OST
Ostschweizer
Fachhochschule

Was ist künstliche Intelligenz, und wie funktioniert die Technik?

Mit Beispielen aus der industriellen Praxis

Prof. Dr. Guido M. Schuster

Gründer und Institutsleiter ICAI
Interdisciplinary Center for Artificial Intelligence

ICAI/IQT/OST

ICAI

ICAI Team

OST - Eastern Switzerland University of Applied Sciences

- **Campus Rapperswil, SG, Switzerland**

AI@OST

- **One of only 3 strategic foci of the OST**
  - Artificial Intelligence since 2021!
  - Climate and Energy
  - Healthy Living and Aging

- **ITBO of the state of St.Gallen**

Ziele	Kurzformen
Z.1: Allen Studiengängen stehen für ihre individuellen Bedürfnisse AI-Ausbildungsformate (Module) zur Verfügung	Z.1: Teach the Teachers
Z.2: Alle Studierende der OST kennen die Möglichkeiten und Limitationen von AI in ihren Fachgebieten	Z.2: Teach the Students
Z.3: Niederschwelliger Zugang zu AI-Beratung und Ressourcen	Z.3: AI Community
Z.4: Interdisziplinäre, AI-basierte Projekte werden gefördert	Z.4: AI Projects
Z.5: Profilierung der OST und des Kantons SG	Z.5: AI Marketing

Teilprojektauftrag «Interdisciplinary Center for Artificial Intelligence» (ICAI)

IT-Bildungsoffensive

Schwerpunkt III «Kompetenzzentrum Angewandte Digitalisierung»

Künstliche Intelligenz von Gerd Altmann für die freie kommerzielle Nutzung

Autorinnen und Autoren:	Prof. Dr. Guido M. Schuster (SCU) Founding Director of the Interdisciplinary Center for Artificial Intelligence
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Freigabe ITBO-ProjA	23.10.2020
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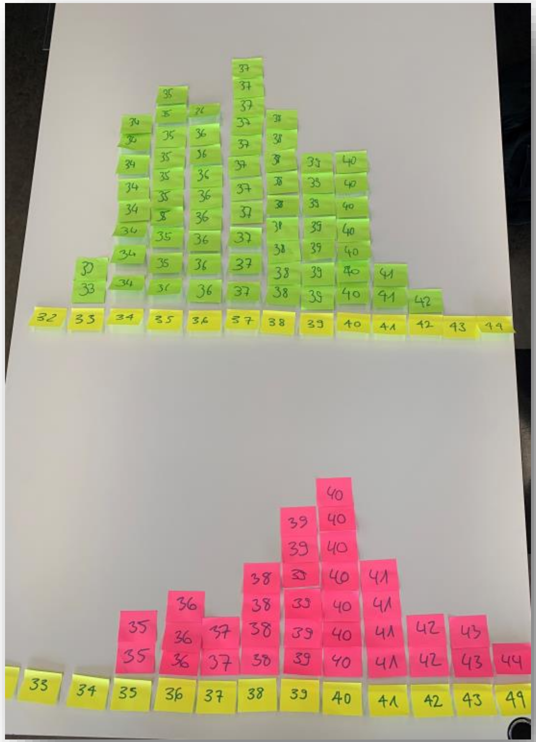
ICAI

AI@OST

- **ITBO: Teach the Students**
  - Teaching the fundamentals of AI to everybody
    - Landscape Architects
    - Spatial Planers
    - Business Majors
    - Nursing
    - Physiotherapy
    - Social Workers
    - ...



Using AI to predict a Ginkgo trees sex

Authors

Antoine, Janssen, Landscape architecture

Antonia Halter, Landscape architecture

David Hermann, Landscape architecture

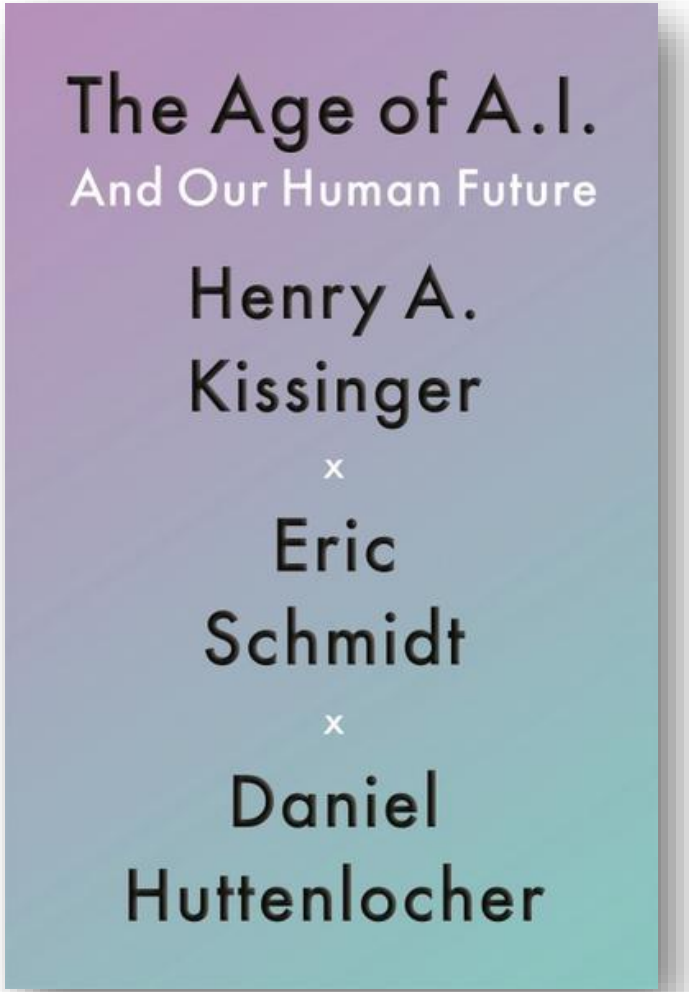
1.0 Abstract

The Ginkgo (Ginkgo biloba) Tree presents a problem due to its dioecious nature, with male and female trees that are difficult to distinguish from one another until autumn, when only the female trees produce fruits that emit an extremely unpleasant odor. This poses challenges in urban areas where public green spaces are utilized, as the odor can deter people from using these areas. Cutting down all the female trees is costly, but the fallen fruits create a messy situation on pavements, which can even be dangerous for pedestrians. This problem affects nurseries, landscape architects, residents, and city gardeners. A solution would benefit all stakeholders by increasing tree sales, reducing public backlash, improving local environments, and preserving the species' history. To gather necessary data, a comprehensive approach involving nurseries, private owners, cities, and arborists would need to be employed to collect data on tree growth, sex determination, and attributes. Data collection methods would include scans, photographs, videography, and visual inspections. Standardization of data collection procedures would ensure reliable and scientifically valid data. The proposed solution involves an algorithm utilizing supervised learning to predict the sex of Ginkgo trees based on collected data. The algorithm would be trained using genetic testing data and attributes such as buds, growth rate, bark, foliage, leaf size, trunk size, and the branches characteristics. Machine learning algorithms, specifically association-based techniques, are considered suitable for this task. The performance of the approach would be measured based on the accuracy of sex prediction, with the goal of saving costs for planners and gardeners and reducing environmental impact. Limitations include variations in environmental and nutritional conditions among Ginkgo trees.

Figure 1: a Ginkgo in fall, source: pixabay.com

Age of AI

- **We are entering the Age of AI**
  - Comparable in its effects only to the introduction of
    - Fire
    - Agriculture
    - Electricity
- **Decisions, Decisions, Decisions …**
  - In the age of AI, computers make decisions for and about us every day
    - Work: HR Analytics
    - Love: Tinder
    - Entertainment: YouTube Video
    - Finances: Credit Card Approval
    - And many more …



Data

- **Data** is fundamental to AI, but what kind of data is there and where does it come from?

- IT systems
  - Official documents
  - Books
  - Personnel files
  - Medical records
  - Credit cards
  - Access cards
  - Cell phone positions
  - Browser history …

- Dedicated sensors
  - Cameras
  - Microphones
  - Pressure sensors
  - IMU
  - LIDAR
  - RADAR
  - And many more …

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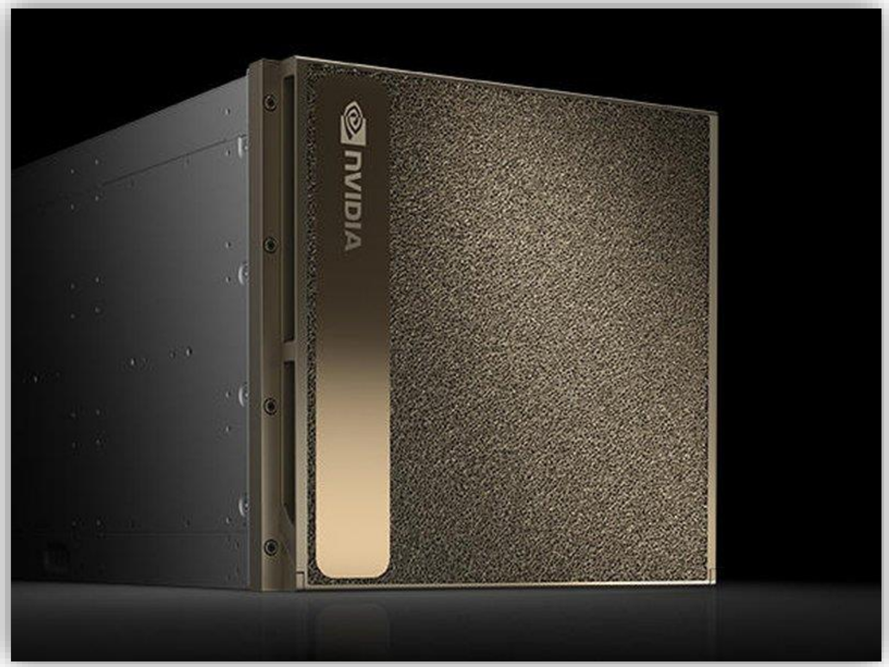
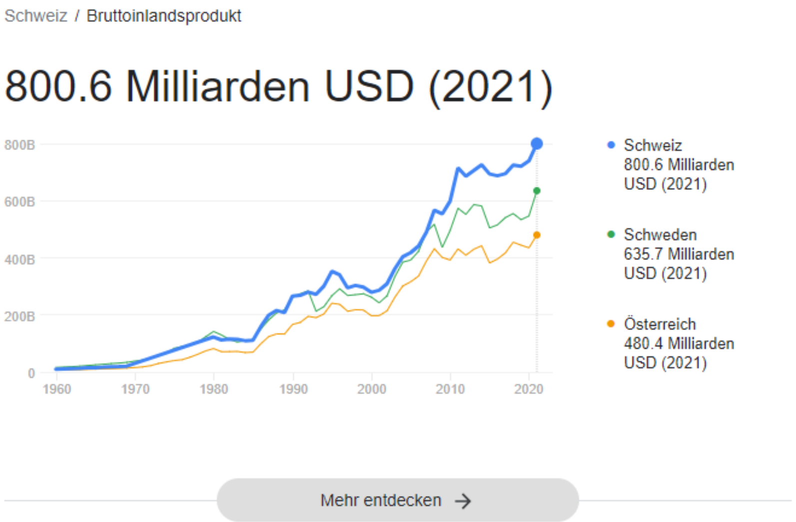
Data & Computing





