

These slides are based on material I developed while working at the University of Bern. This version has been adapted for public educational use.

About Me



Loubet—Bonino Grégory

Research Focus

Robotic Monitoring and Self-Adaptability in Robotics

Enhancing Simulation Fidelity

Improving Robot Performance



Preparatory Class, Dijon 2020-2022



Master of Embedded systems
Centrale-Lyon 2024-2025



Electronics Engineering school
Telecom 2022-2025



Competed in the French Robotics
Cup with Projet&Tech team



From 2022 to
2025



<https://github.com/dragonfuneste>



Gregory.loubet-bonino@unibe.ch

Objective

Autonomous
Navigation
Principles



1

Benefit of Pre-
Testing
Simulation



2

Path planning
Principles



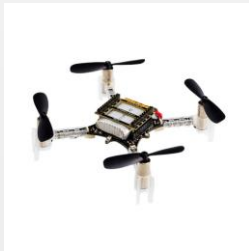
3

What is a robot ?

A robot is an embodied system that perceives its environment through sensors, makes decisions, and acts on the physical world using actuators, with a certain level of autonomy.

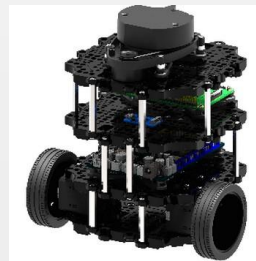
This definition includes :

UAVs
(Unmanned aerial vehicle)



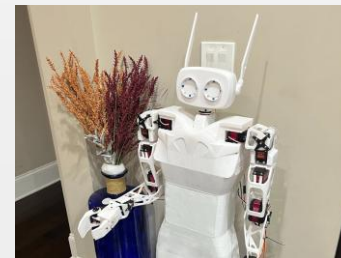
Crazyflie

Ground Robot



Turtlebot3

Humanoid robots



Sparky

...

An old idea



Talos Myth in ancient Greek

It was a legend of a giant bronze man who protected Crete

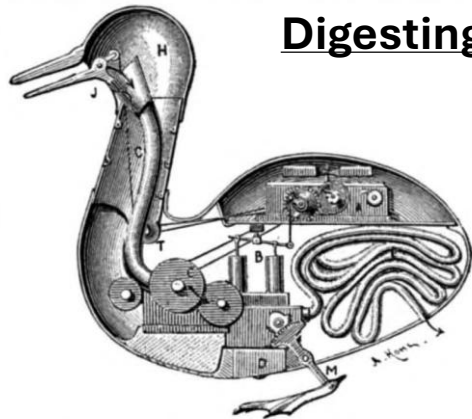


The Golem in Jewish culture

a being shaped from clay and brought to life to protect the community.



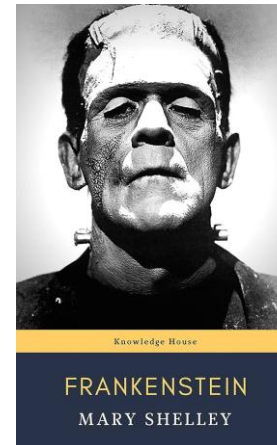
An old idea



Digesting Duck of Vaucanson 1764

One of the first mechanical dolls ever built; this one could digest and flap its wings.

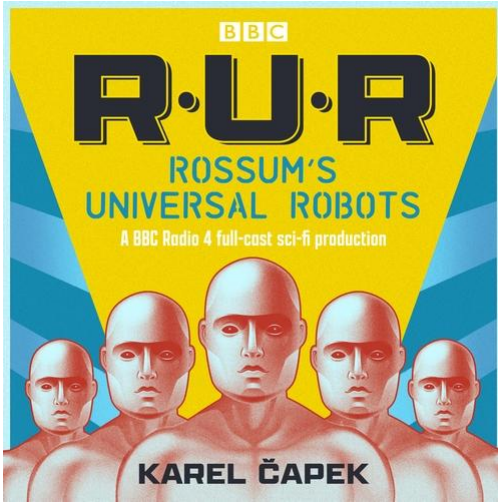
INTERIOR OF VAUCANSON'S AUTOMATIC DUCK.
A, clockwork; B, pump; C, mill for grinding grain; F, intestinal tube;
J, bill; H, head; M, feet.



The Frankenstein monster 1818

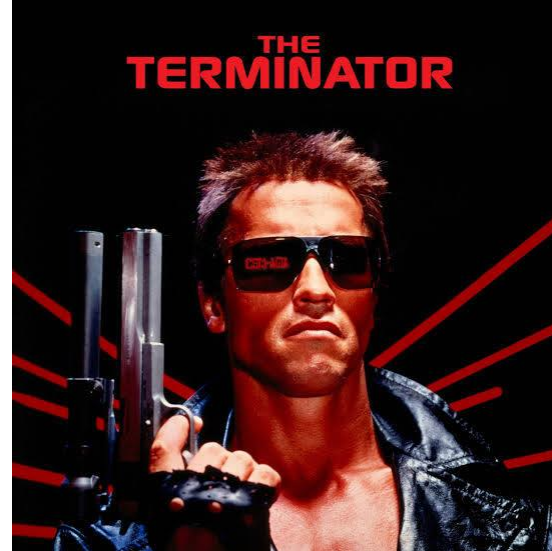
An artificial life created **by humans**.
It is a precursor to the idea that robots should be **artificial and man-made**.

