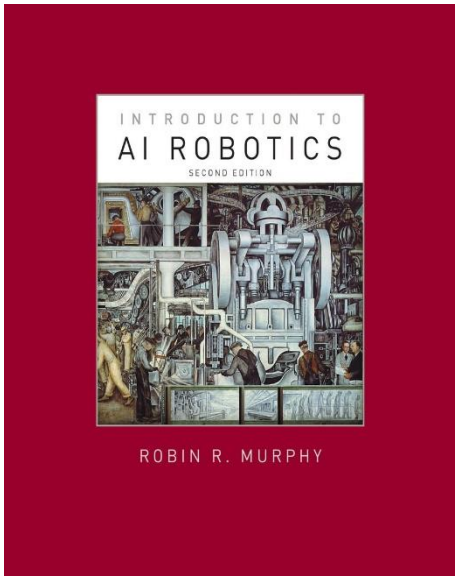
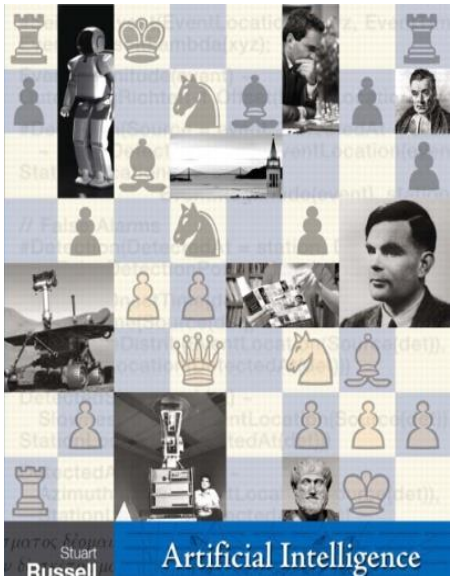
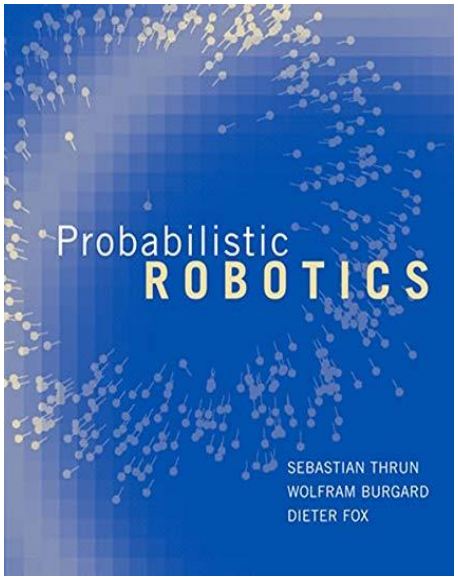
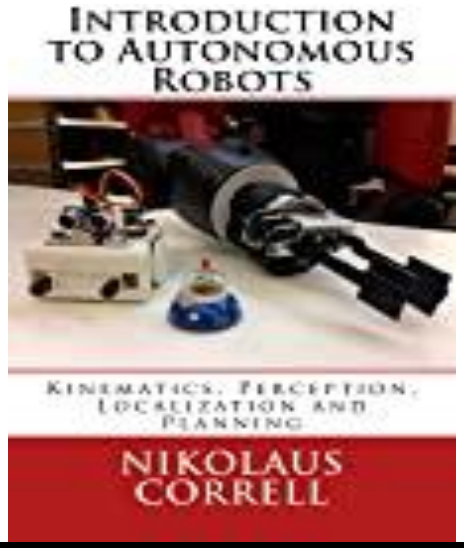
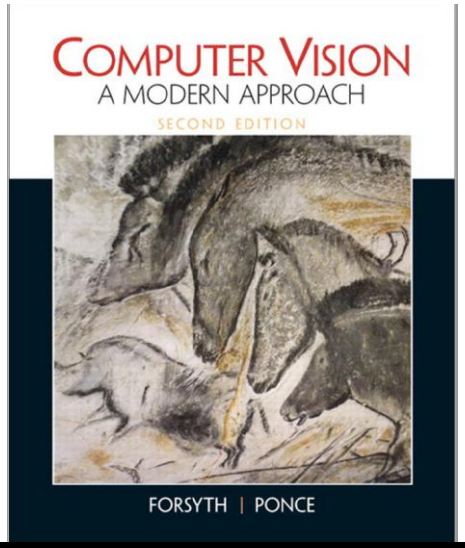
Lecture 3: What is Robot Autonomy? Part II











DASE 4460

CS 3460

Adham Atyabi

What Makes Autonomy Different?