NVIDIA

- DGX-2 Deep Learning Supercomputer
  - 2 Petaflops (2e15) per second
  - Earth: 8e9 people
    - 2e15/8e9=1/4e6=250’000 flops/person per second

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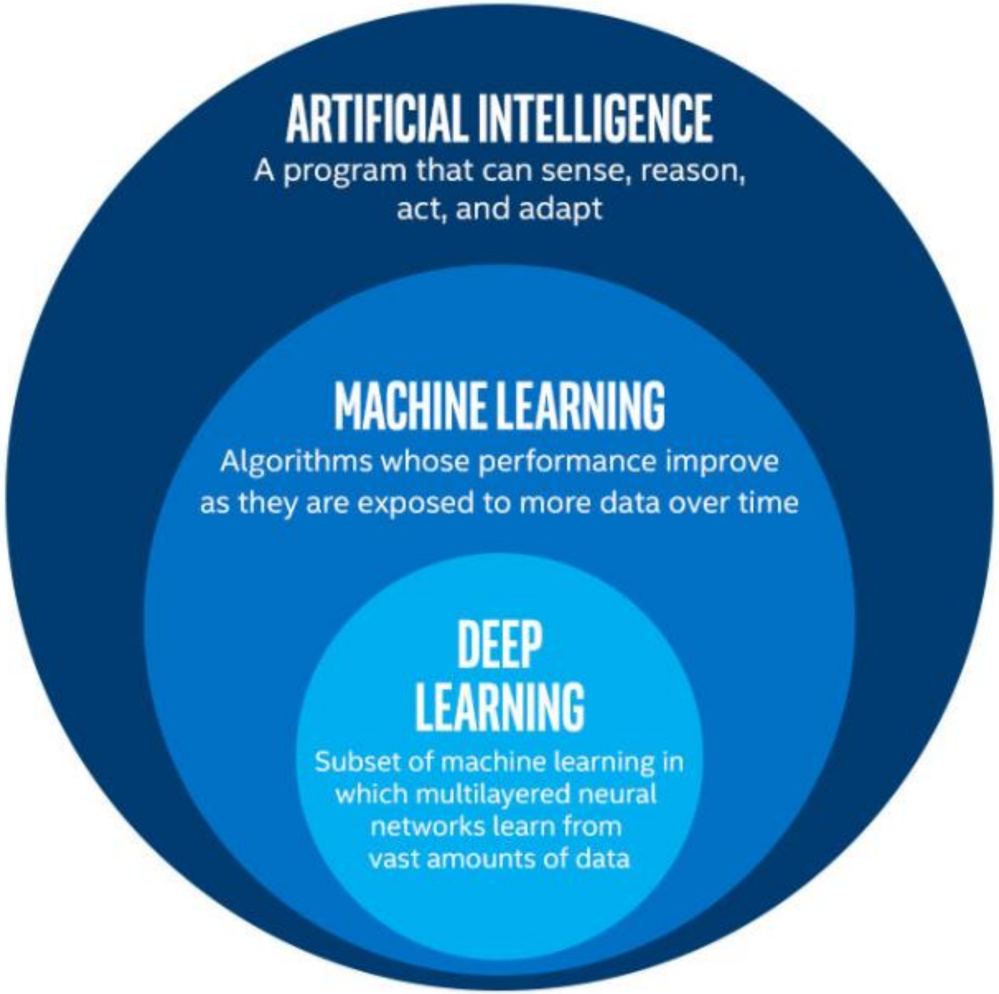
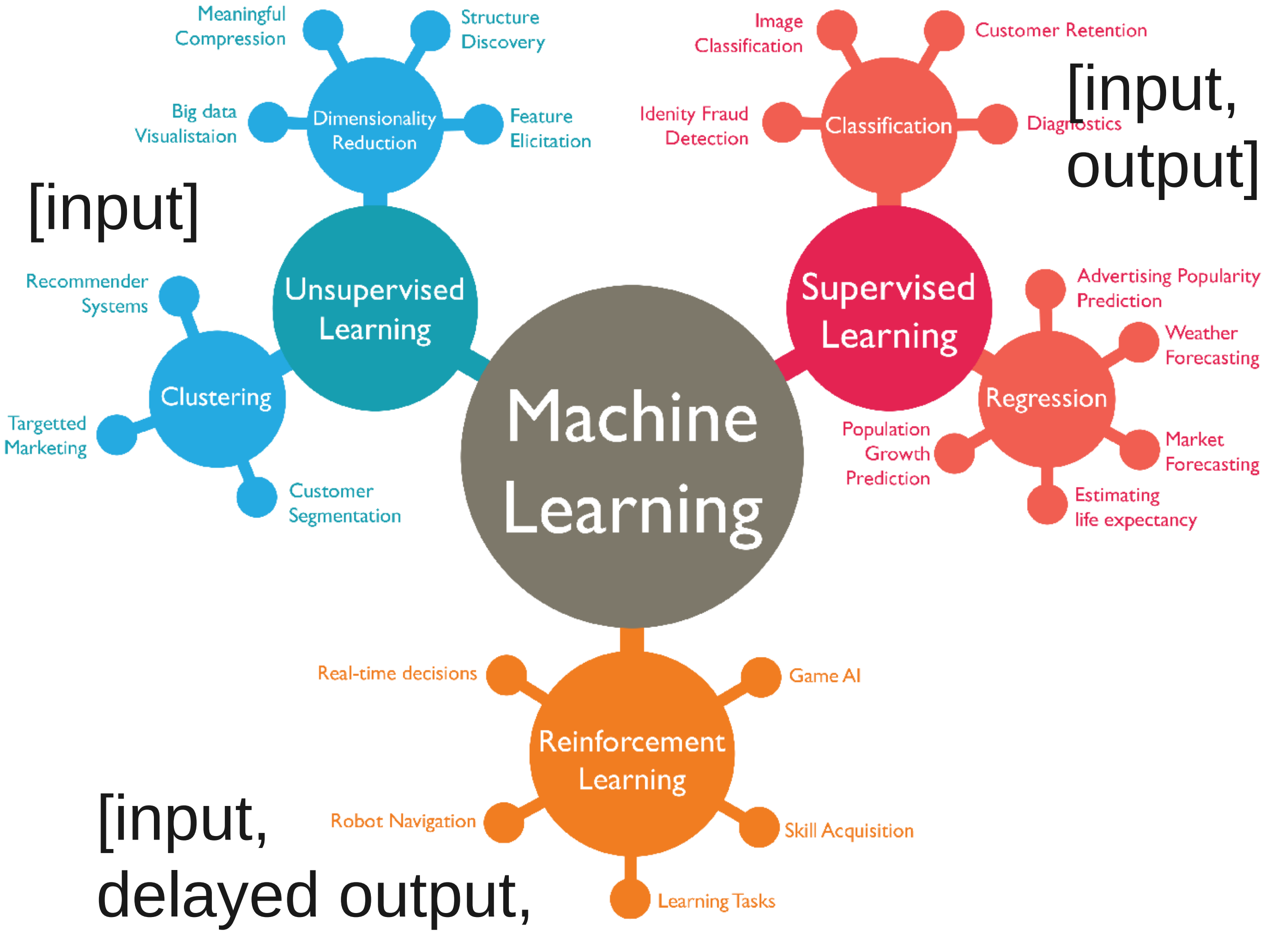
Data & Computing & Algorithms

[What kind of data?]





[input]

[input, output]

[input, delayed output, grade for this delayed output]

