Autonomy and autonomous systems, the state of play

AI Nuclear Risk Workshop, SIPRI

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Autonomous systems

Figure: Autonomous device warning, © Lifeboat Foundation

What are autonomous systems?

A definition

Definition (An attempt)

An **autonomous system** is a technical device that can

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- observe its environment (“Where am I?”)

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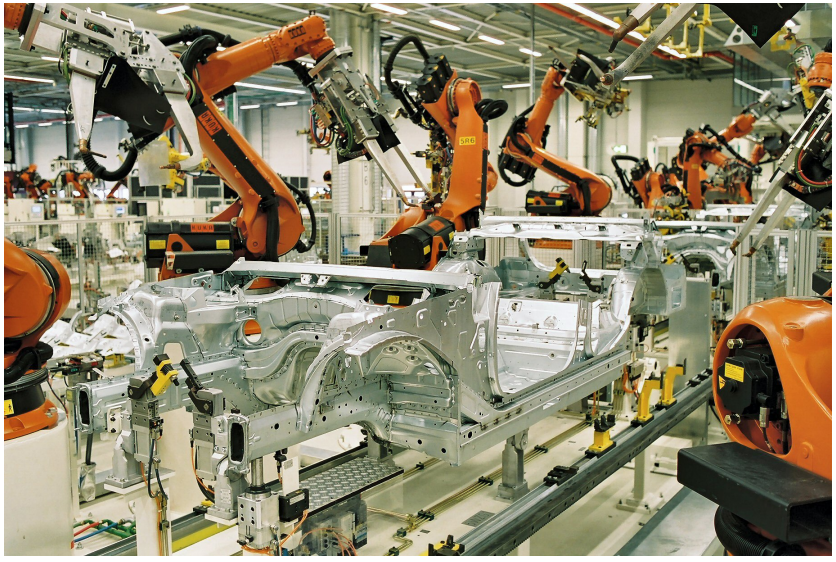
$\rightsquigarrow$ Goal required!

Notes on definition

(a) DARPA 2007 Urban challenge participant



(b) Spot welding robots, CC BY-SA 2.0 BMW Werk Leipzig

Distinction autonomy vs. automation

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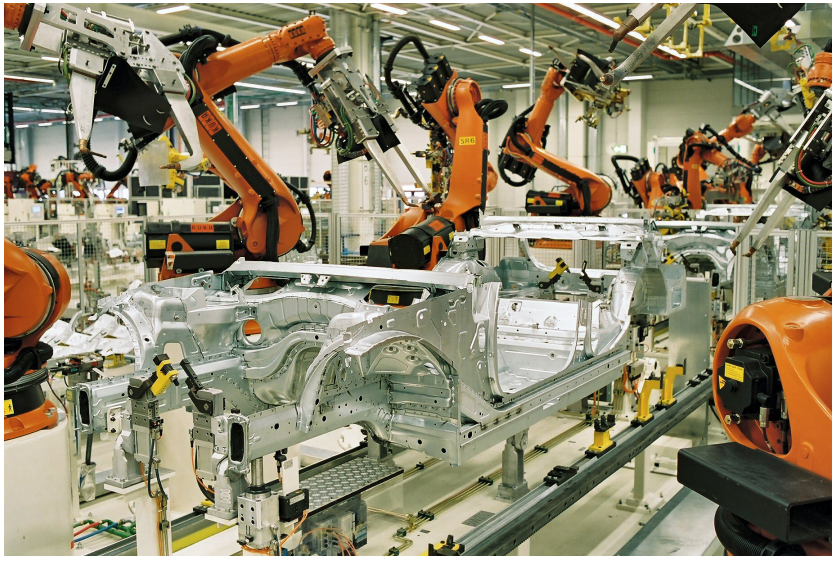

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Distinction autonomy vs. automation

