KU LEUVEN

ESAT-STADIUS

The STADIUS Center for Dynamical Systems, Signal Processing, and Data Analytics

Bart De Moor

Content

- Research division STADIUS

- AI and machine learning

- AI in Health Care – Projects/Cases/Examples

- Clinical Decision Support Systems

- Leuven.AI KU Leuven Institute

- Flanders AI Program

KU Leuven

Established 1425
>60,000 Students
>21,000 Staff
15 Faculties
227 programs
“Most innovative university in Europe”*

KU LEUVEN

Science Technology and Engineering Group

595 professors, 633 Post-docs,
2322 PhD students
5 Faculties
14 Research departments

SCIENCE, ENGINEERING & TECHNOLOGY GROUP

Department of Electrical Engineering (ESAT)

>300 PhD students
>100 Staff
Focus areas: energy, integrated circuits, information processing, image & speech processing, and telecommunication systems

ESAT

STADIUS

18 Professors
100 PhD students
12 Post-docs
Focus areas: Mathematical engineering, Biomedical signal processing, Decision Support systems, Artificial Intelligence and Data Science

STADIUS
Center for Dynamical Systems, Signal Processing and Data Analytics

Source: Reuters https://www.reuters.com/article/rpbtop1002019-idUSKCN1S60PA

STADIUS
History of the name

Johannes Stadius 1527(?)-1579)

The Flemish astronomer, astrologer, and mathematician, Johannes Stadius, computed the ephemeris tables in 1554, that remained the primary reference for predict the position of celestial bodies in the sky on any given day. These were used for several practical and societal applications for decades to come.

The STADIUS group develops and applies **mathematical engineering for addressing technological and societal issues**.

Broadly, mathematical engineering is the use of generic information processing methodologies such as numerical linear and multilinear algebra, statistics, differential geometry, and optimization.

STADIUS
Distinguished Professors

Josep Balash

STADIUS,
Group T Leuven
Campus

Alexander Bertrand

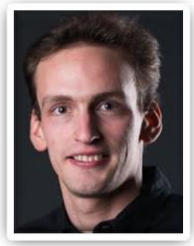
STADIUS,
Leuven Arenberg
Campus

Lieven De Lathauwer

STADIUS,
Kulak Kortrijk
Campus

Bart De Moor

STADIUS,
Leuven Arenberg
Campus



Maarten De Vos

STADIUS,
Leuven Arenberg
Campus

Aritra Konar

STADIUS,
Leuven Arenberg
Campus

Tjonnie Li

STADIUS,
Leuven Arenberg
Campus &
Theoretical Physics

Marc Moonen

STADIUS,
Leuven Arenberg
Campus

Yves Moreau

STADIUS,
Leuven Arenberg
Campus

Panagiotis Patrinos

STADIUS,
Leuven Arenberg
Campus

Johan Suykens

STADIUS,
Leuven Arenberg
Campus

Maria Torres Vega

STADIUS,
Group T Leuven
Campus

Toon van Waterschoot
Head of the division

STADIUS,
Group T Leuven
Campus

Bart Vanrumste

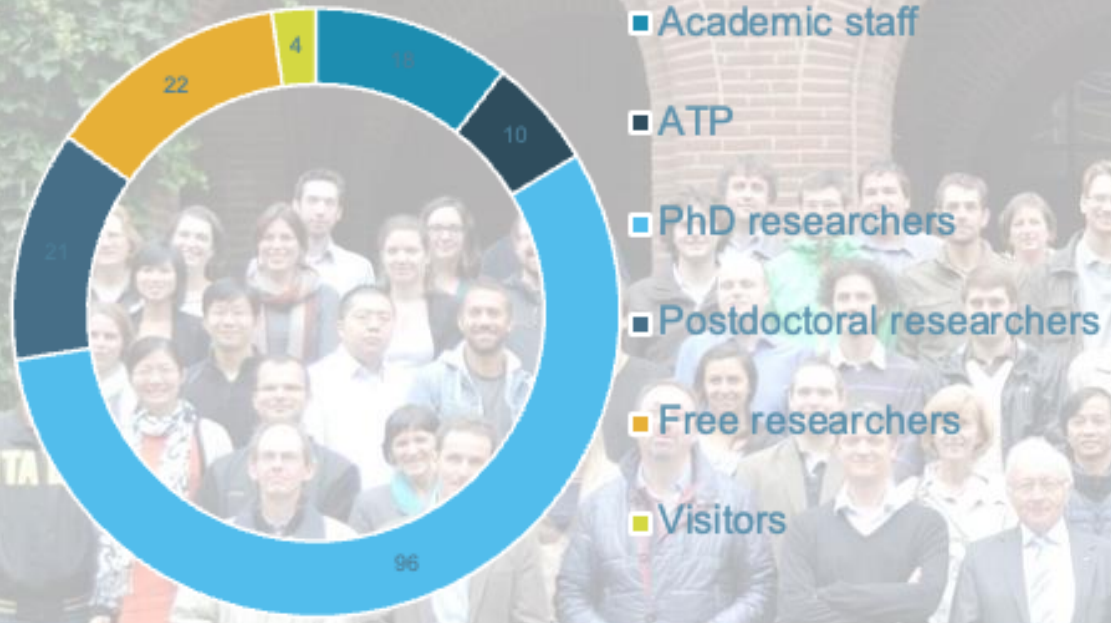
STADIUS,
Group T Leuven
Campus

Matthias Verbeke

STADIUS,
Leuven Arenberg
Campus & Computer
Science

KU LEUVEN

STADIUS
Numbers



18 Senior Academic Staff
Professors (incl 3 emeriti)

7 Admin and Tech Staff
IT, Project management, accounting, secretariat, IOF Innovation Managers…

121 Junior Academic staff
PhD researchers and Post Docs

26 Associate staff
Free researchers and Visitors

Keywords: data science, AI, algorithms, monitoring and control, Biomedical signal processing, genomics, clinical monitoring and control systems, Decision Support Systems.