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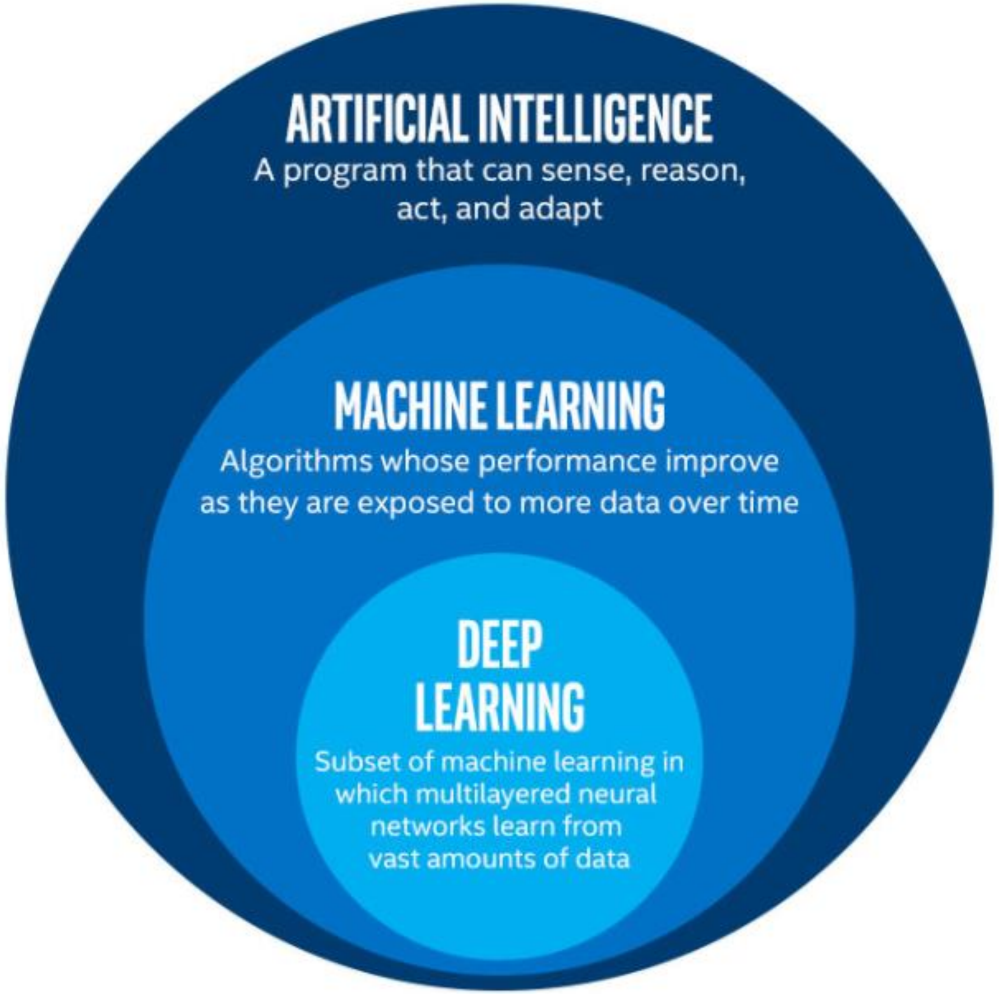
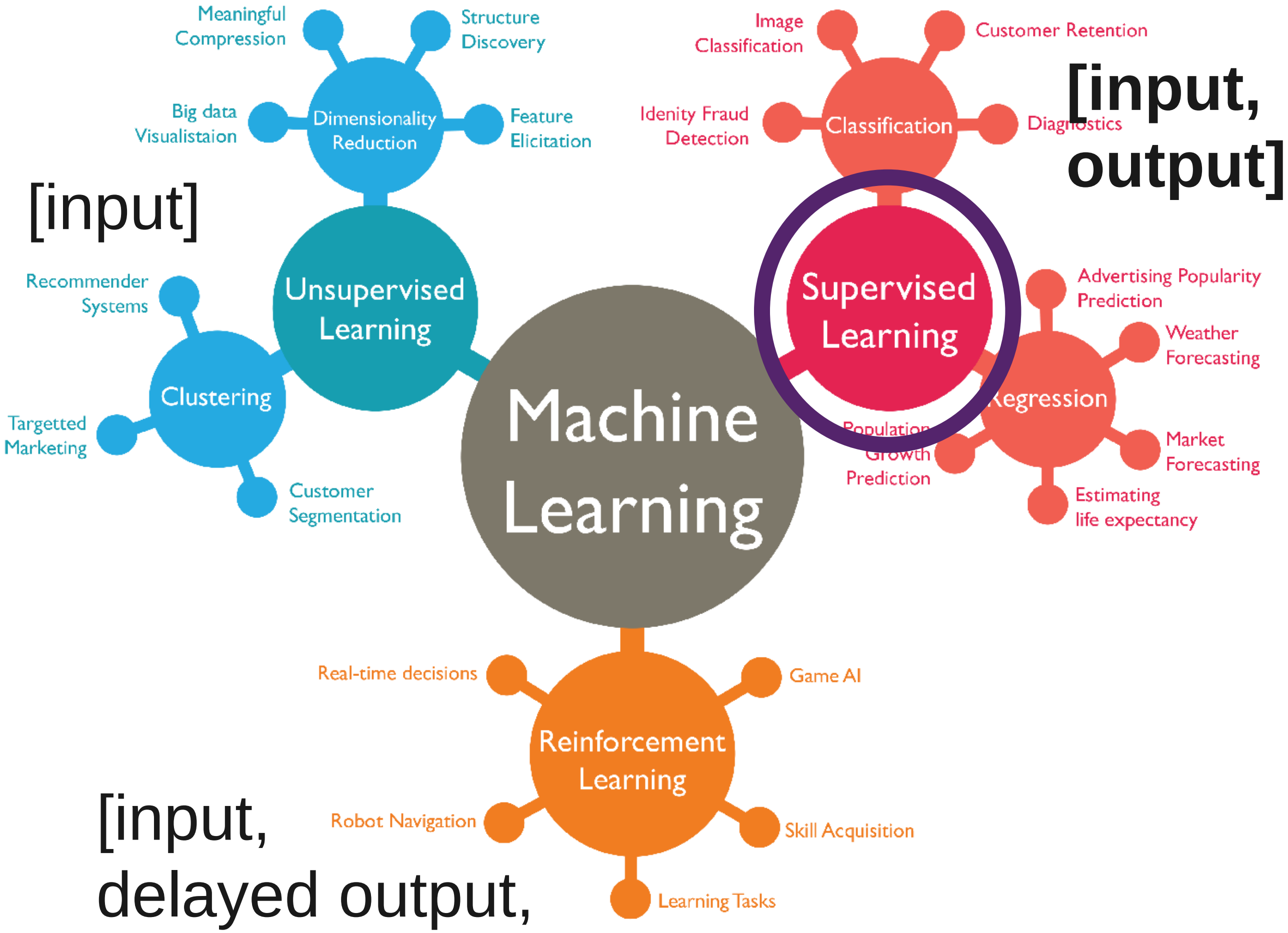
Focus: Supervised Learning

[What kind of data?]





[input]

[input, output]

[input, delayed output, grade for this delayed output]

Supervised Machine Learning

- **A simple example**
  - Based on the temperature, the <u>AI estimates the probability</u> whether a person is **healthy**

    P(**healthy**|temperature)

  - For this crucial estimation, <u>data from the past</u> (examples, also called training data) are used, where <u>doctors have made this decision</u>

Training data

Person #	Temperature [C]	Doctor decision [healthy] [sick]
1	37.00	healthy
2	36.75	healthy
3	39.50	sick
4	40.25	sick
5	38.25	healthy
6	36.75	healthy
…	…	…
100'000	41.25	sick

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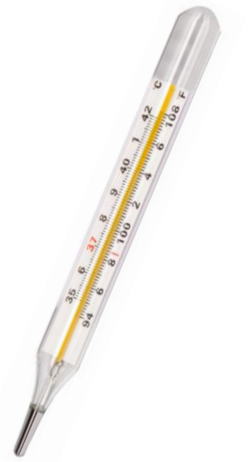
Supervised Machine Learning

Labels!

Person #	Temperature [C]	Doctor decision [healthy] [sick]
1	37.00	healthy
2	36.75	healthy
3	39.50	sick
4	40.25	sick
5	38.25	healthy
6	36.75	healthy
…	…	…
100'000	41.25	sick



The steps of Supervised Machine Learning:

1. **Training data**: Labeled data in a table
2. **Measurement**: Temperature in Celsius
3. **AI-Decision**: **healthy** or **sick**

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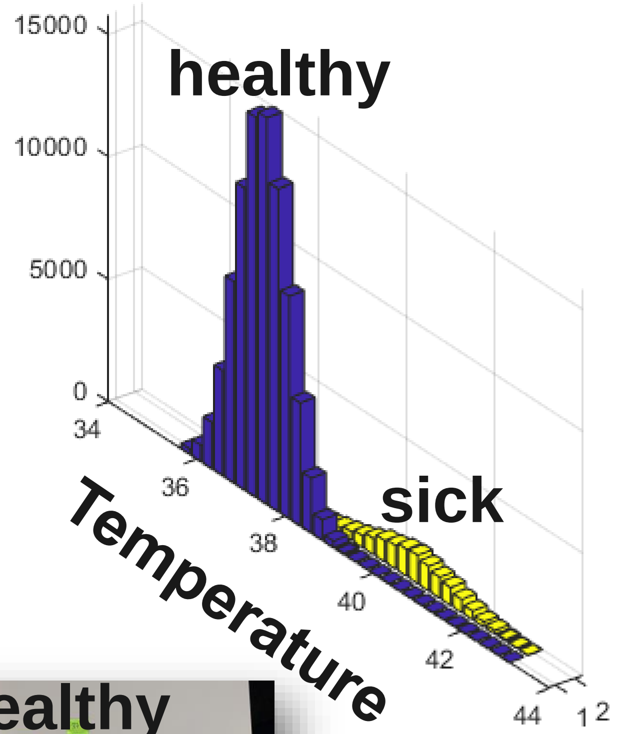
Supervised Machine Learning

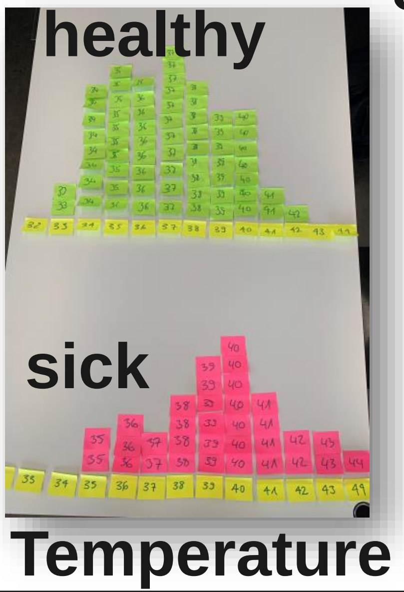
- **Training data (examples):**

Person #	Temperature [C]	Decision [healthy] [sick]
1	37.00	healthy
2	36.75	healthy
3	39.50	sick
4	40.25	sick
5	38.25	healthy
6	36.75	healthy
…	…	…
100'000	41.25	sick

Create a 2D Histogramm

Temperature	#healthy	#sick
35.75	229	0
36.00	676	0
36.25	1910	0
36.50	4314	1
36.75	8253	1
37.00	12356	3
37.25	15542	2
37.50	15812	4
37.75	13209	13
38.00	9119	32
38.25	5044	76
38.50	2261	120
38.75	850	232
39.00	271	352
39.25	65	485
39.50	9	664
39.75	1	882
40.00	0	964
40.25	0	1111
40.50	0	1154
40.75	0	1004
41.00	0	845
41.25	0	733
41.50	0	544
41.75	0	360
42.00	0	211
42.25	0	153
42.50	0	82
42.75	0	28
43.00	0	23





- Labeled training data (examples), here, <u>doctors made the decisions</u> (**healthy** or **sick**)

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Supervised Machine Learning

- **Minimum error decisions making**
  - A reasonable goal is <u>to make as few mistakes as possible</u>
  - **Bayes' theorem**
    - For a measured temperature, estimate (based on the training data) the probabilities that the person is **healthy**

      P(**healthy**|temperature)

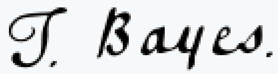
Decide **healthy**, if P(**healthy**|temperature) > ½

→**On average, by taking the <u>most likely option</u>, the fewest mistakes are made → optimal decision making**

The Reverend
Thomas Bayes

Portrait purportedly of Bayes used in a 1936 book,[1] but it is doubtful whether the portrait is actually of him.[2] No earlier portrait or claimed portrait survives.

