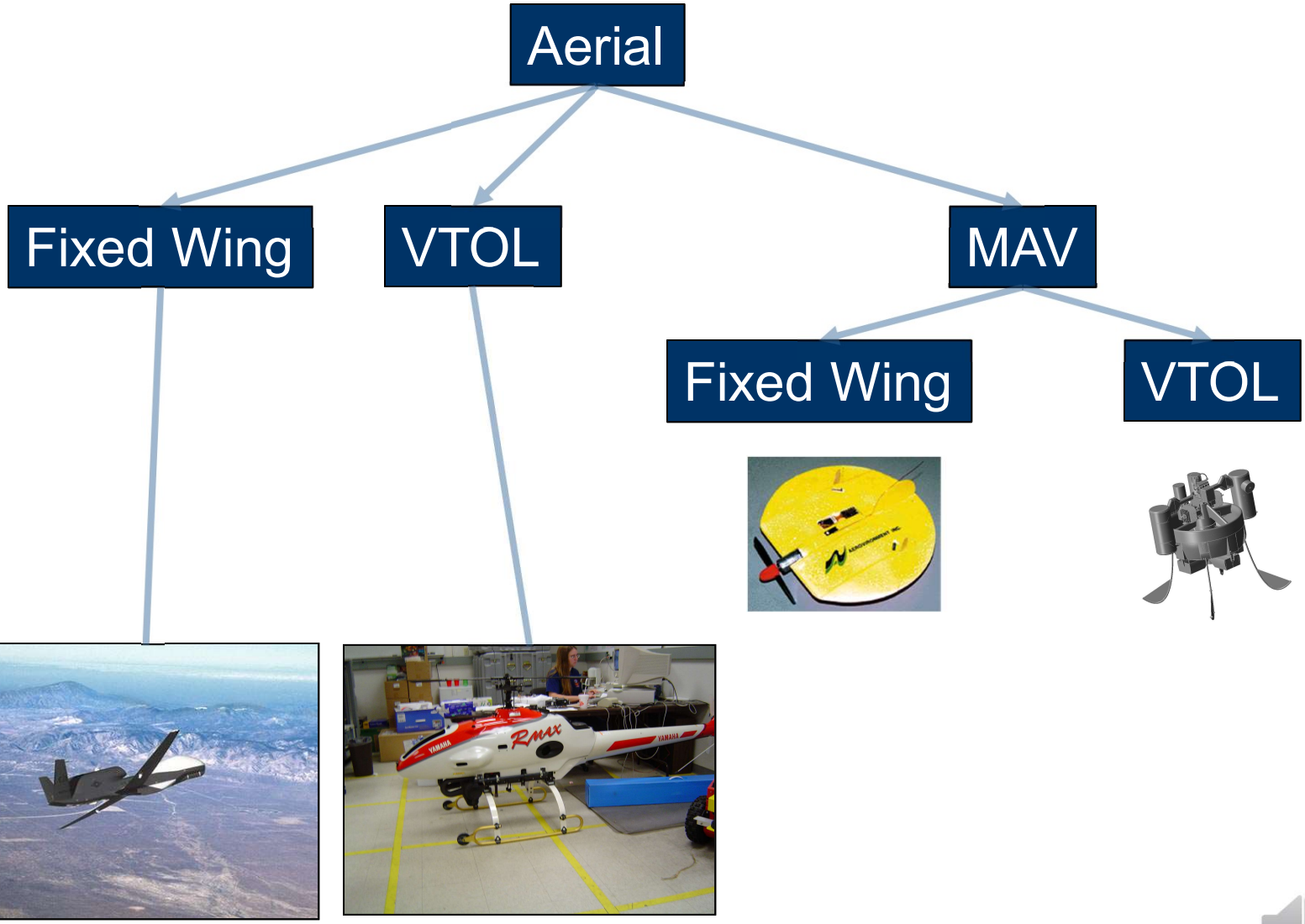
Taxonomy of UAS

Objectives
Definition
Why
Where
-Ground
-Aerial
-Marine
How
Summary





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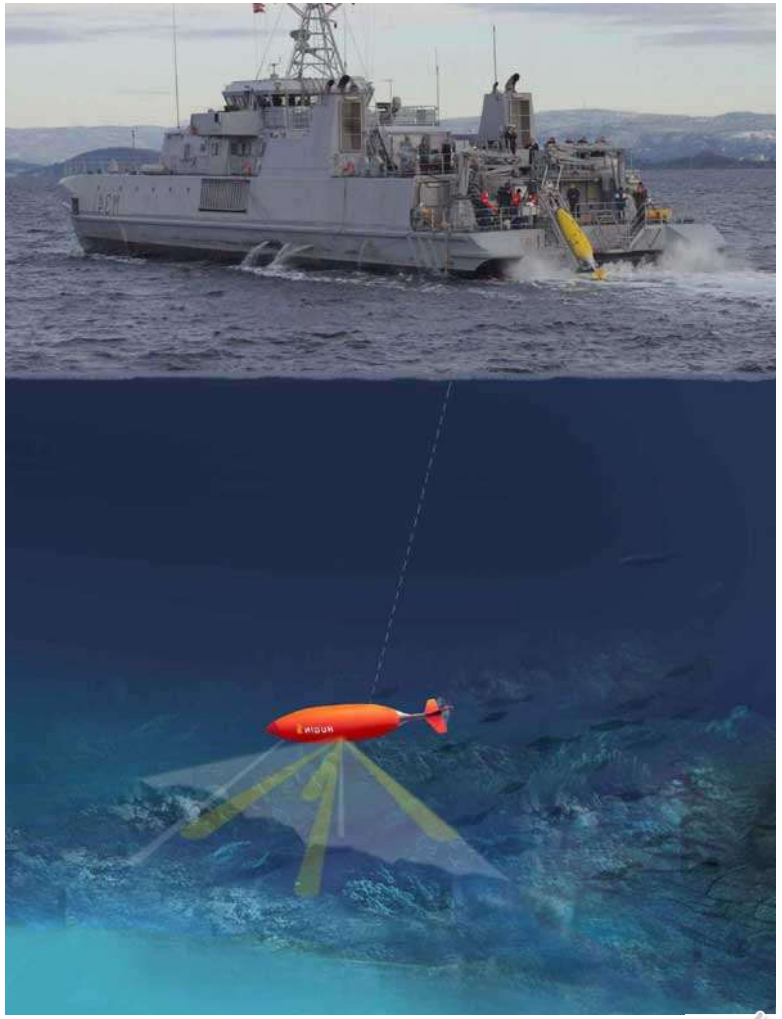
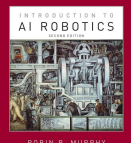
1 Unmanned Underwater Vehicle (UUV)

Objectives
Definition
Why
Where
-Ground
-Aerial
-Marine
How
Summary

- Categories
  - Remotely operated vehicles (ROVs), which are tethered

  - Autonomous underwater vehicles (AUVs), which are free swimming





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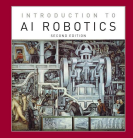
Unmanned Surface Vehicle (USV)

Objectives
Definition
Why
Where
-Ground
-Aerial
-Marine
How
Summary

- Categories
  - Air-breathing submersible
  - Jet-ski based
  - Rigid Inflatable Boat based