An old idea



Rossum's Universal Robots 1921

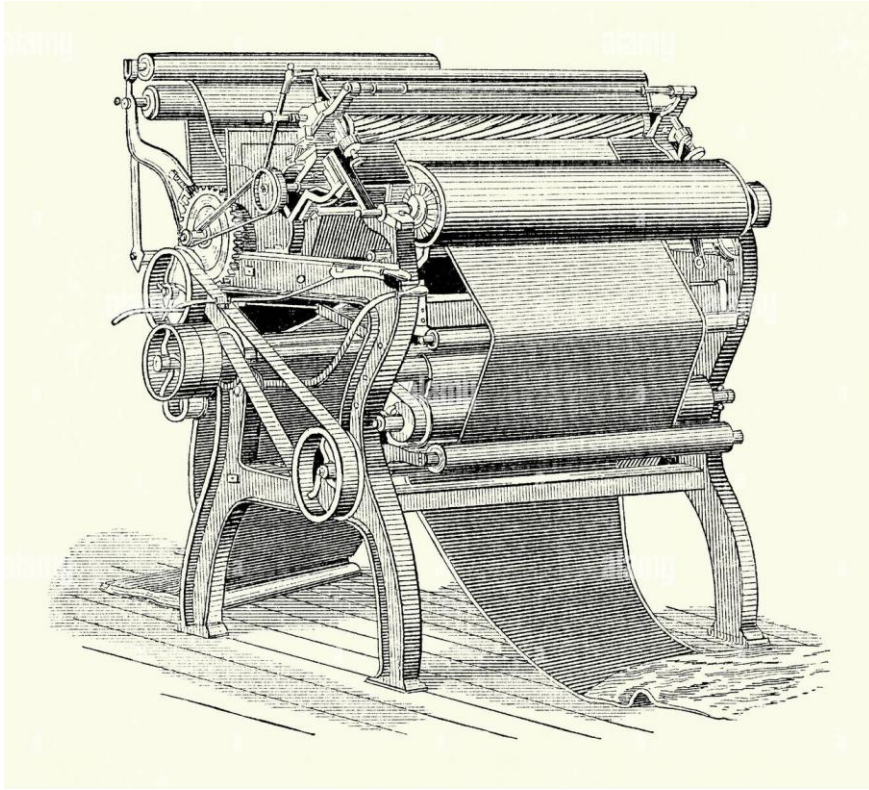
First time the word robot was put. Talk about artificial beings build like Frankenstein as working force



Terminator saga



Automation



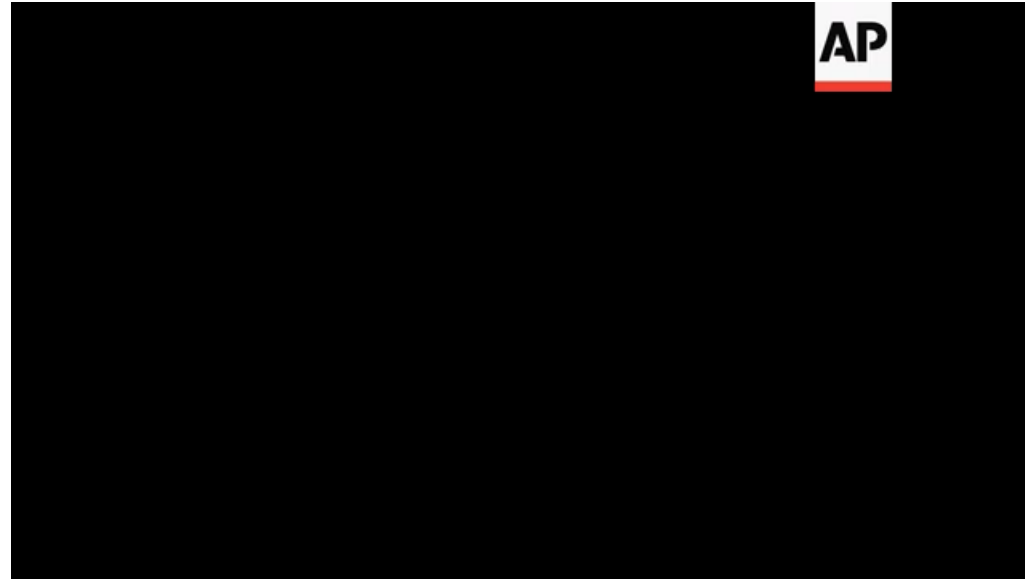
Power loom, the first industrial machine,
1890s

increased output by a factor of 40

Steam engines and electricity were invented
and made automation of the work possible.

Launched the second industrial revolution,
where manual work gradually started to be
replaced.

The first Robot



<https://www.youtube.com/watch?v=hxsWeVtb-JQ>
Unimate , 1961 , General Motors

Electronics and computer science started to become more important.

Hydraulic technology became very advanced

What is a robot now ?