What is the difference between automation and autonomy?

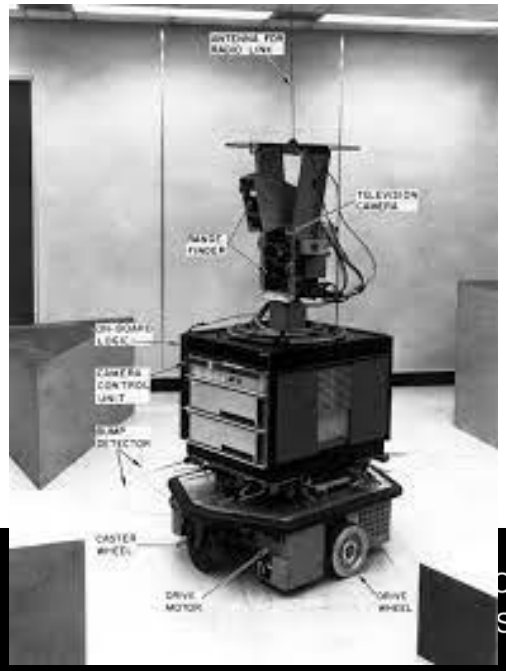
Why does it matter that there is a difference between autonomy and automation?

What are the advantages of autonomy over automation? Can you tell me when to use one over the other? How much autonomy do I need?

Amazon Kiva Robot

Automation vs Autonomy: criteria to assess capabilities

- Plans: Generation vs Execution
- Actions: Deterministic vs non-Deterministic
- Models: Open vs Closed world
- Knowledge Representation



Closed World Assumption

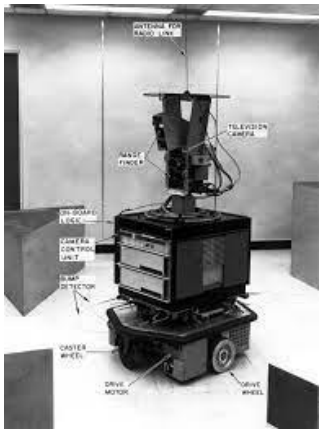
- ***Execution of precise, repetitious actions or sequence in a controlled or well-understood environment***

Closed World Assumption

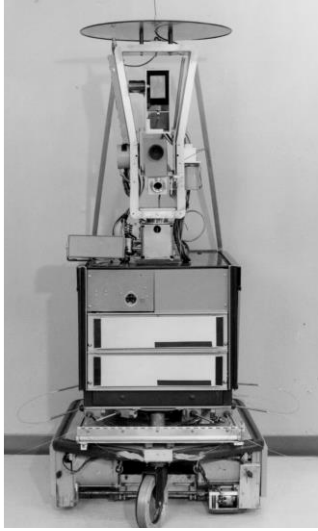
CLOSED WORLD

- Everything relevant is known *a priori*, that there are no surprises
- Everything relevant can be completely modeled
- If world is modeled accurately enough, **can create stable control loops to respond to all expected situations**
- If world is controlled, **can minimize or eliminate sensing**

But What If Not Closed World?



OPEN WORLD



Shakey, the first AI robot.

- **Open World Assumption**
- Models may be available but are only partially (and unpredictably) correct
- There is a **Frame Problem**
- Must be able to **sense relevant aspects** of the world in order to **dynamically adapt actions** (e.g., act as an agent)

Or a Human Can't Do It?

- **Open World Assumption**
- Models may be available but are only partially (and unpredictably) correct
- *Must be able to **sense relevant aspects** of the world in order to **dynamically adapt actions** (e.g., act as an agent)*