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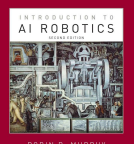
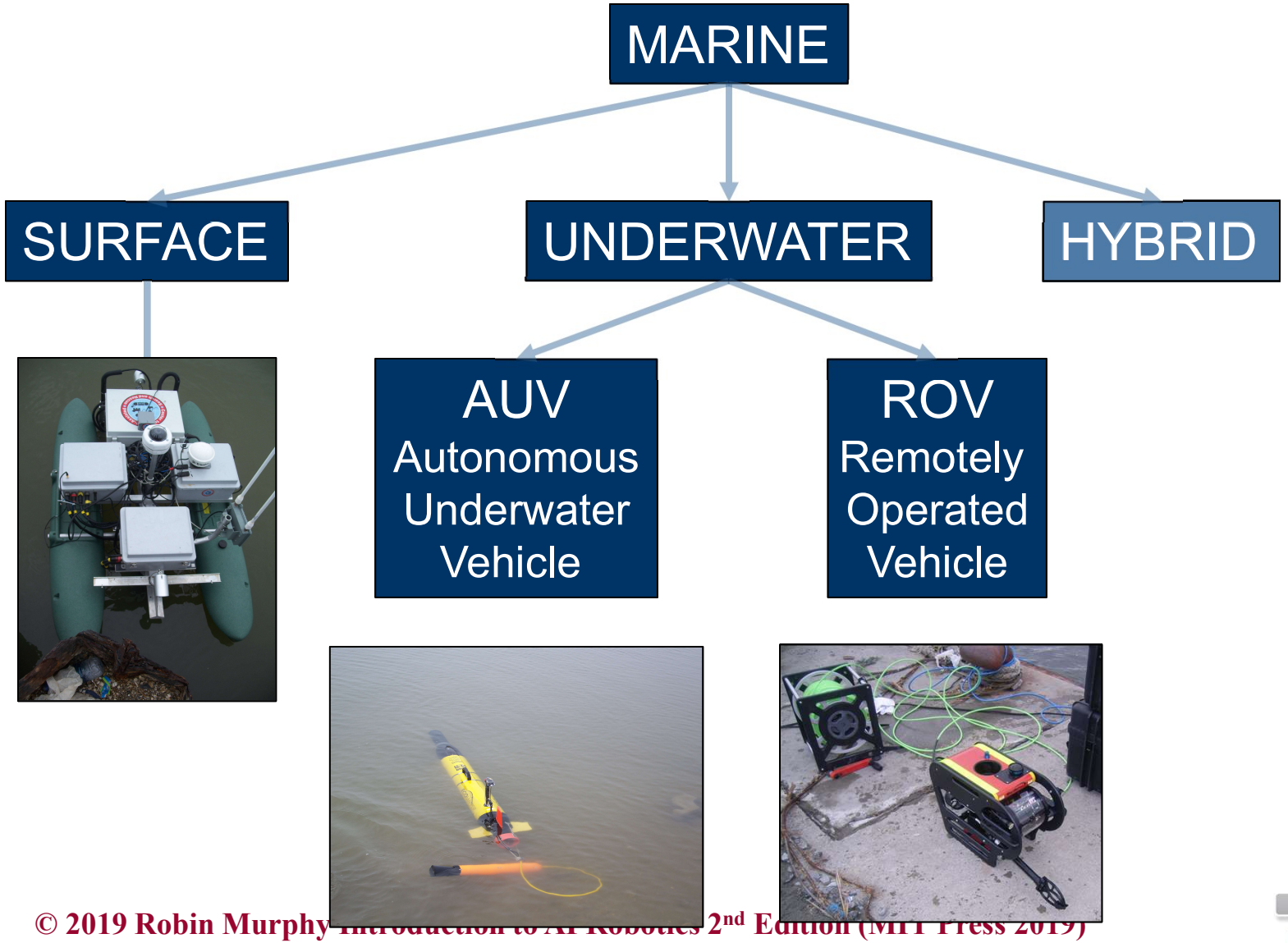
Taxonomy of UMV

Objectives
Definition
Why
Where
-Ground
-Aerial
-Marine
How
Summary





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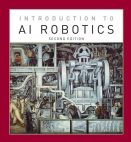
1

Objectives
Definition
Why
Where
How
- Intelligence
- AI areas
Summary

HOW ARE THEY INTELLIGENT?