<https://www.youtube.com/watch?v=tBzU8-z-vtA>

Micro-robots

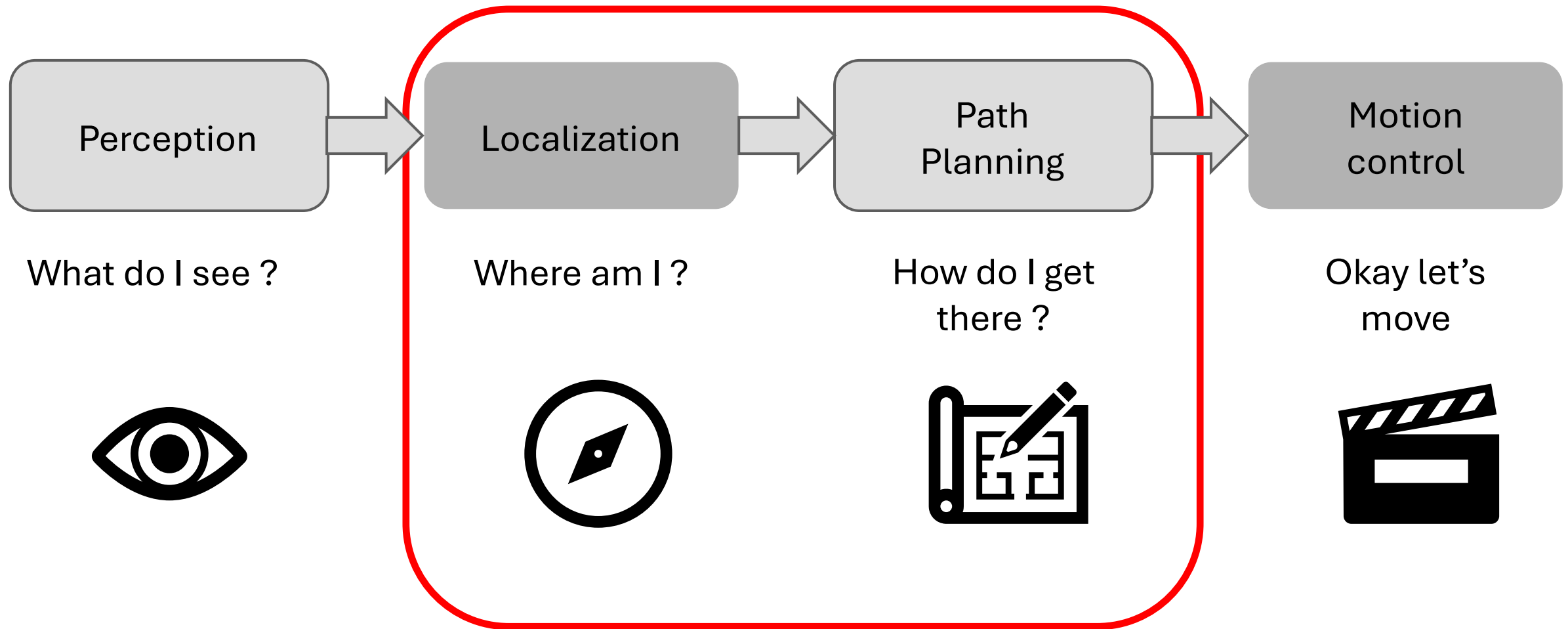


<https://www.youtube.com/watch?v=C1eg-jgLx5o&t=1s>

Living robot

Robots are becoming increasingly present, but how do they work?

How does a robot work today?



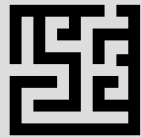
Why Localization is important



Roomba Cleaner



where he is



where people are

What robot need
to know



It can hurt people



It can break things

If not the case

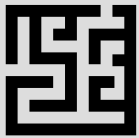


Potential legal
liabilities

Why Localization is important



where he is



where people are

What robot need
to know



It can hurt people

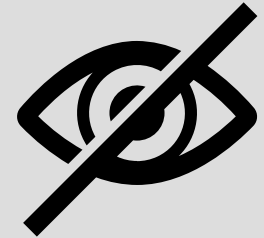


It can break things

If not the case



Potential legal
liabilities



If you move blindfolded **in
an unknown room**, you
collide with obstacles and
move quite randomly

A parallel with Human

Line follower robots

<https://www.youtube.com/watch?v=VwG451K62oE>



Sensor-based
localization



Uses sensors to determine
where the robot is

1960s – 1980s



amazon warehouse storing robot

<https://www.youtube.com/watch?v=lWsMdN7HMuA>



Beacons based
localization



Use beacons put in a room
to be able to tell
where the robot is

1980s – 1990s



Localization methods



GPS based
localization



Use GPS to localize
yourself in the world

1900s - 2000s



E.g. Google Maps

AT crawler heavy duty robot

<https://www.youtube.com/watch?v=G9RXRht6SaA>



Localization methods

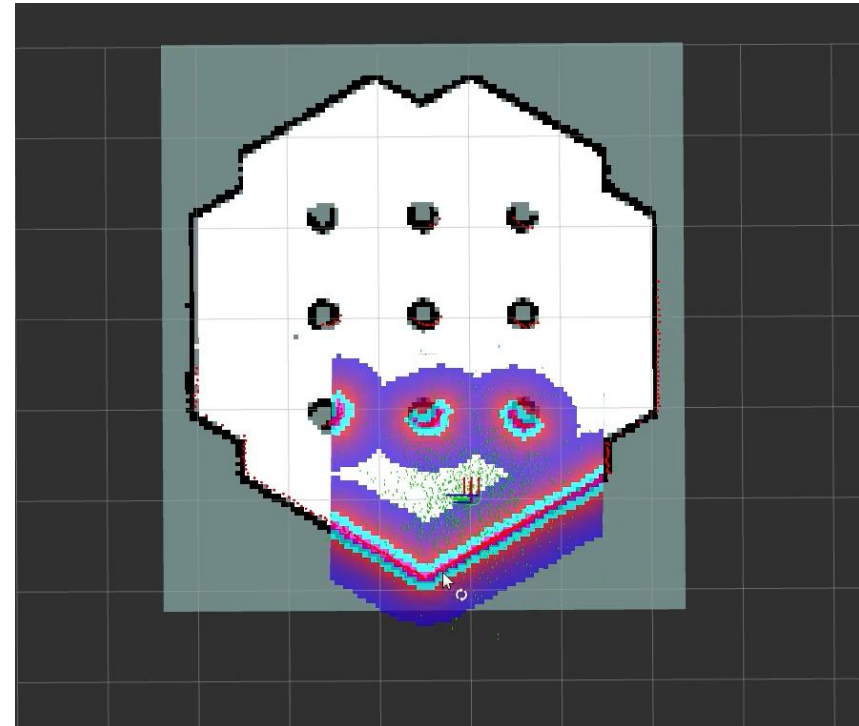


Maps based
localization



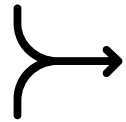
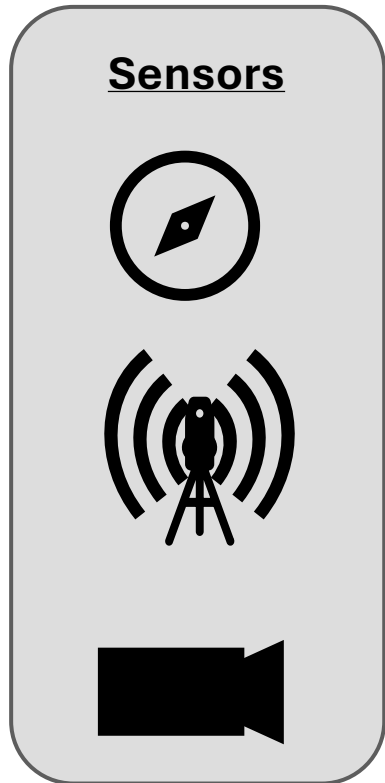
Use a saved map to know
where you are