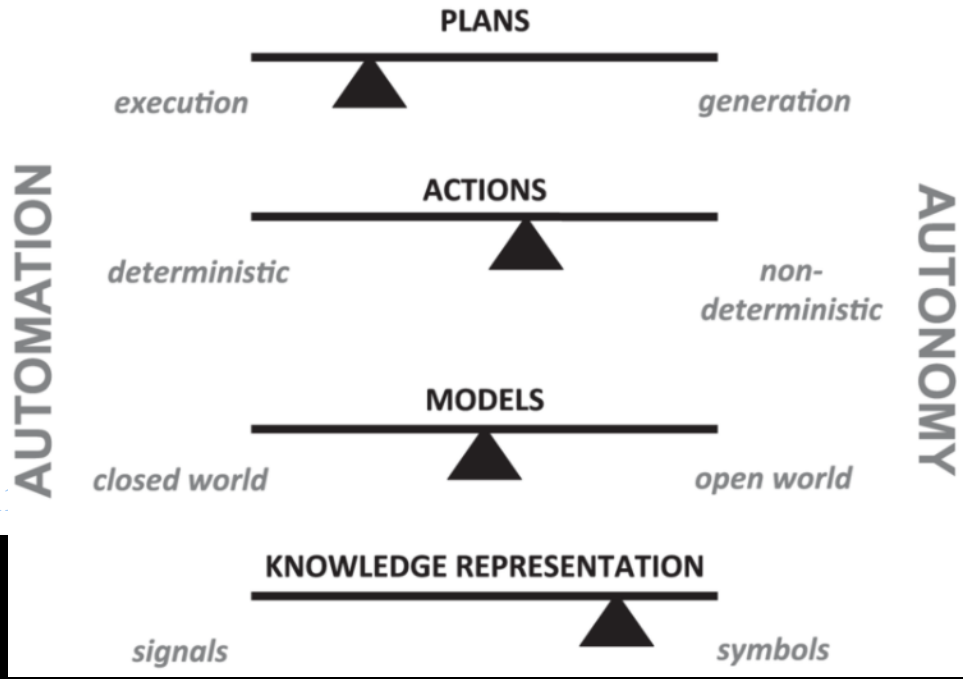
- **This is associated with being autonomous**

Automation vs Autonomy: criteria to assess capabilities

- Plans: Generation vs Execution
- Actions: Deterministic vs non-Deterministic
- Models: Open vs Closed world
- Knowledge Representation: Symbol vs Signal

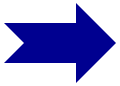
Why does it matter that there is a difference between autonomy and automation?

- Impact on Programming Style
- Impact on Hardware Design
- Impact on Types of Functional Failures
- Impact on Types of Human Error



It Affects Programming Style

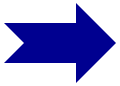
- Closed world
- Delegating for a small set of repetitious tasks



Focus is on formal, stable control loops

Automation

- Open world
- Delegating for a variety of tasks while operating in dynamic environments



Focus is on artificial intelligence

Autonomy

See a Difference?

Automation

- Closed world
- Delegating for a small set of repetitious tasks

Focus is on formal, stable control loops

Autonomy

- Open world
- Delegating for a varie of tasks while operati in dynamic environme

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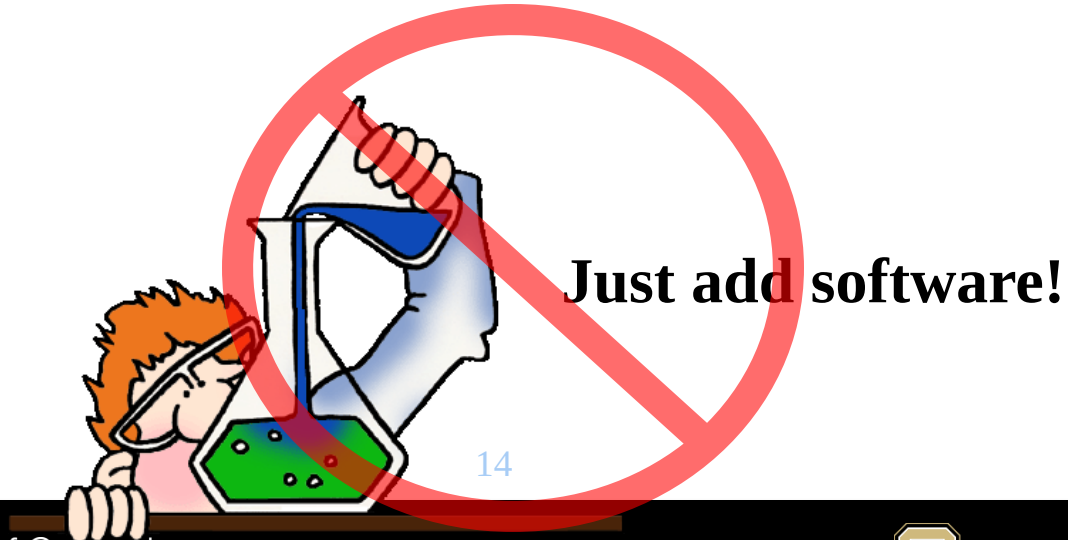
It Affects Hardware Design

- Recall: autonomy requires **rich sensing** in order to monitor the key elements of the dynamic world; so a robot designed for automation or for teleoperation is not necessarily able to be used autonomously by just adding software