Born	c. 1701 London, England
Died	7 April 1761 (aged 59) Tunbridge Wells, Kent, Great Britain
Alma mater	University of Edinburgh
Known for	Bayes' theorem
Scientific career	
Fields	Probability
Signature	



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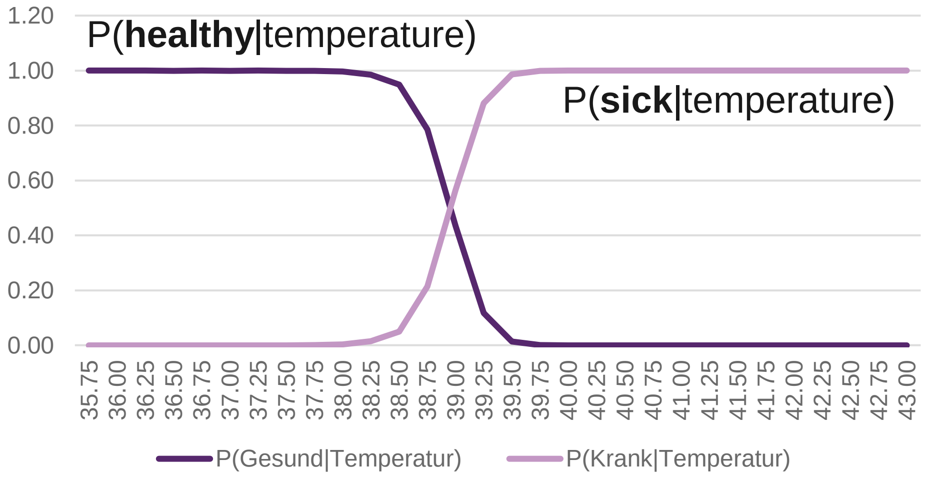
Supervised Machine Learning

Key question:

How is P(**healthy**|temperature) estimated from the **training data**?

$$P(\textbf{healthy}|\text{temperature}) = \frac{(\textbf{\#healthy}|\text{temperature})}{(\textbf{\#healthy}|\text{temperature}) + (\textbf{\#sick}|\text{temperature})}$$

- Where each row in the histogram table corresponds to a given temperature → P(**healthy**|temperature) can be calculated per temperature (line)
- Now for every measured temperature, pick the more likely option (**healthy** or **sick**)



Training data

Temperature	#healthy	#sick	P(**healthy**|temperature)= **#healthy**/(**#healthy**+**#sick**)
35.75	229	0	1.00
36.00	676	0	1.00
36.25	1910	0	1.00
36.50	4314	1	1.00
36.75	8253	1	1.00
37.00	12356	3	1.00
37.25	15542	2	1.00
37.50	15812	4	1.00
37.75	13209	13	1.00
38.00	9119	32	1.00
38.25	5044	76	0.99
38.50	2261	120	0.95
38.75	850	232	850/(850+232)=0.79
39.00	271	352	0.43
39.25	65	485	0.12
39.50	9	664	0.01
39.75	1	882	0.00
40.00	0	964	0.00
40.25	0	1111	0.00
40.50	0	1154	0.00
40.75	0	1004	0.00
41.00	0	845	0.00
41.25	0	733	0.00
41.50	0	544	0.00
41.75	0	360	0.00
42.00	0	211	0.00
42.25	0	153	0.00
42.50	0	82	0.00
42.75	0	28	0.00
43.00	0	23	0.00

Supervised Machine Learning

- **Minimum risk decisions making**
  - A reasonable goal is to take as small a risk as possible
  - Risk is defined as the product between a probability of a particular event and its associated cost **R=P·C**
  - Hence, we need to define costs, since we have learned how AI can estimate probabilities
  - Costs are associated with errors:

		Truth!	
		healthy!	**sick!**
AI?	**healthy?**	C_HH=0	**C_HS=1**
	sick?	**C_SH=1**	C_SS=0

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Supervised Machine Learning

Key question:

How is Risk(**healthy?**|temperature) estimated from the **training data** and **the cost**?

Risk(**healthy**?|temperature) = C_HH*P(**healthy**!|temperature)+**C_HS***P(**sick**!|temperature) =

= 0*P(**healthy**!|temperature)+ **1***P(**sick**!|temperature) =

= **1***P(**sick**!|temperature)

		Truth!	
		healthy!	**sick!**
AI?	**healthy?**	C_HH=0	**C_HS=1**
	sick?	**C_SH=1**	C_SS=0

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Supervised
Machine Learning

Key question:

How is Risk(**healthy?**|temperature) estimated from the **training data** and **the cost**?

Risk(**healthy**?|temperature) = C_HH*P(**healthy**!|temperature)+**C_HS***P(**sick**!|temperature) =

= 0*P(**healthy**!|temperature)+ **10***P(**sick**!|temperature) =

= **10***P(**sick**!|temperature)

		Truth!	
		healthy!	**sick!**
AI?	**healthy?**	C_HH=0	**C_HS=10**
	sick?	**C_SH=1**	C_SS=0

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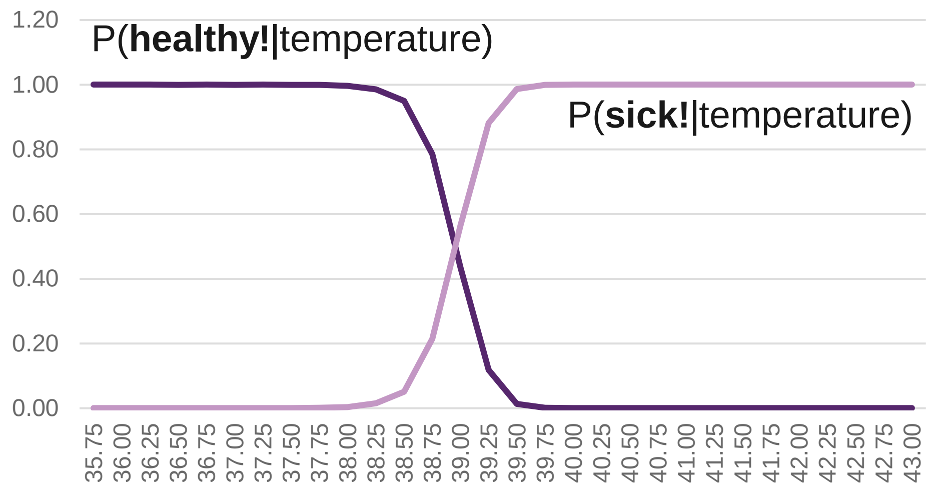
Supervised Machine Learning

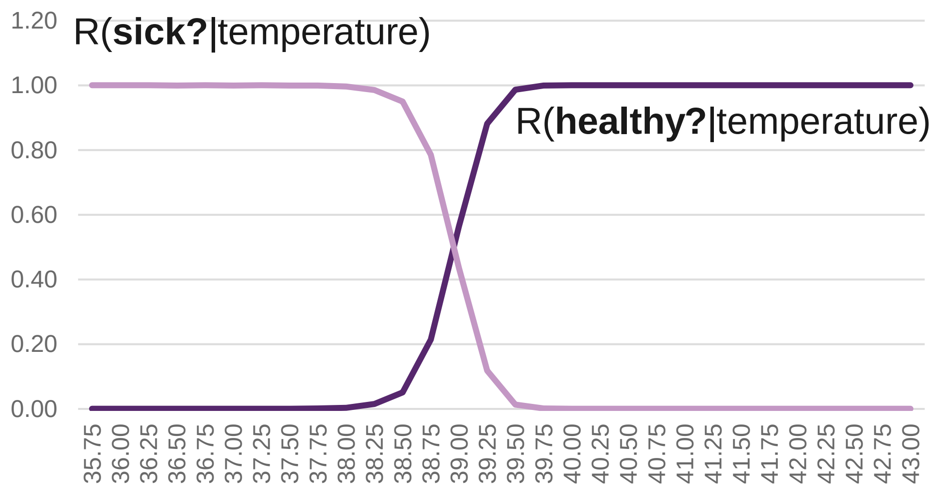
		Truth!	
		healthy!	**sick!**
AI?	**healthy?**	C_HH=0	**C_HS=1**
	sick?	**C_SH=1**	C_SS=0



Risk(**healthy**?|temperature)=

C_HH*P(**healthy**!|temperature)+**C_HS***P(**sick**!|temperature) =

= 1*P(**sick**!|temperature)



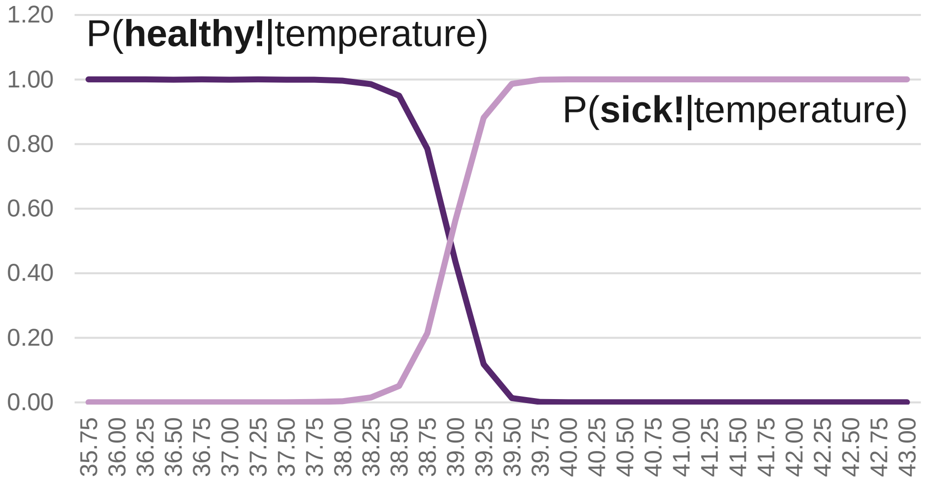
Risk(**sick**?|temperature) =

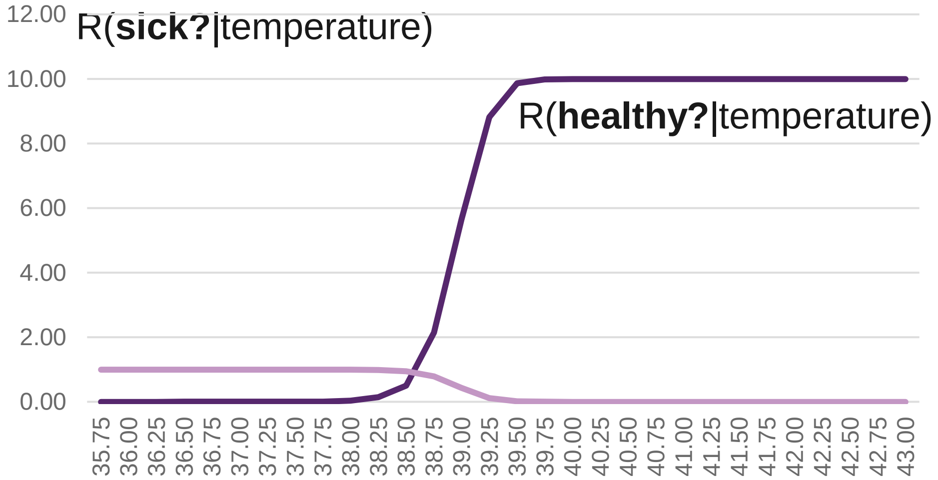
C_SH*P(**healthy**!|temperature)+C_SS*P(**sick**!|temperature) =

= 1*P(**healthy**!|temperature)

Supervised Machine Learning

		Truth!	
		healthy!	**sick!**
AI?	**healthy?**	C_HH=0	**C_HS=10**
	sick?	**C_SH=1**	C_SS=0