2000s – Today's



Create a map

See Lecture 5



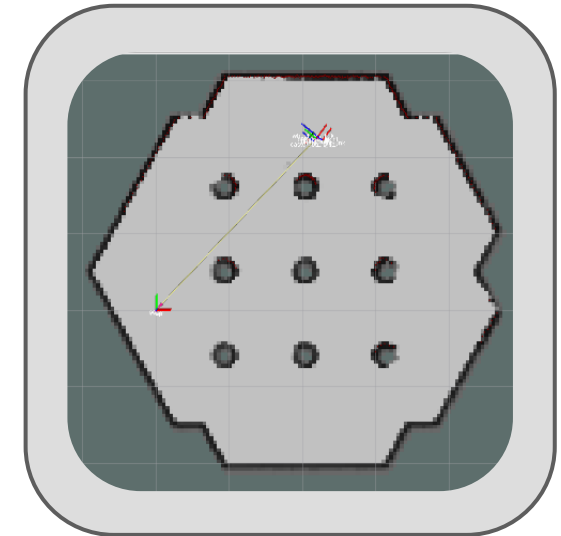
Fuse sensor data to be consistent



Build a representation of the maps



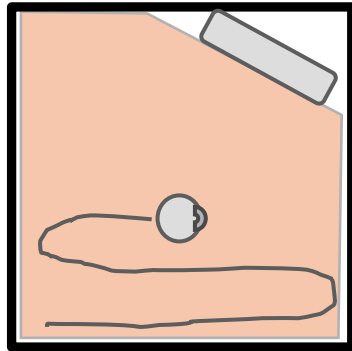
Estimates position based on feature matching



The robot doesn't understand everything. It **create a simplified map**

Navigation with and without maps

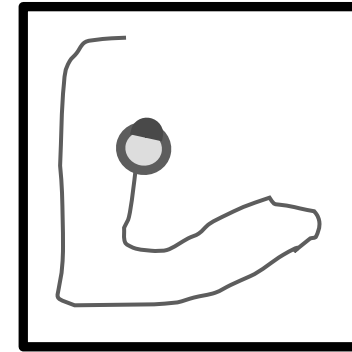
*Cleaning robot
Seeing the world*



Map of the environment

The robot know where he is and where are the obstacle because of mapping. He can clean more efficiently the floor

*Cleaning robot
That don't see the
world*



The robot don't know where he is and where are the obstacle. He won't be able to clean everything correctly

Having a Map make the navigation of the robot safer

Localization methods



Map-less localization



The robot build the map
when moving

2010s – Today's

Human Example

Draw a map and at the same
time discover an unknown
environment



No map

The robot know nothing of
where he is

Discover the place

He move around, see, and build
the maps from what he see



Where is he ?

He then use the map to
determine where he is



Localization methods



Map-less
localization

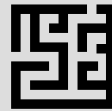


The robot build the map
when moving

2010s – Today's

Mapping

Map unknown environment



Localization

Know the position without the
need of external data



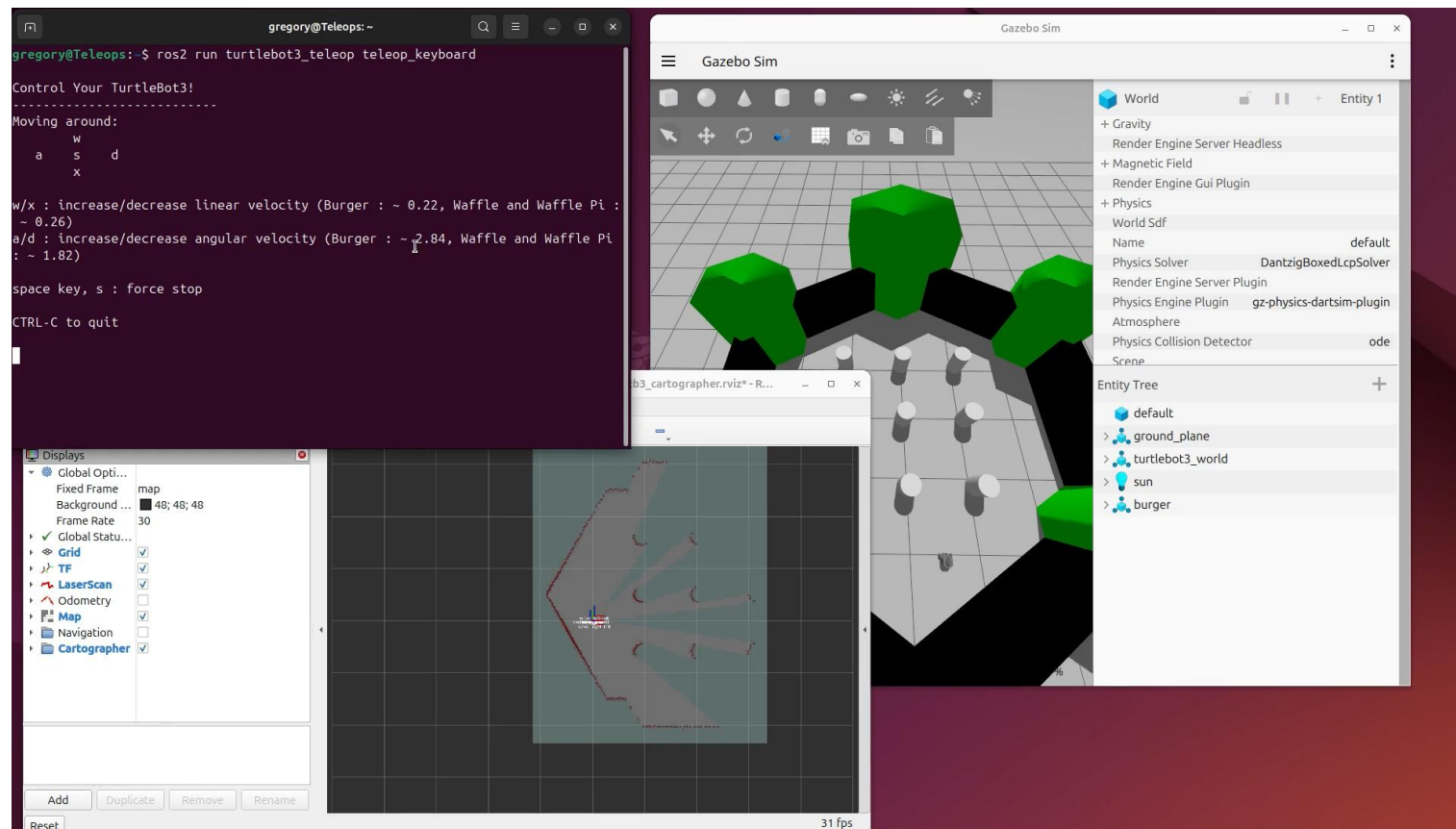
Simultaneous

Being able to perform both tasks
at the same time



S.L.A.M (simultaneous localization and mapping

Map-less demo



Localization methods



AI and Predictive localization



The robot use his vision to predict where he will be later

2020s – Today's

Use Probability and AI to predict the future position and future situation

He anticipate the move of the object and of the human

Correct his situation using dynamic path planning

Current AI driven robot



https://www.youtube.com/watch?v=s8hABHmA_NE

Russian AI robot failure



<https://www.youtube.com/watch?v=-MEtLTVtDiE>

Nvidia Keynote robot

There is so much to be done That's why there is a huge research development on AI based robot