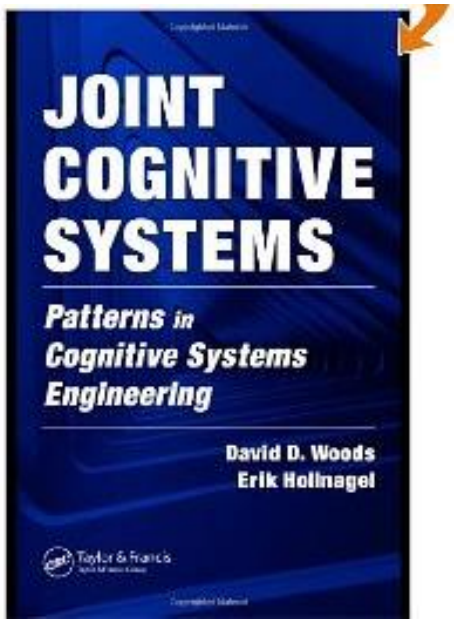
It Affects Hardware Design

- Recall: autonomy requires **rich sensing** in order to monitor the key elements of the dynamic world; so a robot designed for automation or for teleoperation is not necessarily able to be used autonomously by just adding software

- **Think of it as an ecology**, what ecological niche is the robot going to fit
  - Tasks the robot must do to be successful ("survive")
  - Environment
  - **Platform**

It Affects How Systems Break

- If models are incorrect in a complex world, the robot may get tunnel vision and miss things
  - Ex. blindly following rules of engagement overruled what was really happening
- If the robot has a problem, the human may not be able to fix it fast enough unless the robot also provides transparency, smooth transfer
  - Ex. autopilot failures
- The Substitution Myth that a machine perfectly substitutes for a person
  - Ex. 2 heads are 9 times better than 1 for systems intended for 1 operator



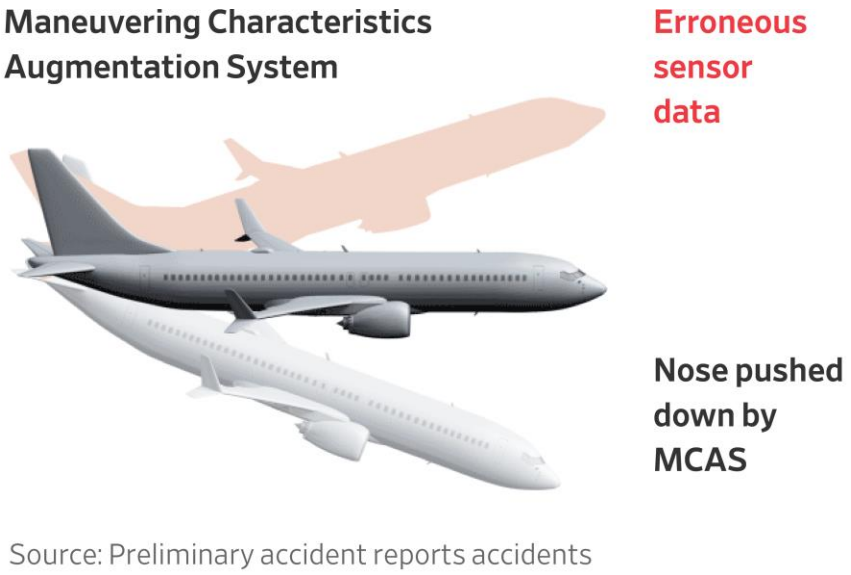
50% of the failures in disaster robotics are human error, **but** it is not clear what the human could have done differently!!!

Types of functional failures

- Functional Failures
  - If the robot's expectation of the environment is incorrect in a complex world, it may get the equivalent of "tunnel vision" and miss things.
  - U.S. military autonomous image processing system not being able to identify troop movements
- Human Errors

Types of functional failures

- Human Errors
  - ***Substitution myth****:* the myth that a machine will perfectly replace a human for a particular task
  - Human Out-Of-The-Loop (OOTL) control problem
    - Early Auto-Pilot system problem
    - if the system is designed to allow the human to easily visualize the internal state of the robot and to facilitate smooth transfer of control, then it would be possible for the human operator to overcome the OOTL problem.
  - It is usually cheaper to pay to keep a worker engaged full time to handle rare, but challenging problems, rather than eliminate a full-time person and call them in only when a problem occurred.



Can You Solve a Problem With Automation or Autonomy?

