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Intelligent Robot's Autonomy

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Summary:

- Definition of robot
- New applications for robots
- Industry 5.0
- Intelligence == Automation vs Autonomy
- Software to create autonomy
- Sensors to support Autonomy
- Once autonomous, interaction with the humans

Intelligent Robots

- 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.



So What's the Difference?

- **Automation** is about physically-situated tools performing highly repetitive, **pre-planned actions for well-modeled tasks** under the closed world assumption.
- **Autonomy** is about physically-situated agents who not only perform actions but can also adapt to the open world where the environment and **tasks are not known a priori** by generating new plans, monitoring and changing plans, and learning within the constraints of their bounded rationality.

Practical Examples:

Automation



Autonomy





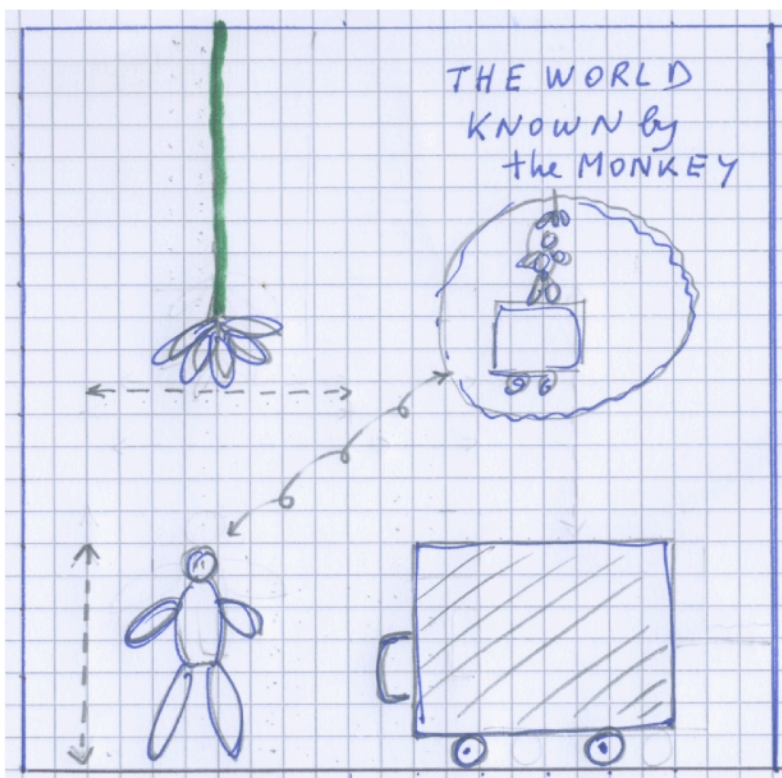
Closed World Assumption

CLOSED WORLD

- Everything relevant is known *a priori*, there are no surprises
- In formal logic, this means that any object, condition, or event that is not specified in the database is false
- 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**

The monkey and banana problem

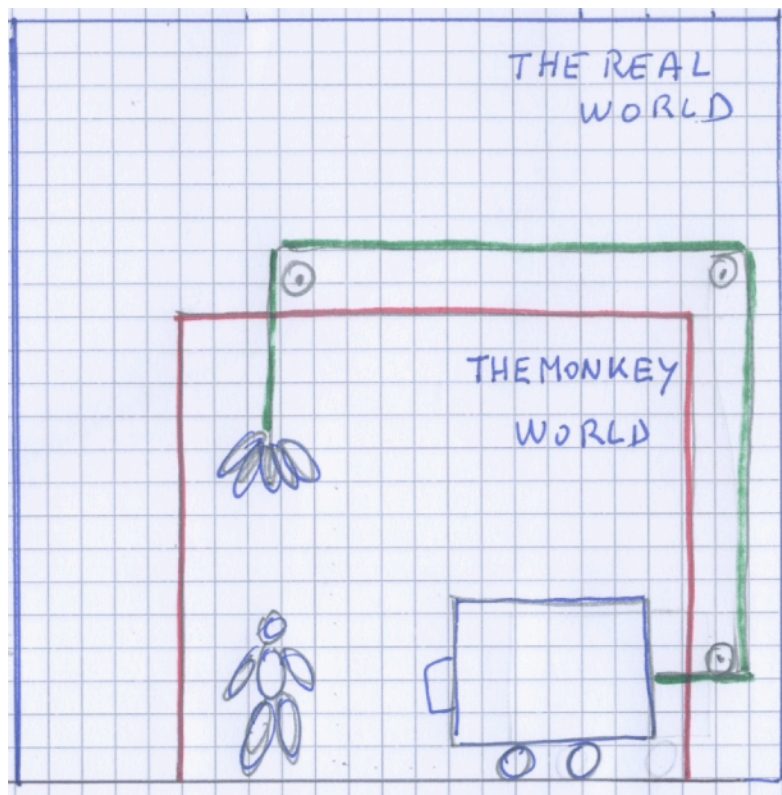
The **monkey and banana problem** is a famous toy problem in artificial intelligence, particularly in logic programming and planning.



**CLOSED WORLD
ASSUMPTION**

The monkey and banana problem

Pat Hayes introduced this paradox in Brighton, at AISB-1976, the first Conference of the British Association of AI, that was also the 1st European Conference on Artificial Intelligence



**REAL WORLD
is
NOT CLOSED WORLD**

But What If Not Closed World?



- **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**



WHY DOES IT MATTER THAT THERE IS A DIFFERENCE BETWEEN AUTONOMY AND AUTOMATION?

This difference affects the:

- the hardware design
- the programming style
- the kind of failures

1. 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



Adapted from R. Murphy

1. 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**

2. 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?

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



Focus is on formal, stable control loops

Automation

- Open world
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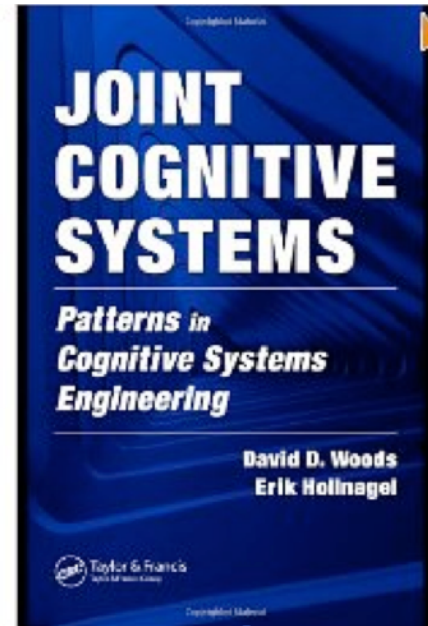


Focus is on artificial intelligence

Autonomy

3. 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 can cause failures on the socio-technical organization
 - Ex. 2 heads are 9 times better than 1 for systems intended for 1 operator





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