Localization currently use methods



AI and Predictive
localization



The robot use his vision to
predict where he will be
later

2020s – Today's

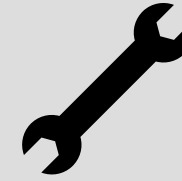


Map-less
localization



The robot build the map
when moving

2010s – Today's



Maps based
localization



Use a saved map to know
where you are

2000s – Today's

Liability concerns

Lot of potential issue with this tree current method

What if the map
is Poorly
constructed



Why the robot make
an accident



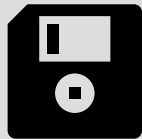
Who is responsible ?



Geofencing and Regulatory
Compliance



And for AI localization it's worst because of AI :



From which
dataset the AI was
trained

What happen if
the prediction is
false ?



Legal question



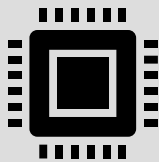
Responsibility

Who is liable for localization failure ?



Qualification

Is the map part of the product or a service ?



Failure

Does incorrect localization qualify as a defect ?



Proof

How can we prove that localization caused the accident

Interpretation

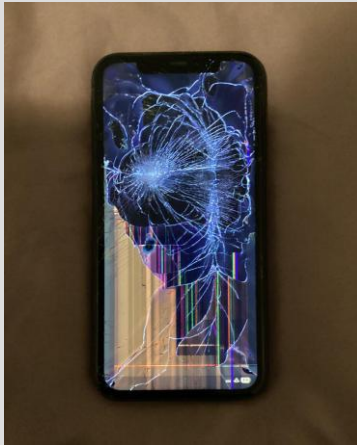
Liability really depends on the source of the error

Some level of error is expected in every systems

**Normal
uncertainty**



**Abnormal
malfunction**



Liability can be assessed by identifying:

- the failing component
- the expected performance
- the context of use

Responsibility can be shared between multiple actors :

- Manufacturer
- Developer
- operator

Concrete example

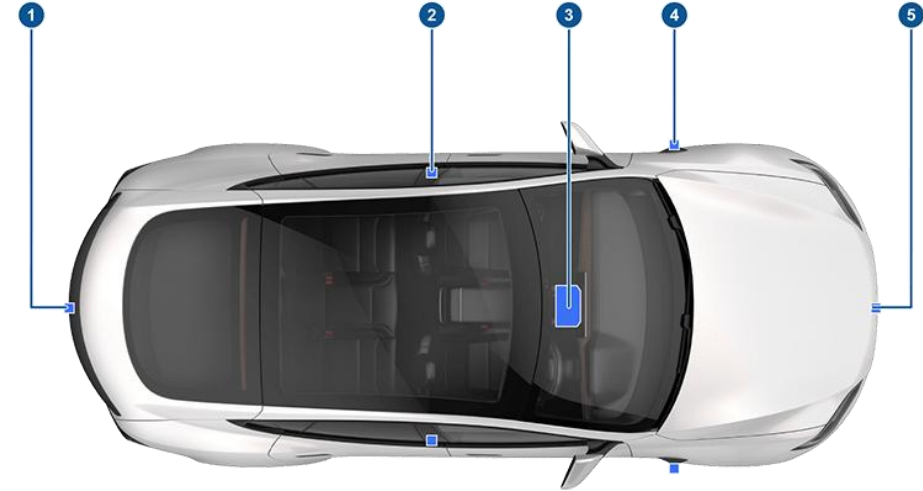
05:51 24-03-2026

Tesla Autopilot investigation expanded by NHTSA over safety issues



NHTSA investigates Tesla's Autopilot system after crashes in bad weather. Learn about camera-only approach vs. competitors and potential industry impacts.

www.32cars.ru/en/posts/id20502-mitsubishi-returns-to-uk-with-new-outlander-phev-hybrid-model



Concrete example



To localize and decide you build a map collect personal information

And the vacuum cleaning robot are almost always connected to the Wi-Fi...

December 23, 2025

Roomba Knows Where You Hid Your Safe ... Now China Will Too

in LinkedIn

f Facebook

X X

Send

Embed

<https://www.jdsupra.com/legalnews/roomba-knows-where-you-hid-your-safe-1061373/>



DJI Romo Robot Vacuum Security Flaw Allowed Remote Camera and Data Access

Last updated February 27, 2026

<https://vacuumwars.com/dji-romo-security-flaw/>

planned obsolescence

In 2017, Apple recognized slow down old iPhone officially for reducing the risk of old battery

User weren't informed and just buy new phones



The system was working correctly, but the legal issue came from how it was presented to users.



Is it a defect or an optimization ?
Is the user should be informed ?
Is the communication being a lie ?



planned obsolescence

In France, from 2015, a law exist forbidding programmed obsolescence



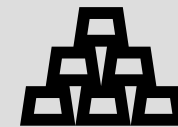
In Europe, there is **no specific law on planned obsolescence**, but it is addressed through consumer protection and product law



But few law were made after the incident to try to protect the user :

- Right to repair products
- Consumer protection
- New rules on the battery (the battery must be replaced)

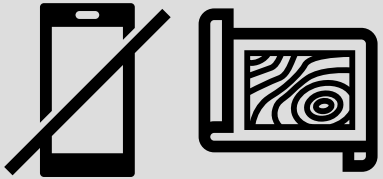
Apple had to pay 25 millions of euros because users weren't informed