Automation execution of simple, hard-coded tasks

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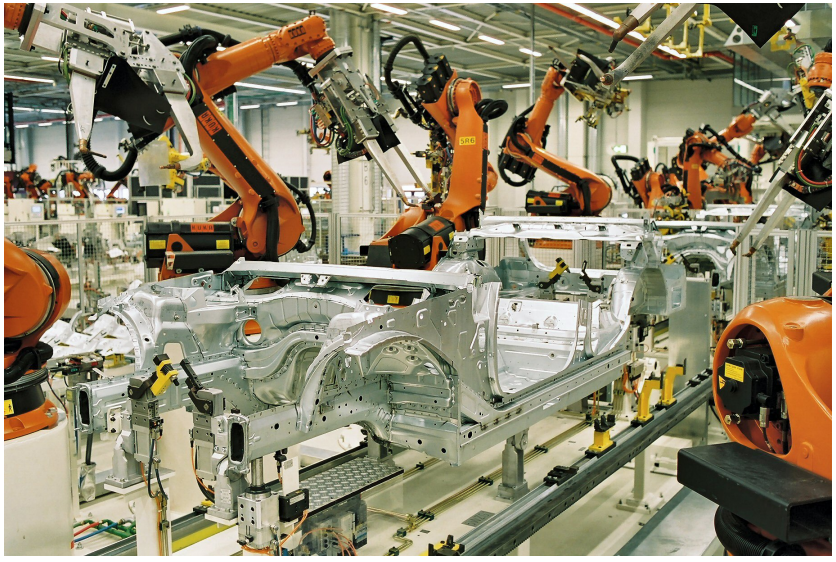

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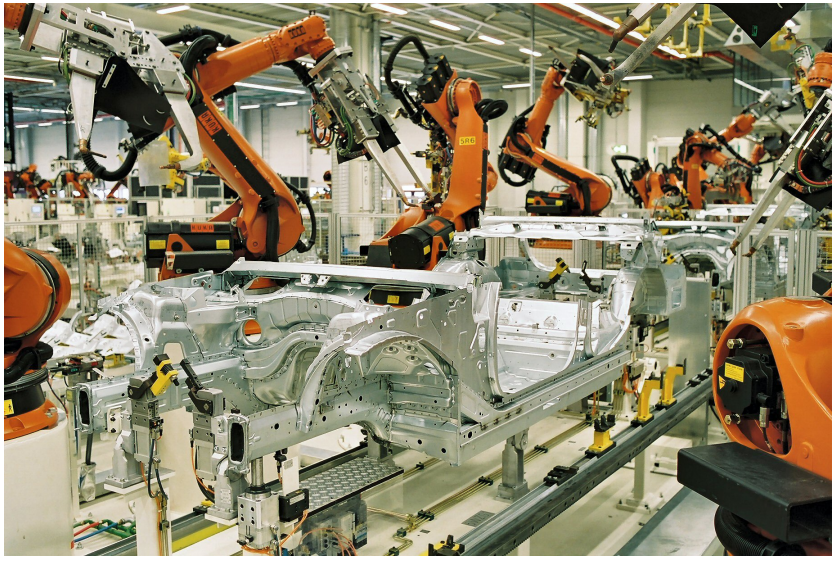

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Automation execution of simple, hard-coded tasks

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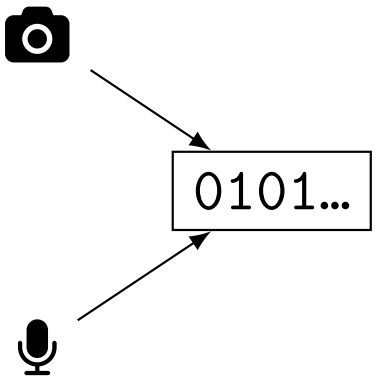
Note distinction fuzzy

