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### What is an Agent?

- An (intelligent) agent perceives its environment with sensors and acts (rationally) upon that environment with its actuators
- Perception-Action cycle
- Agent gets percepts sequentially, and maps this percept sequence to actions (to achieve some goal)



# Agent Program

- Maps percepts to actions
- Basic cycle
  - 1. perceive
  - 2. reason/decide
  - 3. act
  - 4. repeat

## Why Agents?

- The agent metaphor provides a useful framework for thinking about and designing AI systems
  - Percepts/sensors (inputs)
  - Actions/actuators (outputs)
  - Environment/world
  - Goals

## **Examples of Intelligent Agents**

- Game Playing
  - Game agent takes your moves as percepts and its moves as actions
- Robots
  - Robot takes input from cameras, microphones and its output is motor controls, voice, etc.
- Finance
  - Trading agent takes rates and news from stock market and produces buy/sell trades as actions
- Medicine
  - Diagnostic agent takes test results for a patient as percepts and outputs diagnostic recommendations



## Some Key Problem Characteristics

- Is the environment fully observable or partially observable?
- An environment is fully observable if the agent's sensors give it access to the complete state of the environment at any point in time
- If all aspects that are *relevant* to the choice of action are able to be detected, then the environment is effectively fully observable
- Noisy and inaccurate sensors can result in partially observable environments

## **Problem Characteristics**

- Is the task deterministic or stochastic?
- A problem is deterministic if the next state of the world is completely determined by the current state and the agent's actions
- Randomness and chance are common causes stochastic environments

## **Problem Characteristics**

- Is the environment static or dynamic?
- An environment is static if it doesn't change between the time of perceiving and acting
- An environment is semi-dynamic if it doesn't change but the agent does (performance score)
- Time is an important factor in dynamic environments since perceptions can become "stale"

## **Problem Characteristics**

- Is the problem episodic or sequential?
- An environment is episodic if each perceptaction episode does not depend on the actions in prior episodes
- Games are often sequential requiring one to think ahead

## **Problem Characteristics**

- Is the problem discrete or continuous?
- A problem is discrete if there are a bounded number of distinct, clearly-defined states of the world, which limits the range of possible percepts and actions

#### How Do We Make a Robot?

### Autonomous Robots

- Key questions in mobile robotics
  - -What is around me?
  - -Where am I?
  - Where am I going ?
  - How do I get there ?
- Alternatively, these questions correspond to
  - Sensor Interpretation: what objects are there in the vicinity?
  - Position and Localization: find your own position on a map (given or built autonomously) and position on road
  - Map building: how to integrate sensor information and your own movement?
  - Path planning: decide the actions to perform for reaching a target position

### Autonomous Robots

- Key questions in mobile robotics
  - -What is around me?
  - -Where am I?
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  - How do I get there ?



## Example: Robot Vehicles

- UAV unmanned aerial vehicles
  - airplanes, helicopters, birds
- UGV unmanned ground vehicles – cars, insects









# How Do You Build a Robot Car?

- What actions does the car need to perform?
- What does it need to know about its environment?
- What **sensors** can be used to acquire the needed information?



- Car Information
  - Position and orientation of car, velocity and turning rate of car
- Environment Information
  - Where is the road, curb, road signs, stop signs, other vehicles, pedestrians, bicyclists, ...
- Actions
  - Velocity, steering direction, braking, ...
- Sensors
  - Video cameras, microphone, GPS, depth cameras, radar, ...









### Sensors

- Video cameras
- LIDAR (depth/range) sensor
  - times how long it takes a beam of laser light to bounce off something
- Radar sensors on front and rear
- Position sensor on one wheel
- GPS
- Inertial motion sensor (IMU)















#### The 2005 "Grand Challenge" Race





## Lots of Hard Tasks!

- Where is the road, lanes, curbs, other vehicles, road signs, stop lights, pedestrians, bicyclists?
- How to navigate, pass, merge, park, stop, avoid obstacles?

# Learning What Cars Look Like





Autonomous Car Parking	









#### The Future of Autonomous Driving?

• "In 20 years I will trust my autonomous car more than I trust myself"

– Sebastian Thrun

• "It won't truly be an autonomous vehicle until you instruct it to drive to work and it heads to the beach instead."

- Brad Templeton

#### Summary

- An agent perceives and acts in an environment to achieve specific goals
- Characteristics of agents:
  - percepts
  - actions
  - goals
  - environment

# Summary

**Characteristics of Problems** 

- fully observable vs. partially observable
- deterministic vs. stochastic
- episodic vs. sequential
- static vs. dynamic
- discrete vs. continuous