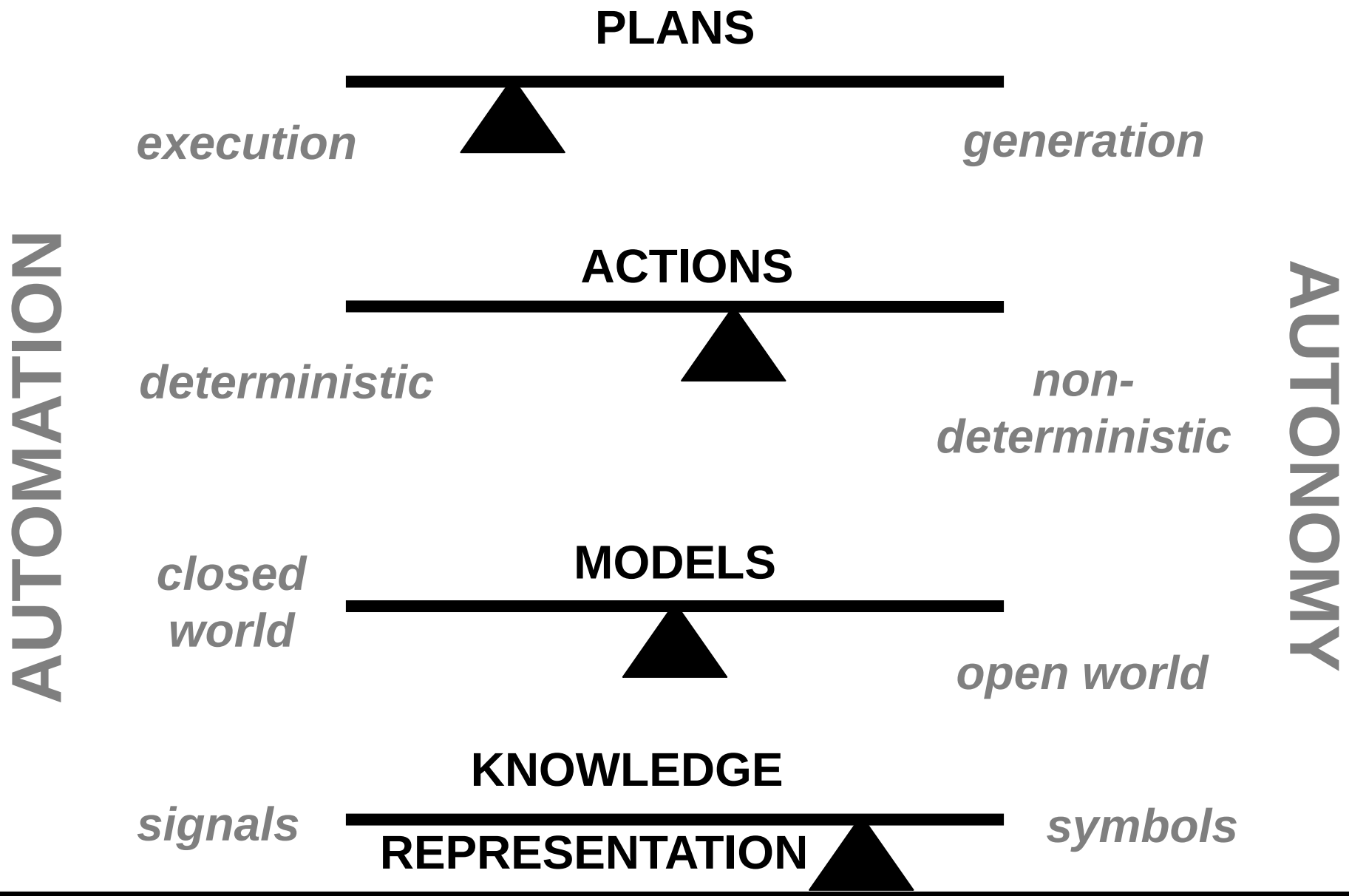
Automation

- Execution: perhaps plan once, then repeat that plan forever
- Deterministic: can model the system deterministically

- Closed world: the model contains everything
- Signals: control or decision-making is at the signal level