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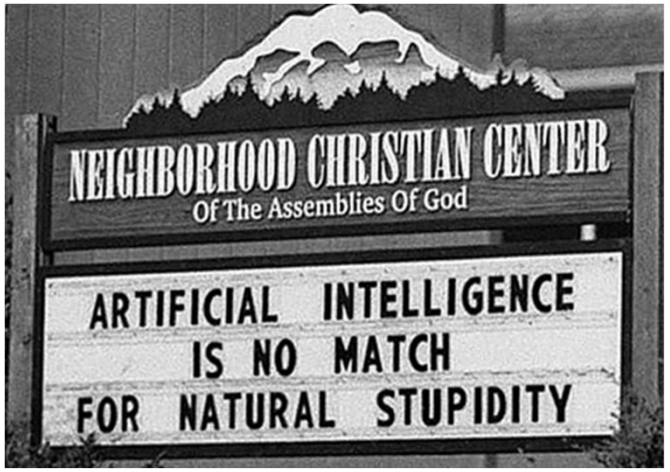
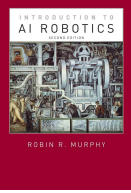
1

What is Intelligence?

Objectives
Definition
Why
Where
How
- Intelligence
- AI areas
Summary

Intelligence is a general mental capability that involves the ability to reason, plan, solve problems, think abstractly, comprehend ideas and language, and learn.
en.wikipedia.org/wiki/Intelligence_(trait)





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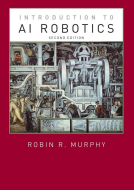
1 What is Artificial Intelligence?

Objectives
Definition
Why
Where
How
- Intelligence
- AI areas
Summary

The science of
making machines act intelligently



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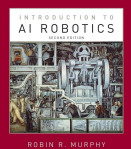
7 Major Areas of AI

Objectives
Definition
Why
Where
How
- Intelligence
- AI areas
Summary

1. Knowledge representation
   - how should the robot represent itself, its task, and the world (if at all)
2. Search
   - *Finding* answers in a knowledge base, finding objects in the world
3. Inference
   - *Generating* an answer when there isn't complete information
4. Planning and problem solving
   - Mission, task, path planning
5. Understanding natural language
6. Learning
7. Vision



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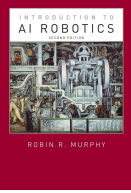
7 Major Areas of AI

Objectives
Definition
Why
Where
How
- Intelligence
- AI areas
Summary



1. Knowledge representation
   - how should the robot represent itself, its task, and the world (if at all)
2. Search
   - *Finding* answers in a knowledge base, finding objects in the world
3. Inference
   - *Generating* an answer when there isn't complete information
4. Planning and problem solving
   - Mission, task, path planning
5. Understanding natural language
6. Learning
7. Vision
8. *Distributed intelligence*

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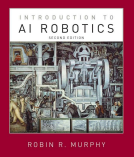
Summary

Objectives
Definition
Why
Where
How
Summary

- In AI, a robot is a physically situated intelligent agent
- Four reasons for robots are:
  - Replace
  - Project
  - Assist
  - Amuse
- The five components of every robot are: *effectors, sensors, power, control, communications*
- The three modalities of robots are: *land, air, and sea*
- The seven major areas of AI are: *knowledge rep, natural language, learning, planning and problem solving, inference, search, vision*



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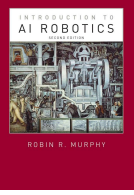
For More Information

- Robots Alive! (Very old video, 1997)
  - https://www.youtube.com/watch?v=2aa6vMpMSho
  - Please watch the “schedule a meeting” and “clean the room” competitions, and try to describe the role of the AI areas in making the robot intelligent
- Crash Course: Artificial Intelligence - Robotics #11
  - https://www.pbs.org/video/robotics-11-ouvqgj
  - Talk about the role of AI in overcoming three key challenges in the field of robotics: localization, planning, and manipulation.
- How to engineer a dog
  - https://www.youtube.com/watch?v=6igNZiVtbxU
  - Talk about how to design legged robots like dogs
- AlphaPilot: Autonomous Drone Racing (RSS 2020 Video Pitch)
  - https://www.youtube.com/watch?v=ZIHjswKDods
  - A novel system for autonomous, vision-based drone racing
  - It deployed at the first autonomous drone racing world championship: the 2019 AlphaPilot



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