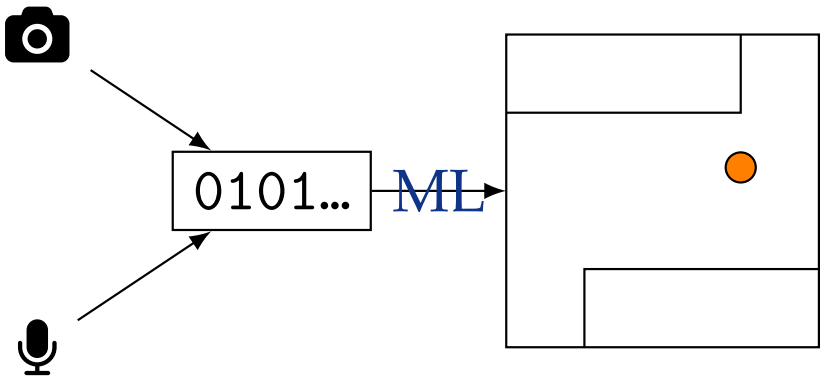
Building blocks



Any autonomous device needs

- sensors

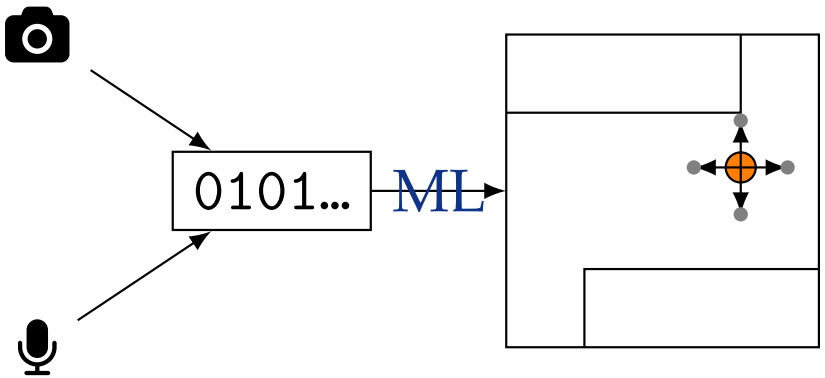
Building blocks



Any autonomous device needs

- sensors
- internal domain representation

Building blocks



Any autonomous device needs

- sensors
- internal domain representation
- a model of own actions (“What if?..”)

Navigation

(a) DARPA 2007 Urban challenge participant

(b) SailDrone, Photo © Richard Jenkins

(c) Autonomous farming, Photo © Freya Fleckenstein

(d) Cora, Photo © Kitty Hawk

Medicine

Most researched subject: Autonomous surgeries

Figure: CyberKnife, CC BY-SA BLK Cyberknife Hospital

Current stage CNC-like execution of surgical plan

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Cutting edge Tumor recognition and radiotherapy

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Future Autonomous cuts

Non-robot applications

Not always an autonomous device is a (mechanical) robot.

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Example

- Autonomous trading

Non-robot applications

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Example

- Autonomous trading
- Autonomous disaster warning

Non-robot applications

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Example

- Autonomous trading
- Autonomous disaster warning
- Air traffic control

Non-robot applications

Not always an autonomous device is a (mechanical) robot.

Example

- Autonomous trading
- Autonomous disaster warning
- Air traffic control
- Calling companies to update opening hours database

Impossibilities

Three (and a half) main problems

- Observation complexity

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- Observation complexity
- Domain complexity

Impossibilities

Three (and a half) main problems

- Observation complexity
- Domain complexity
- Planning complexity

Impossibilities

Three (and a half) main problems

- Observation complexity
- Domain complexity
- Planning complexity
- Specification