Autonomy

- Generate: constantly generating new plans
- Non-deterministic: system is too complex to model deterministically
- Open world: models will only be partial
- Symbols: control or decision-making is with symbols or labels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generation
ACTIONS
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MODELS
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KNOWLEDGE
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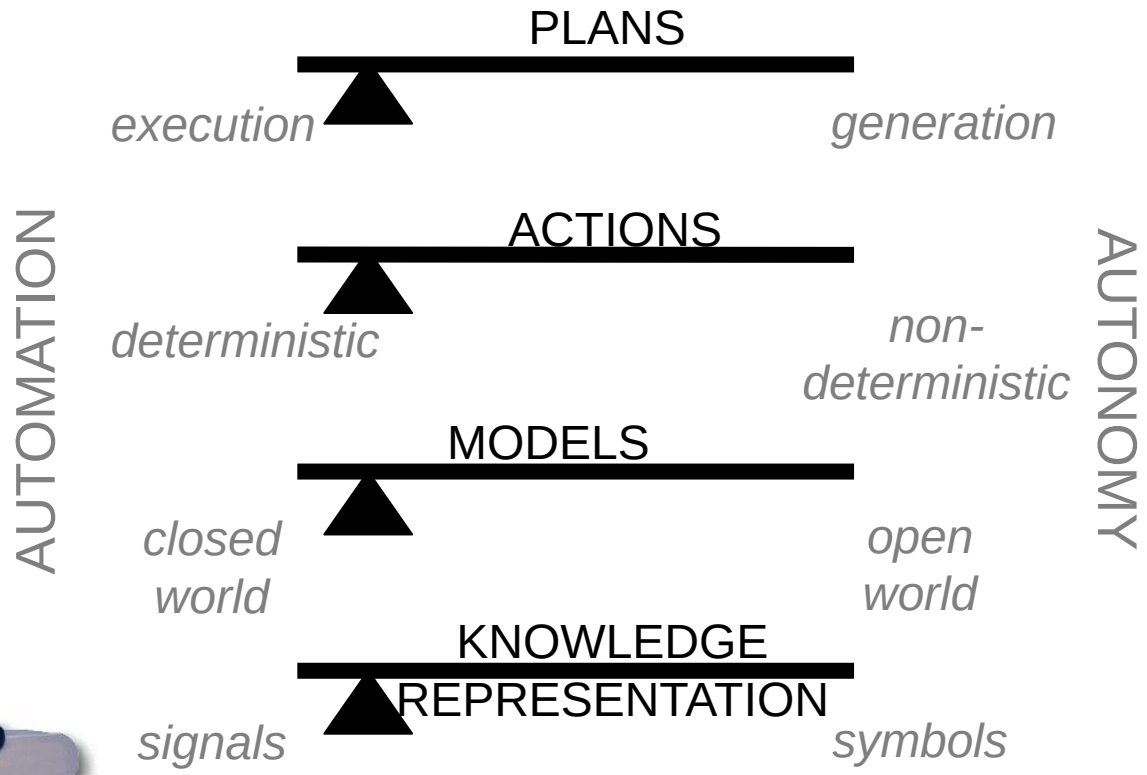
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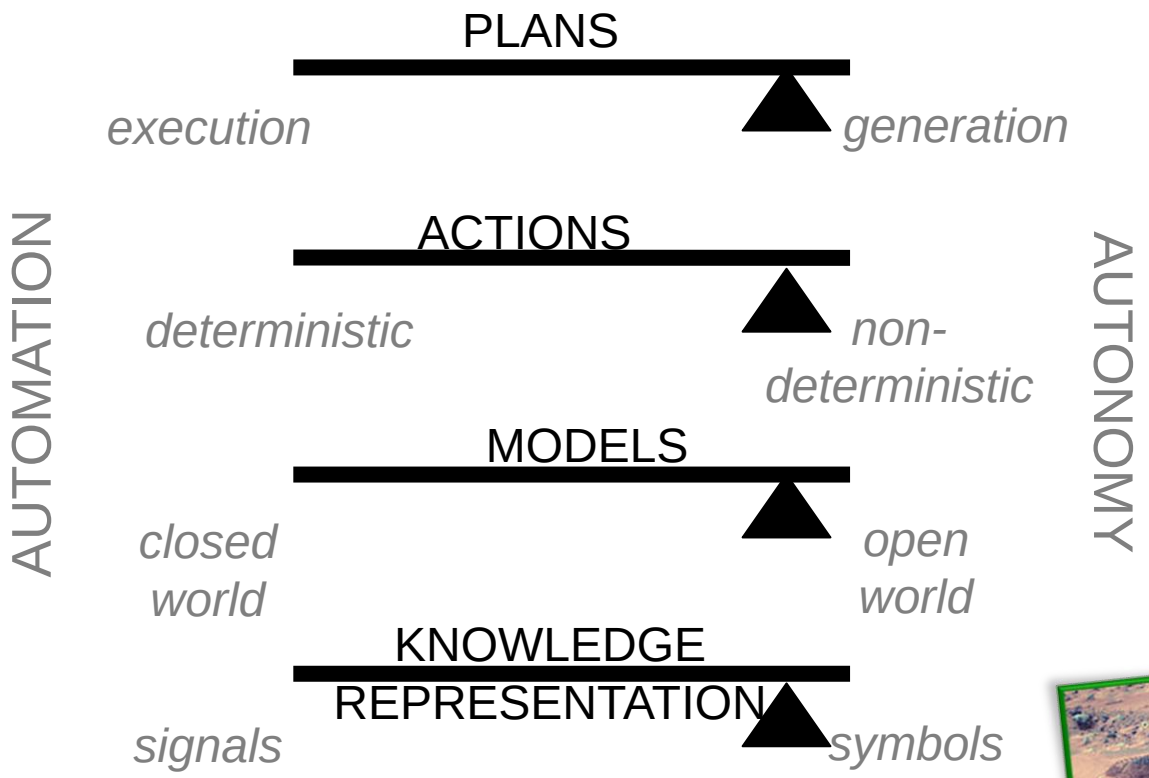
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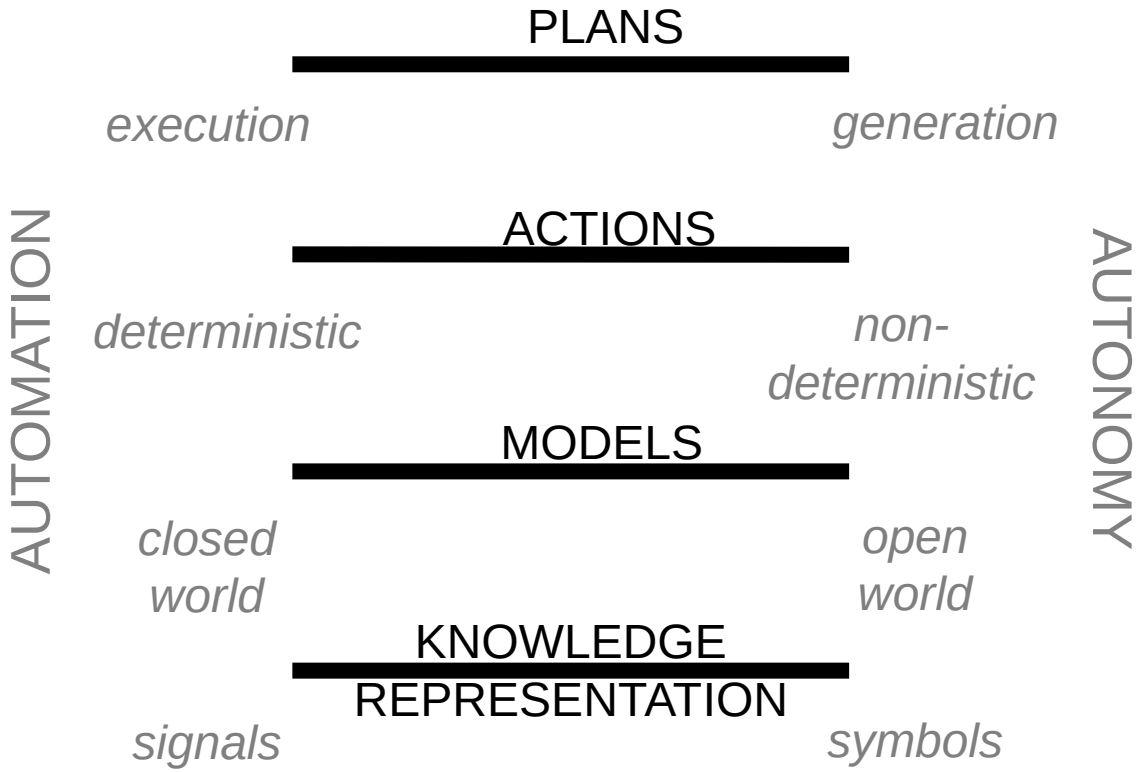