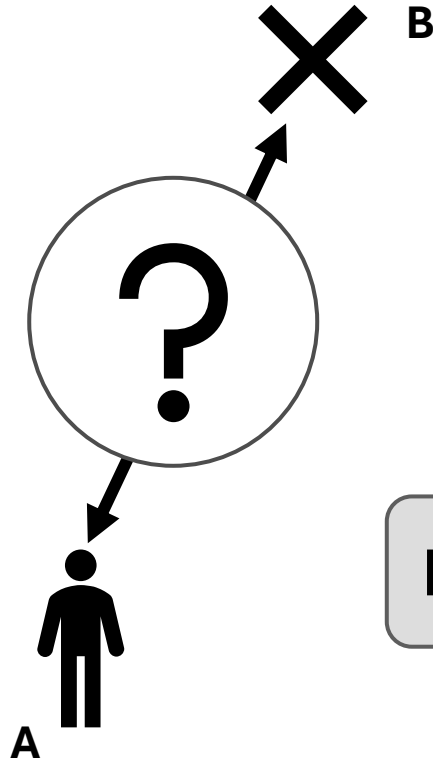
Understand the path planning

Intuitive example “Being lost with a Map”

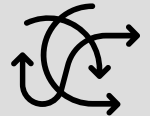
Historically, robots were designed based on human standards



*No GPS
No phone
Only a map*



Imagine you are lost without GPS or phone,
and you need to go to a destination



How will you go to the destination ?

Intuitive example “Being lost with a Map”

Find yourself searching for similarity between the map and where you are



Use sensor data and feature matching algorithm



https://www.youtube.com/watch?v=3iKikjUcO_c

Visual Localization Live Demo

Intuitive example

Try to find the best road possible to do the travel



Static Pathfinding



<https://www.youtube.com/watch?v=zZp2Zv5oOTU>
Some pathfinding algorithm video

Static Path planning

Assumption

The environment is known

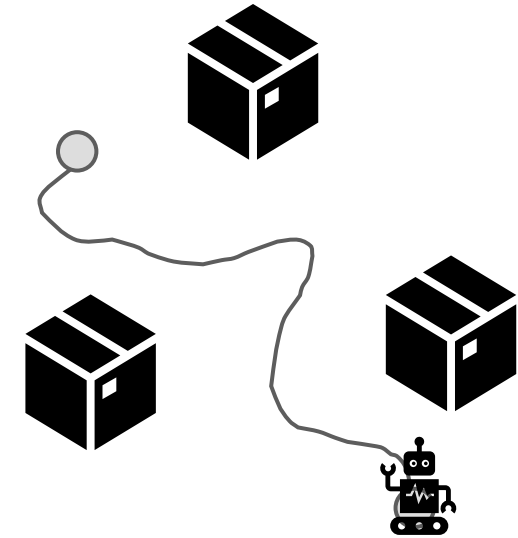
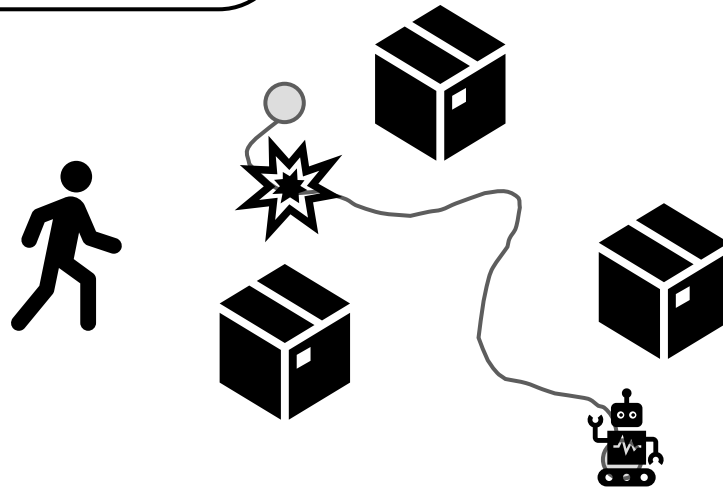
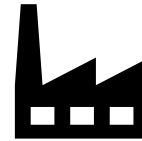
Obstacles are fixed

Robot has map



The example :

Warehouse



The robot calculates the path once and uses its sensors to follow it

The robot doesn't adapt to unexpected scenarios

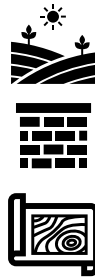
When static path planning cause Accidents

Assumption

The environment is known

Obstacles are fixed

Robot has map



Underlying

No new obstacles

Nothing moves

The map is correct

The real world
is not like that

Who is responsible for the accident ?

The operator ?

The manufacturer ?

The employer ?

Or the worker ?

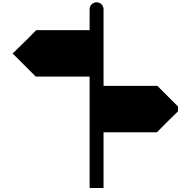
No specific Law on this part

On a technical side ISO
norm exist

Intuitive example “Being lost with a Map”