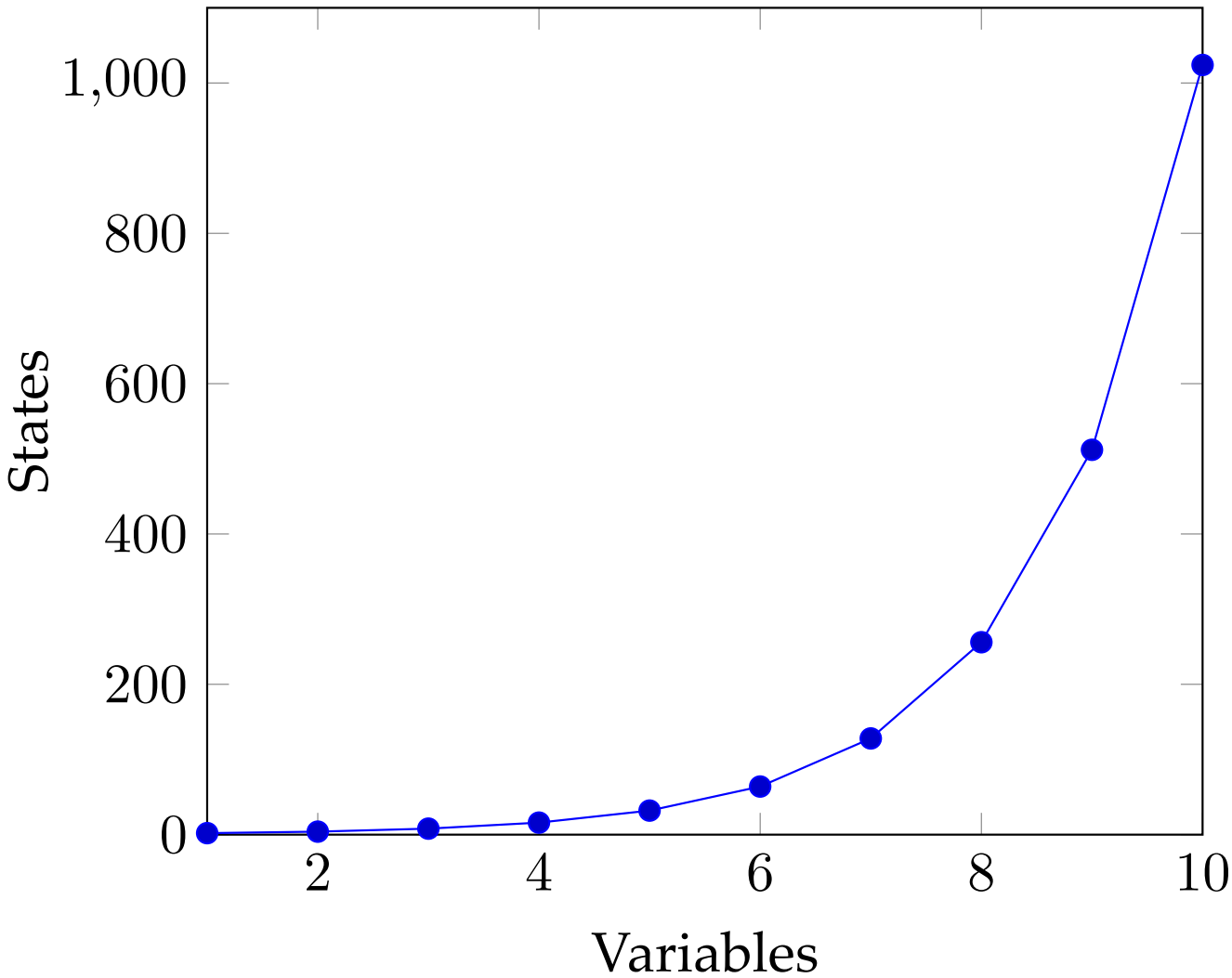
Observation complexity

Not all observation tasks are equal

Figure: German driver's license exam, © `fahrschule.de`

Complex domains: State space explosion

Problem size is exponential in the number of variables



Complex domains II: Multiple parties and uncertainty

Non-cooperative actors and uncertainty lead to difficulties

Figure: 2010 Flash Crash

Need to infer all goals of all actors and hidden information, otherwise: model unusable

Planning

Depending on the goal, planning can get complicated

Example

Get to SIPRI…

Planning

Depending on the goal, planning can get complicated

Example

Get to SIPRI…

- on May 22

Planning

Depending on the goal, planning can get complicated

Example

Get to SIPRI…

- on May 22
- departing in Bad Hersfeld, Germany

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Depending on the goal, planning can get complicated

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Get to SIPRI…

- on May 22
- departing in Bad Hersfeld, Germany
- on May 22

Planning

Depending on the goal, planning can get complicated

Example

Get to SIPRI…

- on May 22
- departing in Bad Hersfeld, Germany
- on May 22
- with a total budget of…

Planning

Depending on the goal, planning can get complicated

Example

Get to SIPRI…

- on May 22
- departing in Bad Hersfeld, Germany
- on May 22
- with a total budget of…
- with at most 4 changes

Planning

Depending on the goal, planning can get complicated

Example

Get to SIPRI…

- on May 22
- departing in Bad Hersfeld, Germany
- on May 22
- with a total budget of…
- with at most 4 changes
- with 10kg luggage

Problem formulation

Not a computational problem…

Problem

Communication, especially with a computer, is non-trivial

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Formalizing a problem is often hard.

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The wrong way

World domination

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The wrong way

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The correct way

Allocate shares to most profitable assets