Risk(**healthy**?|temperature)=

C_HH*P(**healthy**!|temperature)+**C_HS***P(**sick**!|temperature) =

= 10*P(**sick**!|temperature)

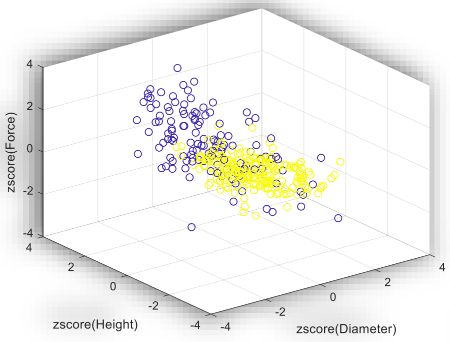
Risk(**sick**?|temperature) =

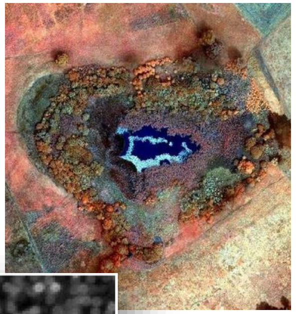
C_SH*P(**healthy**!|temperature)+C_SS*P(**sick**!|temperature) =

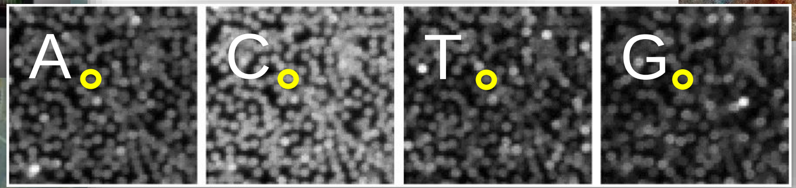
= 1*P(**healthy**!|temperature)

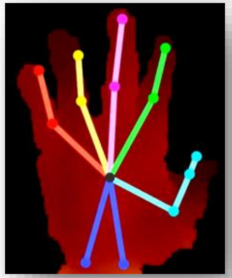
Industrial Applications of Artificial Intelligence

- **Research & Development**









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R&D Projects 2021

- **Mechmine** – *Predictive Maintenance for Ball Bearings*
- **Schiller** – *Deep Learning for ECG Analysis*
- **IWK et al.** – *ML for Injection moulding control*
- **Loft Dynamics** – *VR Helicopter Simulator*
- **TECAN** – *CM/PM of Pipetting Systems*
- **Spühl et al.** – *Embedded Computer Vision for Predictive Maintenance*

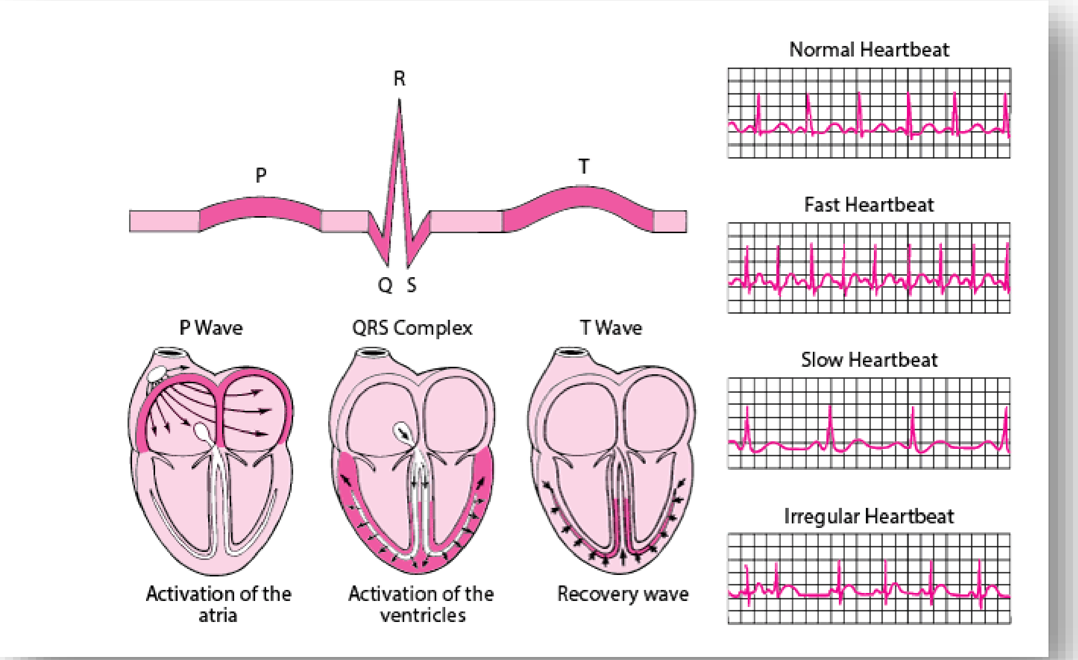
Deep Learning for ECG Analysis

Application Number: 36433.1 IP-LS

Application Title: Data-driven Electrocardiogram Interpretation

Main partners and project manager

Project manager	Ramun Schmid SCHILLER AG
Main research partner	Professor Dr Guido Schuster HSR Hochschule Rapperswil
Research partner	Professor Dr Christian Mueller Universitätsspital Basel
Main implementation partner	Ramun Schmid SCHILLER AG



ML for Injection Moulding Control

iwk
INSTITUT FÜR
WERKSTOFFTECHNIK UND
KUNSTSTOFFVERARBEITUNG

SUBVENTIONSVERTRAG

Innovationsprojekt 29621.1 IP-ENG

Zwischen der **Innosuisse – Schweizerische Agentur für Innovationsförderung**
(nachstehend **Beitragsgeberin** genannt)

und den folgenden Projektpartnern:

Forschungspartner:

HSR Hochschule für Technik Rapperswil
(nachstehend **Empfänger**)

Umsetzungspartner:

Kistler Instrumente AG

Netstal-Maschinen AG

Geberit International AG

Weidmann Medical Technology AG

Krauss Maffei Schweiz AG

betreffend

Machine Learning basiertes Prozessmanagementsystem zur Optimierung des Spritzgiessprozesses

Data Driven Injection Moulding

Curdin Wick(✉), Frank Ehrig, and Guido Schuster

University of applied science Rapperswil, Rapperswil SG, Switzerland
{curdin.wick,frank.ehrig,guido.schuster}@hsr.ch

Abstract. The injection moulding process for the production of plastic parts is a very complex process. Therefore, a lot of experience and expert knowledge is necessary to produce parts with high quality. Changes in granule-batches, environmental influences and wear of the machine and the mould can strongly affect the quality of the produced parts. For this reason an injection moulding machine needs an experienced operator, who reacts properly to changing input variables and sets appropriate countermeasures. Modern injection moulding machines are able to record all countermeasures and have access to a wealth of internal machine data. Consequently, an adequate machine learning (ML) method should be able to observe, to learn the proper countermeasures and to evaluate their effectiveness. With deep learning (DL), a state of the art technology in ML, it will be possible to predictively detect process anomalies for the first time, based only on the knowledge about the internal machine data. If an operator changes the setting parameters of the injection moulding machine, the correlation between the adjustment and the anomaly is being learnt. The aim is to get process adjustment recommendations from the machine learning system.

This is a fundamentally new approach for process management in injection moulding, as the machine learning system detects problems long before they can be seen by an operator. Furthermore, the system provides process adjustment recommendations, based on the supervised and automatically generalized actions from different operators using different injection moulding machines, moulds and materials.

Keywords: Injection moulding · Machine learning · Process anomalies

VR Helicopter Simulator

- **Loft Dynamics**
  - More than 2/3 of the engineering team was educated at the ICAI
  - CTO former ICAI engineer

Loft Dynamics

Erster Virtual-Reality-Simulator EASA-qualifiziert

Das aus dem Labor des Interdiciplinary Center for Artificial Intelligence (ICAI) hervorgegangene Unternehmen VRM Switzerland hat den ersten Helikopter-Flugsimulator entwickelt, der vollständig auf Virtual Reality (VR) basiert und von der Europäischen Agentur für Flugsicherheit (EASA) anerkannt ist.

Application Number: 38437.1 IP-ICT

Application Title: VR motion helicopter hoist operation simulator

Main partners and project manager

Project manager	Fabian Riesen VRMotion AG
Main research partner	Professor Dr Guido Schuster HSR Hochschule Rapperswil
Main implementation partner	Fabian Riesen VRMotion AG

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R&D Projects 2022

- **ASTRA** – *GDPR compliant Privacy Protection*
- **+GF+** – *Weld Inspection based on CV*
- **LINIA** – *AI based Condition Monitoring using Drones*
- **+GF+** – *Nondestructive Testing of Plastic Welds*
- **Spühl** – *3D Spring Shape Modeling and Measuring System*
- **Brütsch Elektronik** – *Intraoral scanner*