Unexpected events may occur

You adapt yourself

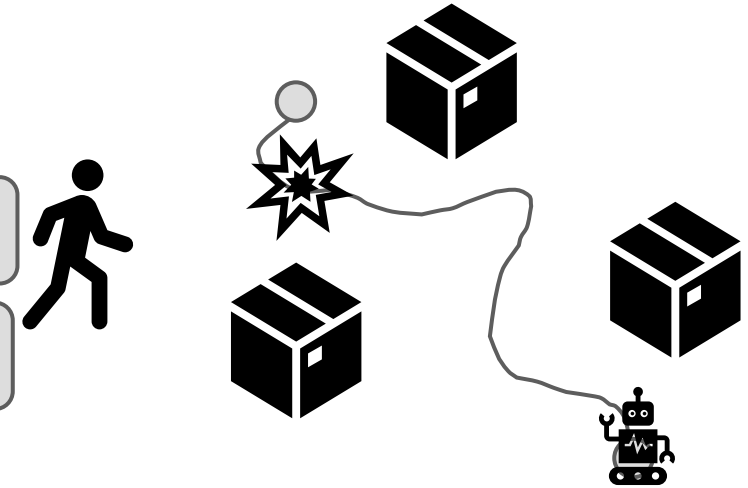


Dynamic Pathfinding

Dynamic Path planning

You don't follow a static environment, there is people, things to consider

It's hard to do it because the robot need to think at the right time



It's a machine not a **living being**

He cannot panic
because it will be
unsafe

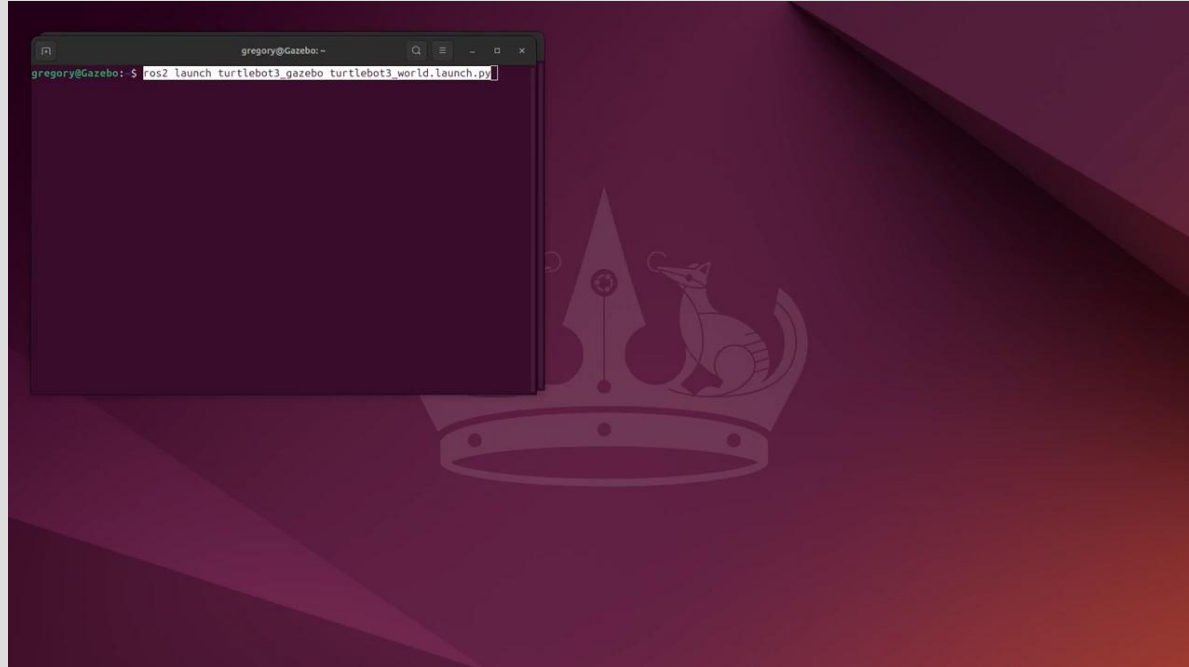


And he has no
certainty that what
he see is correct

He need to handle
his own uncertainty



Demonstration



See Autonomous_full_simulation video
<https://youtu.be/1jcSVPTf9cY>

Why is dynamic path planning difficult for a robot

If the robot doesn't act slow, they will be an accident



Reacting too quickly can also cause accidents

How does the robot take the decision



How can we be sure he see us ?

Volkswagen: Robot kills worker installing it

07/02/2015

Volkswagen has disclosed that a robot has killed a contractor involved in its installation. The fatal accident happened at VW's Baunatal plant, north of Frankfurt on Monday.

<https://www.dw.com/en/robot-kills-worker-at-volkswagen-plant-in-germany/a-18556982>

Robert Williams (robot fatality)

Article [Talk](#)

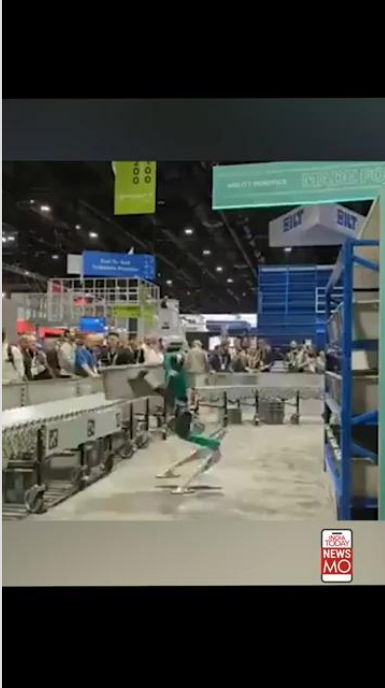
From Wikipedia, the free encyclopedia

Robert Nicholas Williams (May 2, 1953 – January 25, 1979) was an American factory worker who was the first known human to be killed by a [robot](#). While working at the [Ford Motor Company's Michigan Casting Center](#), Williams was struck and killed by the arm of a robotic transfer vehicle.

First robotic accident

[https://en.wikipedia.org/wiki/Robert_Williams_\(robot_fatality\)](https://en.wikipedia.org/wiki/Robert_Williams_(robot_fatality))

Failure example recently



<https://www.youtube.com/shorts/WlejWPCyOMA?feature=share>

Boston dynamic demonstration of
humanoid worker robot



https://youtu.be/0-MYK_i6gl8
Some humanoid failure

ISO norms

International technical reference not a law

Defined by International Organization for Standardization



Who applies them ?

Producer
Designer (engineer,...)
Insurers
Company using the product

Why are they applied

Gives minimal safety
Reduce risk and accidents
Facilitate responsibility in case of accident
Easier to market (CE label in Europe)

ISO norms

The norms are classified in three class



Type A

Fundamental norms that are general but explain the methodologies of the following one

Type B

Give the global requirement of the systems

Type C

Requirement focus on one kind of family concerned

ISO 12100

Type A

ISO 12100

Scope

Applies to all machines
and systems

Risk Evaluation

What are the risk ?

How grave they are ?

Do we need to reduce it ?

Risk Reduction

*How can we reduce the
risk evaluated*

*Emergency Button to
stop the robot*

Documentation

*Explain the risk analyzed , how to they reduce it ,
potential other risk, user manual*

ISO 13482

Type C

ISO 13482:2014

Scope

*Personal care
earthbound robot such
as :*

- *Mobile servant*
- *Physical assistant
robot*
- *Person carrier robot*



Keenon diner Bot T10

Safe by design

Limit the speed

*Make the form of the
robot safe*

Safety protection

*Stop upon detecting a
Human*

*Emergency Button to
stop the robot*

User information

*A datasheet that
explain where to use it*

ISO 3691

Type C

ISO 3691-4:2023

Scope

Ground-based Personal Care Robots such as :

- *Autonomous vehicles and robot in industrial environment*
- *Robot in hospitals*



Lancaster University robot for nuclear manipulation

Safe by design

Robot safe in any critical environment

The robot must stay stable

Safety protection

The monitoring is the most critical

Failure handling

User information

Personnel training

Risk aware chart

Concrete example

Medscape News UK

Da Vinci Malfunctions: How Safe Is Robotic Surgery?