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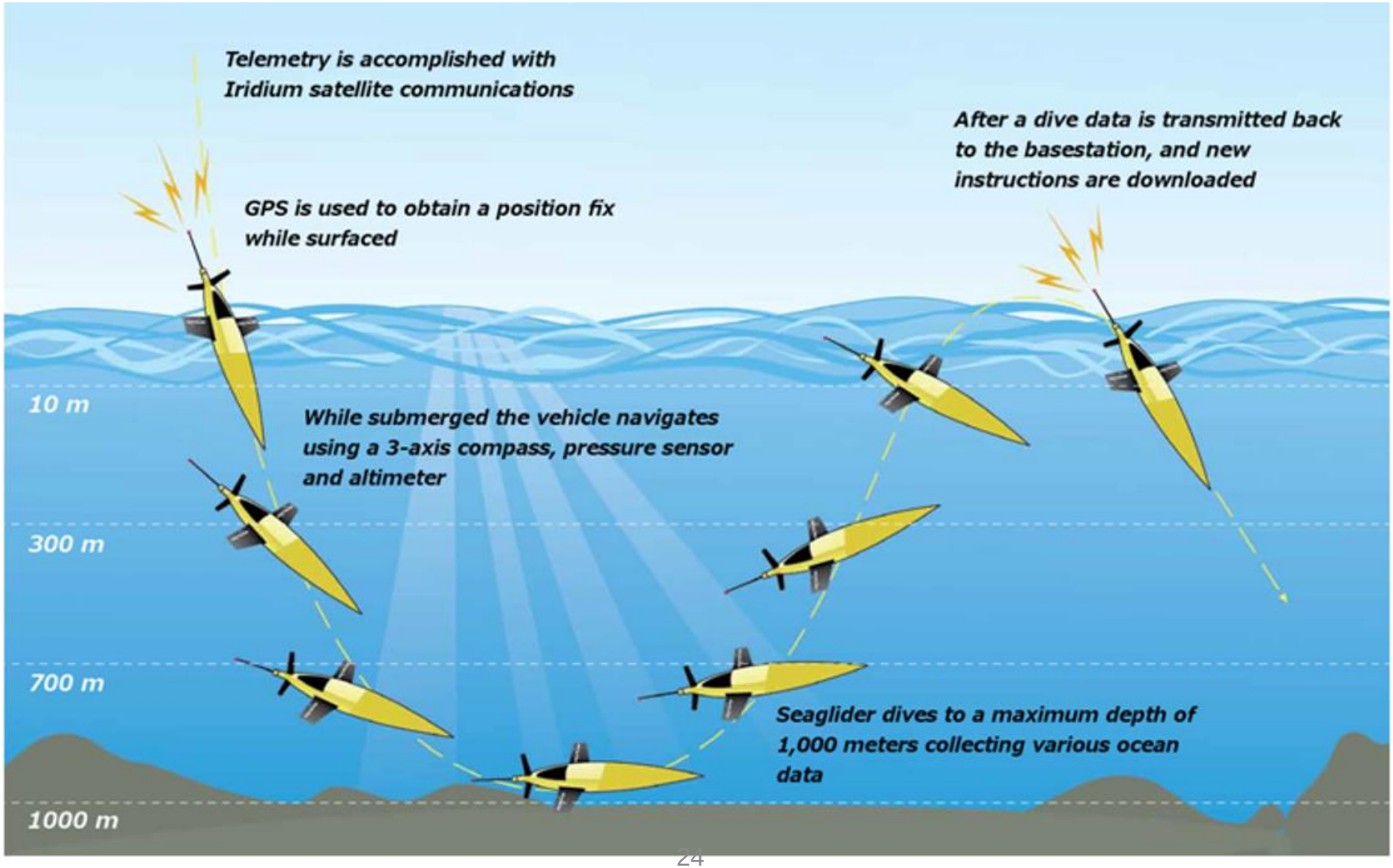
Telemetry is accomplished with Iridium satellite communications
GPS is used to obtain a position fix while surfaced
After a dive data is transmitted back to the basestation, and new instructions are downloaded
10 m
While submerged the vehicle navigates using a 3-axis compass, pressure sensor and altimeter
300 m
700 m
Seaglider dives to a maximum depth of 1,000 meters collecting various ocean data
1000 m

CLASS DISCUSSION

PLANS

execution *generation*

AUTOMATION

ACTIONS

deterministic *non-deterministic*

AUTONOMY

MODELS

closed world *open world*

KNOWLEDGE REPRESENTATION

signals *symbols*

To Conclude

- Intelligent robot is a physically situated *intelligent agent; it* is a system that perceives its environment and takes actions which maximize its chances of success.
- An intelligent robot is also called autonomous, where autonomous means autonomous capability, not political autonomy or that the robot can do the entire job
- If you design a robot application, you will probably use a bit of ideas from automation and autonomy but you will need to consider whether planning is involved, what kinds of actions, what type of model of the world, and knowledge representation

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