AI based Condition Monitoring using Drones

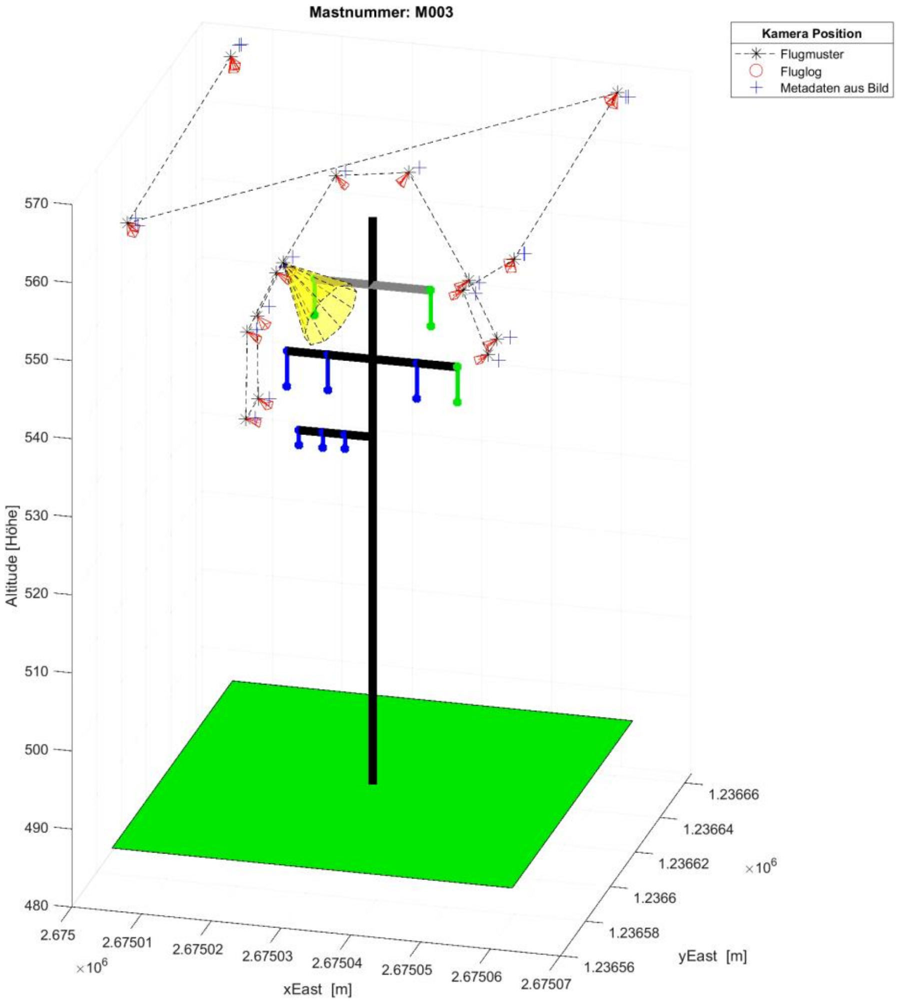
Application Number: 52765.1 IP-EE

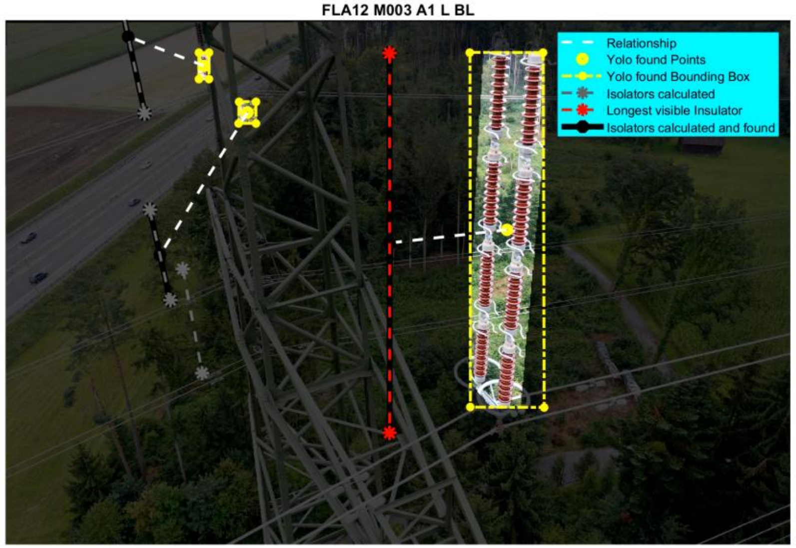
Application Title: CURO: Automatische Zustandsüberwachung und vorausschauende Wartung für Hochspannungsleitungen mittels automatisierten Drohnen und künstlicher Intelligenz

Main partners and project manager

Project manager	Lorenzo Arizzoli-Bulato
	LINIA GmbH
Main research partner	Professor Dr Guido Schuster
	OST - Ostschweizer Fachhochschule
Main implementation partner	Lorenzo Arizzoli-Bulato
	LINIA GmbH

AI based Condition Monitoring using Drones





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Nondestructive Testing of Plastic Welds

- +GF+

FUNDING AGREEMENT

Innovation project 59297.1 IP-ICT

between **Innosuisse – Swiss Innovation Agency**
(hereinafter referred to as **Contributor**)

and the following project partners:

<u>Research partners:</u>

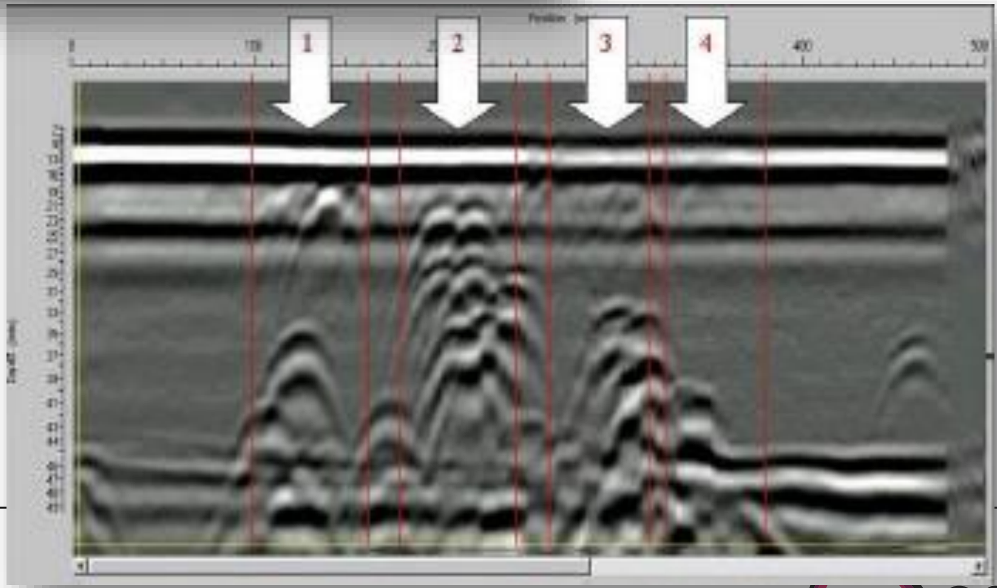
OST - Ostschweizer Fachhochschule
(hereinafter referred to as **Recipient**)

<u>Implementation partners:</u>

Georg Fischer Piping Systems Ltd.

relating to

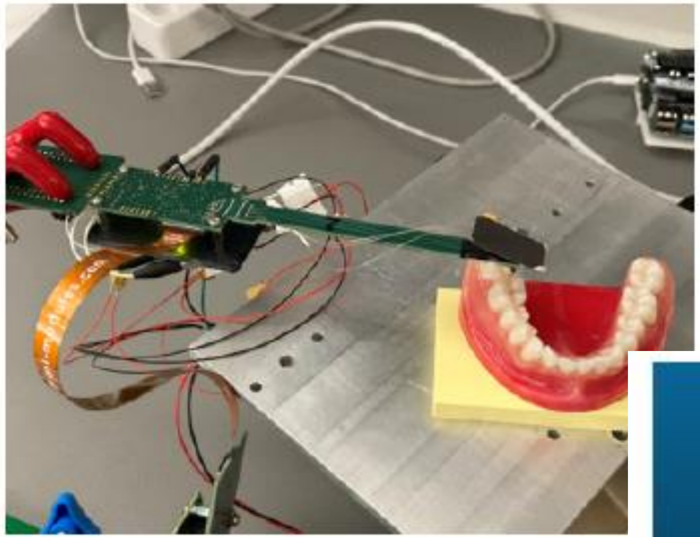
Automatic Nondestructive Testing (NDT) of Plastic Welds based on Ultrasonic Imaging and Computer Vision (CV)

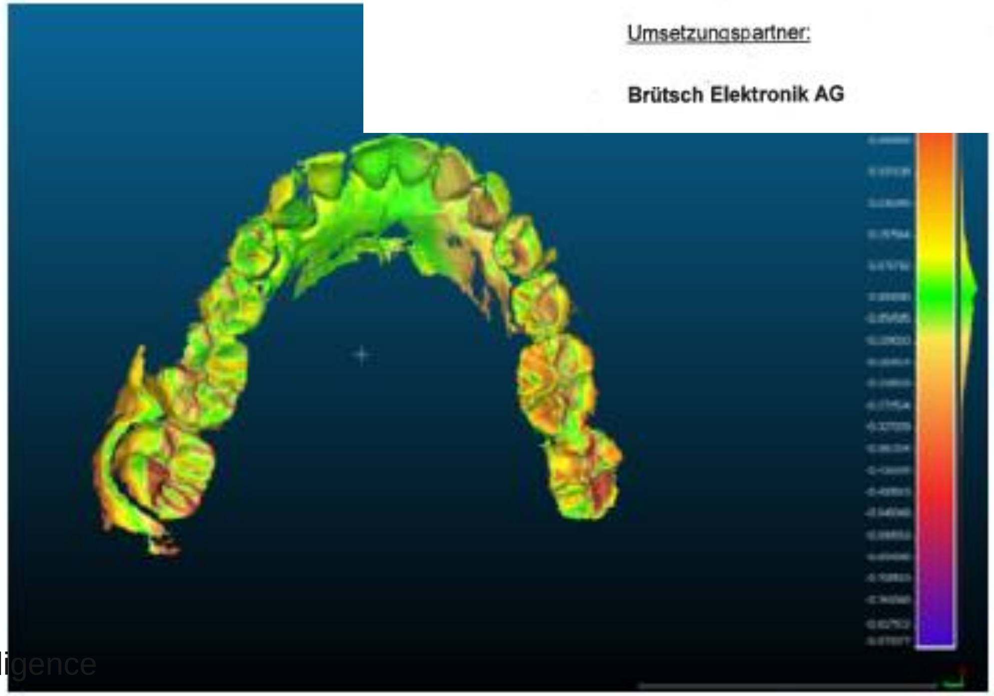


Intraoral Scanner

- **Brütsch Elektronik**

Testaufbau mit integrierten DOE





SUBVENTIONSVERTRAG

Innovationsprojekt 59691.1 IP-ENG

Zwischen der **Innosuisse – Schweizerische Agentur für Innovationsförderung** (nachstehend **Beitragsgeberin** genannt)

und den folgenden Projektpartnern:

Forschungspartner:

ZHAW - Zürcher Hochschule für Angewandte Wissenschaften (nachstehend **Empfänger**)

OST - Ostschweizer Fachhochschule

Umsetzungspartner:

Brütsch Elektronik AG

brütsch

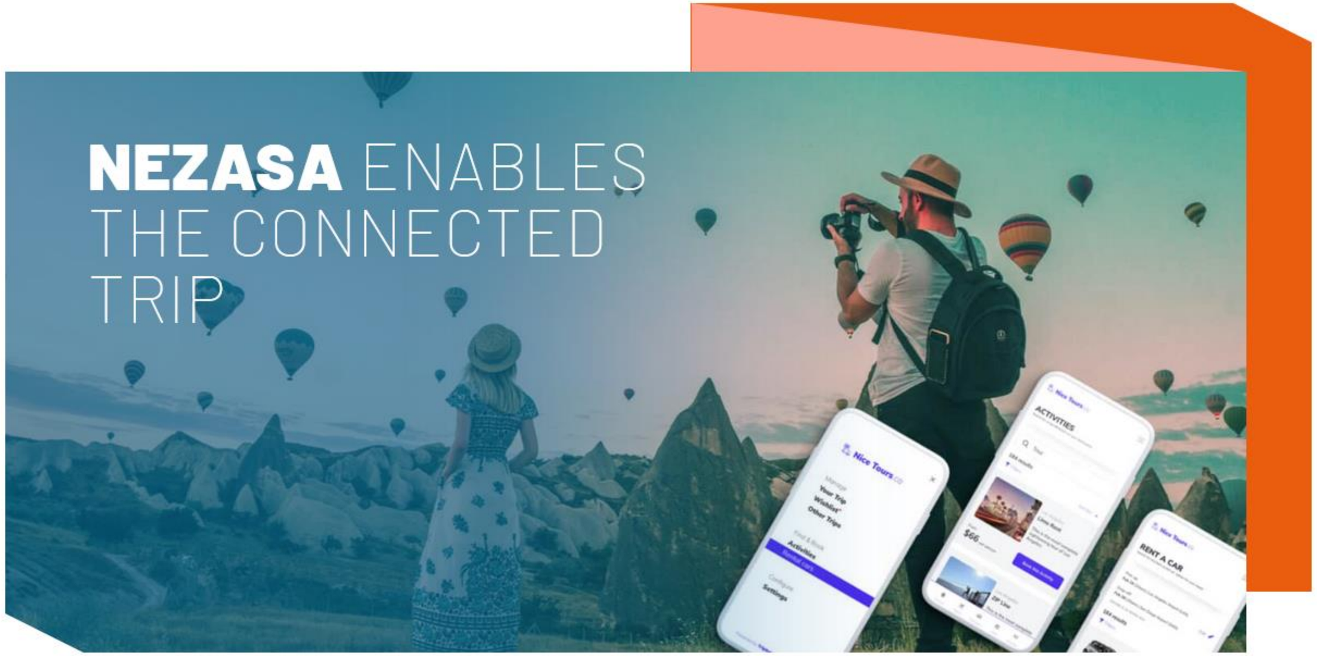
OST

R&D Projects 2023

- **Nezasa** – *Low-CO2 Tour Booking System*
- **ADEC** – *Solar powered pedestrian/bicycle detection/counting system based on low-power and low-cost thermopile arrays using AI and CV*
- **Rittmeyer** – *Low-cost and autarkic water quality measurement and early warning system for drinking water utilities based on IoT technologies and machine learning*
- **Lakers Sport AG** – *Executive functions training (EFT) system based on real-time computer vision (CV) and video projection (VP)*
- **VRMotion** – *Evidence based Training System for Helicopter Pilots*

Low-CO2 Tour Booking System

- **Nezasa**



FUNDING AGREEMENT

Innovation project 101.343 IP-SBM

between **Innosuisse – Swiss Innovation Agency**
(hereinafter referred to as **Contributor**)

and the following project partners:

Research partners:

OST - Ostschweizer Fachhochschule
(hereinafter referred to as **Recipient**)

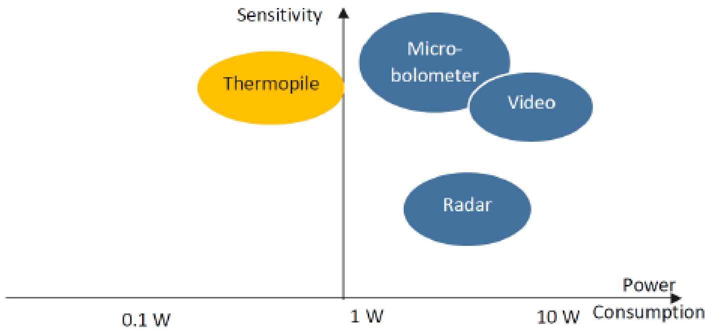
Implementation partners:

Nezasa AG

- Joint project with the IPM @ SG

Solar powered pedestrian/bicycle detection/counting system based on low-power and low-cost thermopile arrays AI & CV

- **ADEC**




FUNDING AGREEMENT

Innovation project 102.568 IP-ENG

between — Innosuisse – Swiss Innovation Agency (hereinafter referred to as Contributor)

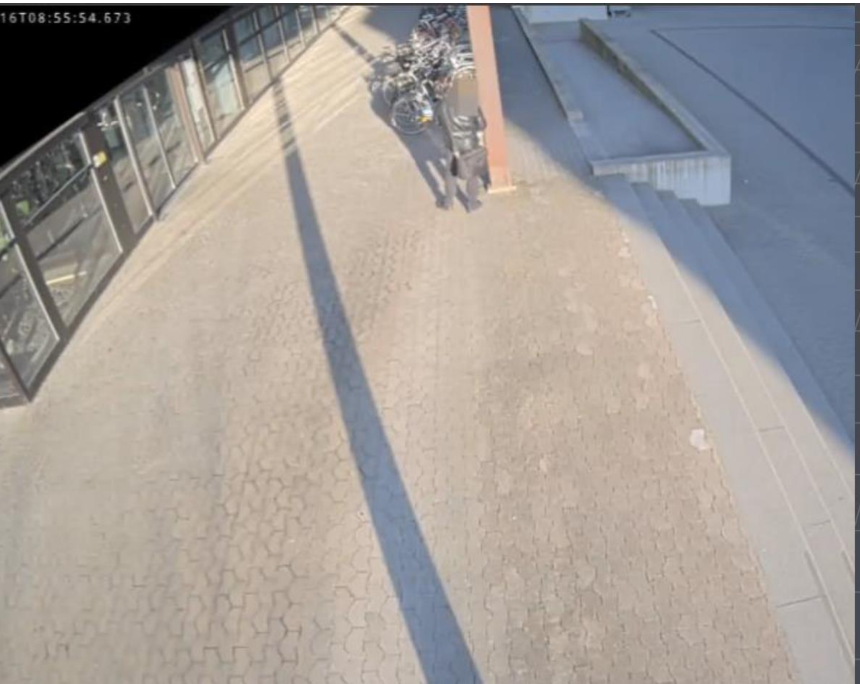
and the following project partners:

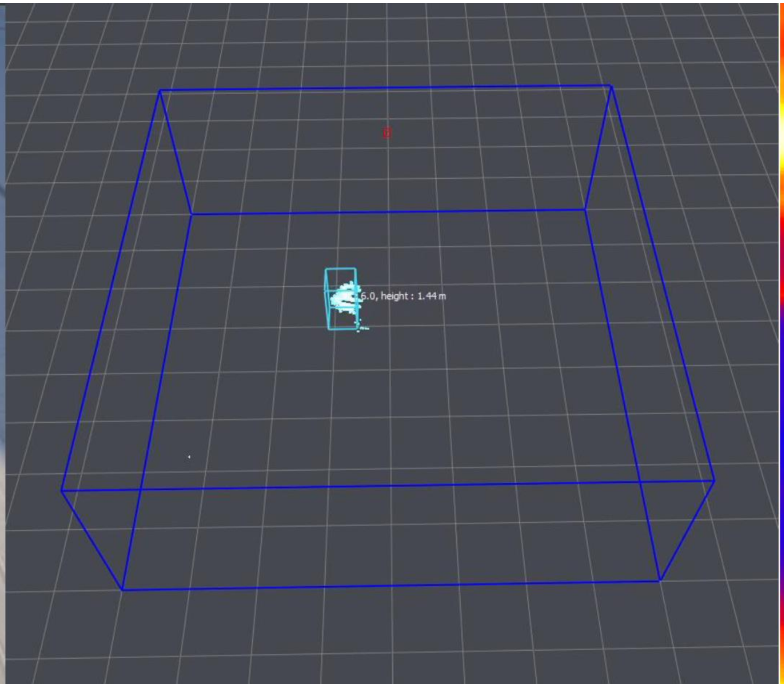
Research partners:

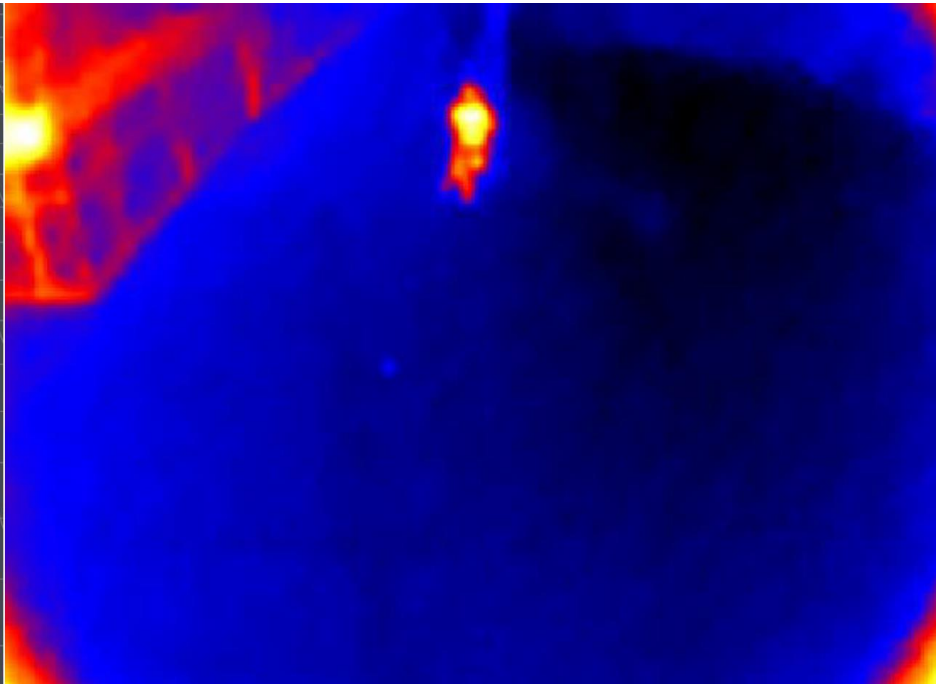
OST - Ostschweizer Fachhochschule

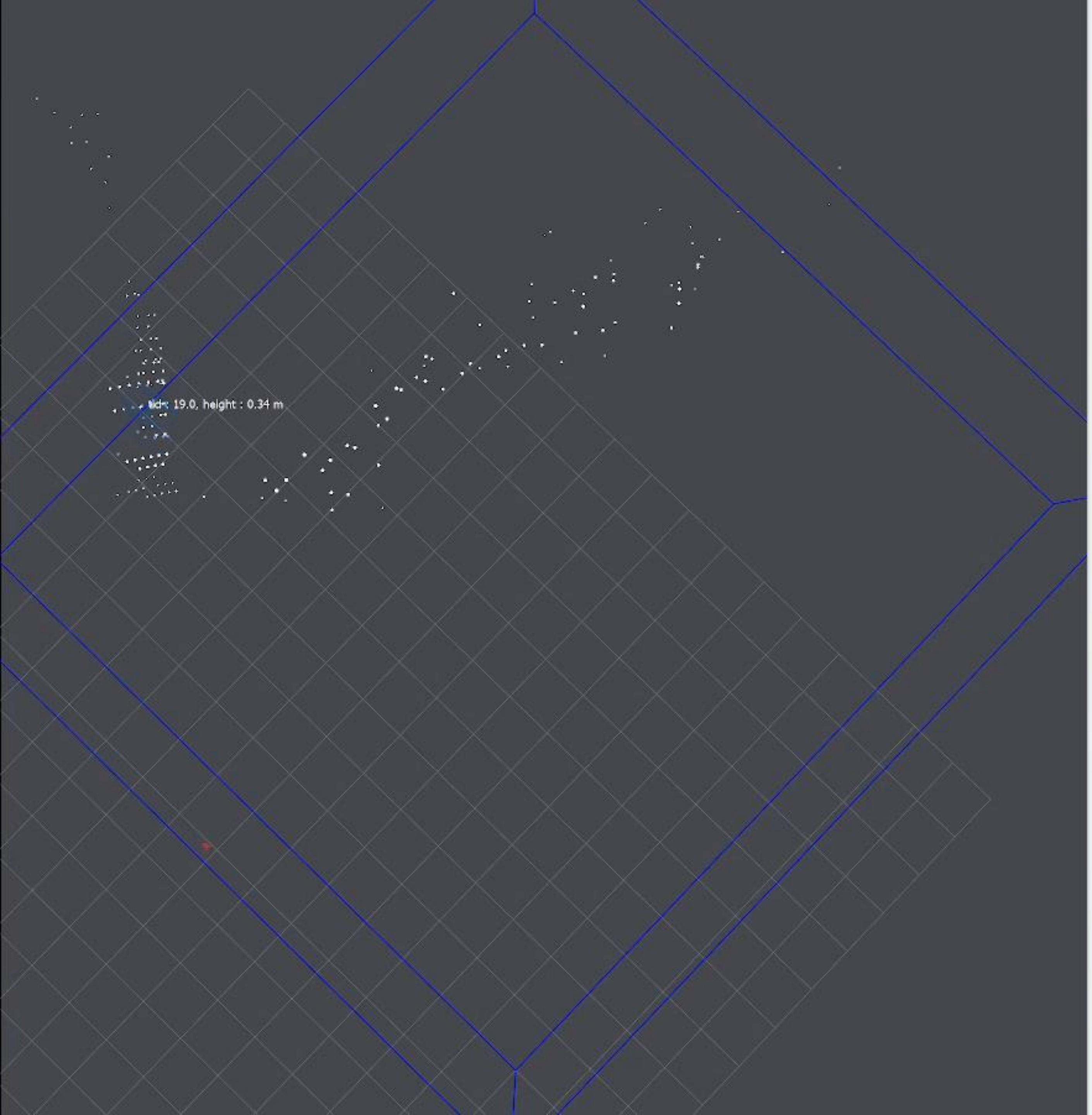
ADEC

- Joint project with the IRAP @ RJ









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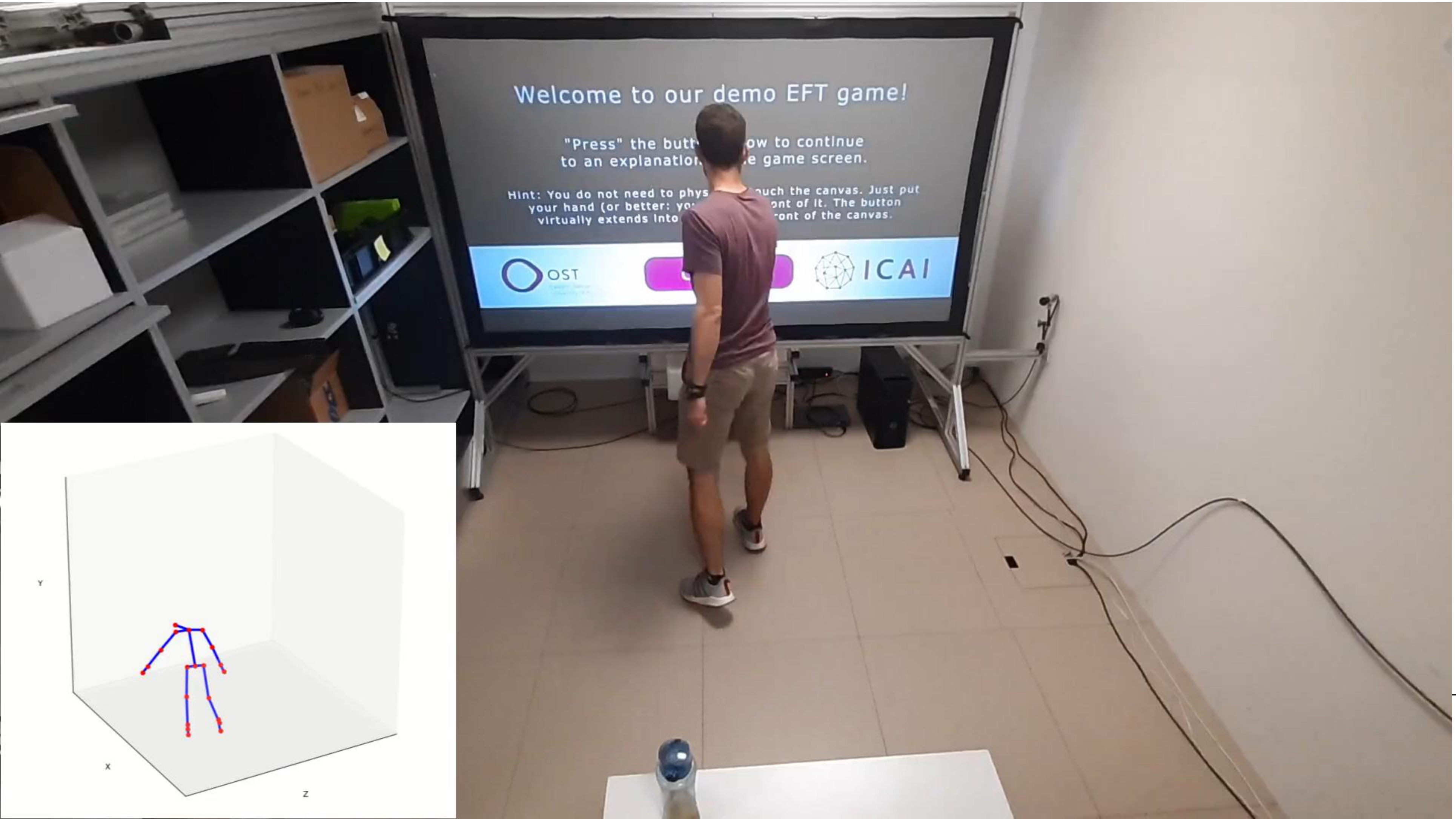
Encoding interval	1	Bitrate limit, kbps	100000

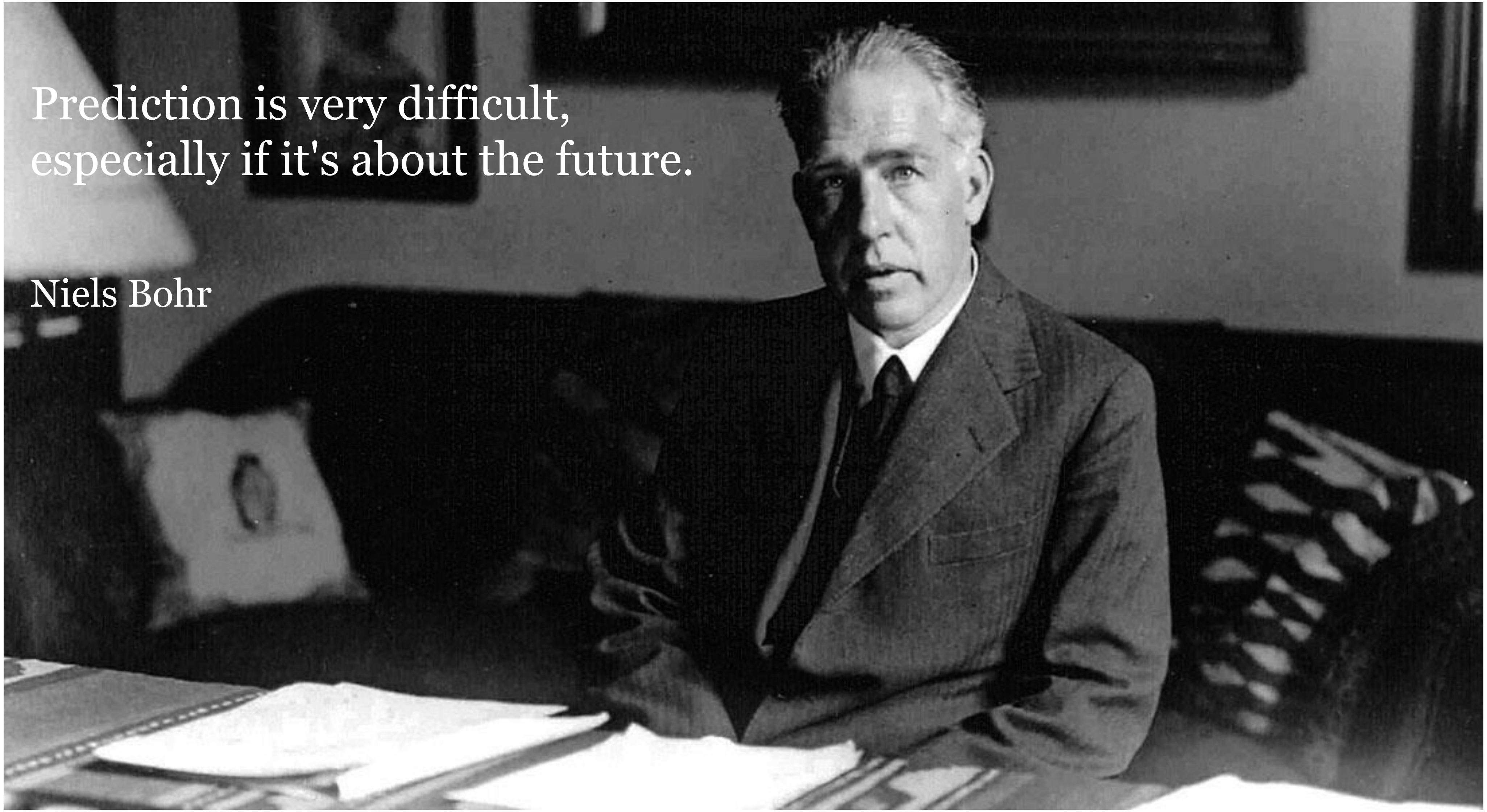
Executive functions training (EFT) system based on real-time computer vision (CV) and video projection (VP)

- **Lakers Sport AG**



- Joint project with Physiotherapy @ SG

Quo Vadis?


Prediction is very difficult,
especially if it's about the future.
Niels Bohr

Was ist künstliche Intelligenz, und wie funktioniert die Technik?

Mit Beispielen aus der industriellen Praxis

Prof. Dr. Guido M. Schuster

Gründer und Institutsleiter ICAI
Interdisciplinary Center for Artificial Intelligence

ICAI/IQT/OST

OST
Ostschweizer Fachhochschule

ICAI