Massimo Sandal

July 29, 2025

6 345

<https://www.medscape.com/viewarticle/da-vinci-malfunctions-how-safe-robotic-surgery-2025a1000jym>



Simulation environment



Swiss Post refines safety processes after drone crash

Swiss Post drone crashes in Zurich – again

Practical case where simulation could have avoided the problem



Swiss Post's drone for the delivery of parcels, as presented in 2017. Ti-press

June 28, 2019 - 15:17

🕒 2 min

[Keystone-SDA/Swiss Post/swissinfo.ch/ij](https://www.swissinfo.ch/eng/keystone-sda/swiss-post/swissinfo.ch/ij)

An interim report into the most recent Swiss Post drone crash recommended improvements to the parachute and warning system. Swiss Post has announced that it has already taken measures to improve drone safety.

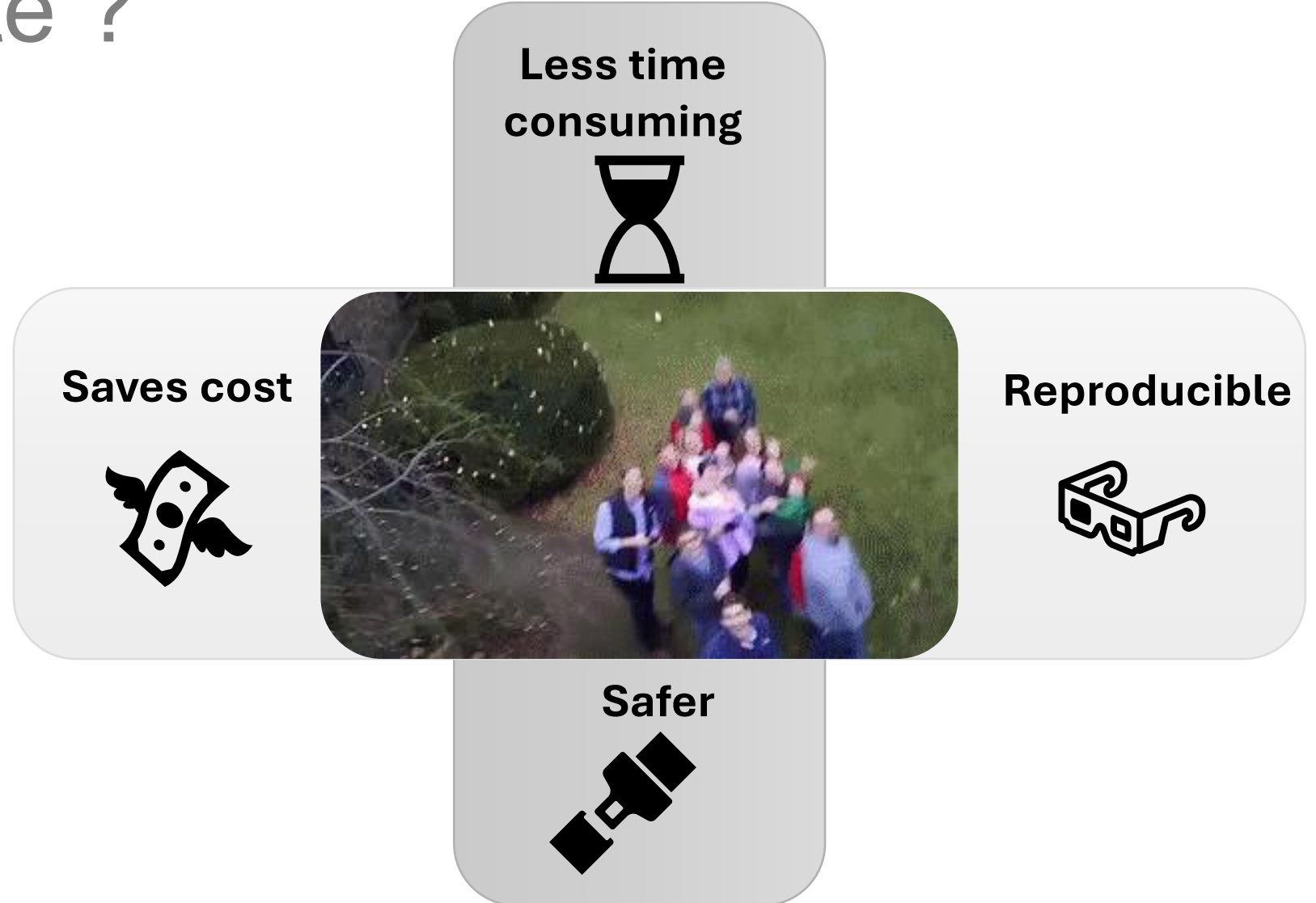
A drone belonging to a Swiss Post medical deliveries programme crashed on Thursday morning in a Zurich forest – the second crash in four months. It was not carrying any supplies but the national postal service has decided to suspend all drone flights.

[+ Read more about the May crash here](#)



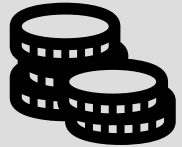
A drone belonging to a Swiss Post medical deliveries programme crashed on Thursday morning in a Zurich forest – the second crash in four months. It was not carrying any supplies but the national postal service has decided to suspend all drone flights.

Why simulate ?



Why simulation is essential

Limitations of Real-World Testing



It's costly



It's dangerous

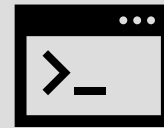


It's time consuming

Advantage of simulation



Early identifications of failure points



Test on controlled environment



Easier to implement

Simulation pros in ISO norms

Why simulation help to follow iso norms

ISO 12100

Simulation allow
risk testing

ISO 3691-4

Simulation allow
to test complex
scenarios

ISO 13482

Simulation allow
test between
human and robot
safely

Key Take away

Why simulation help to follow iso norms

Navigation is a Multi-Step Process

If a robot fails, we must identify which layer failed to determine liability (e.g., sensor error vs. software logic error).

The Map is the "Law" for the Robot

Who is responsible for map updates? The manufacturer, the software provider, or the end-user?

Standardization & Safety

Simulation as a Risk Mitigation Tool