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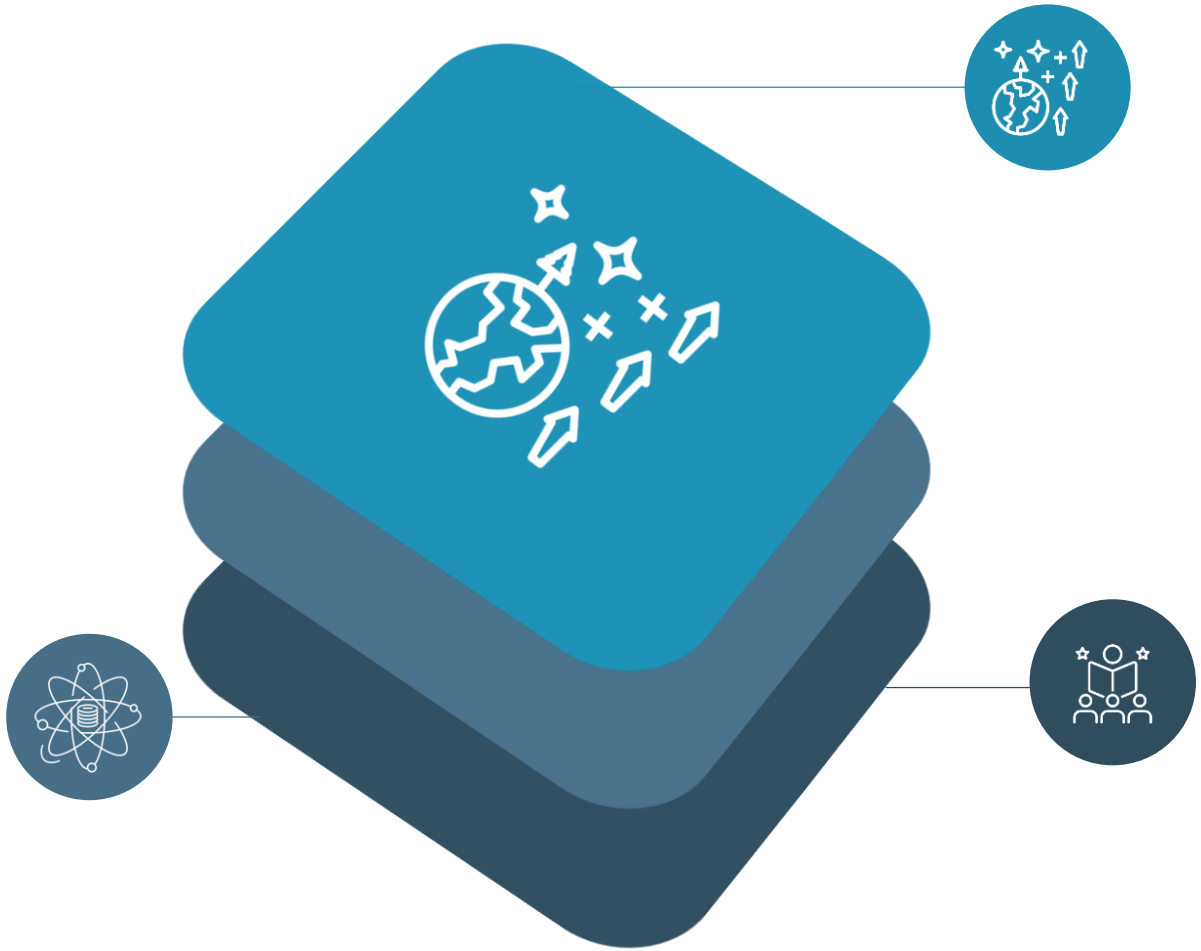
STADIUS
Mission

Research

With core concepts from linear and multi-linear algebra, statistics, optimization, machine learning, and artificial intelligence, the fundamental research is focused on the development of mathematical engineering tools and numerical algorithms.



Valorisation

Transfer of innovation to industry and society.

Building upon this foundation, the applied research is geared towards putting these tools and algorithms into motion in order to advance the current state of technology across a wide range of relevant application fields, including industrial automation and control, speech and audio signal processing, digital communications, biomedical data analysis and signal processing, bioinformatics and systems biology.

Education

Courses in

- Bachelors engineering
- Masters
  - Math. Eng.
  - Biomed.Eng.
  - Bioinformatics
  - AI
  - Elect. Engineering
  - …
- PhD Graduate
  - National
  - International

STADIUS
Research Themes

Theoretical research

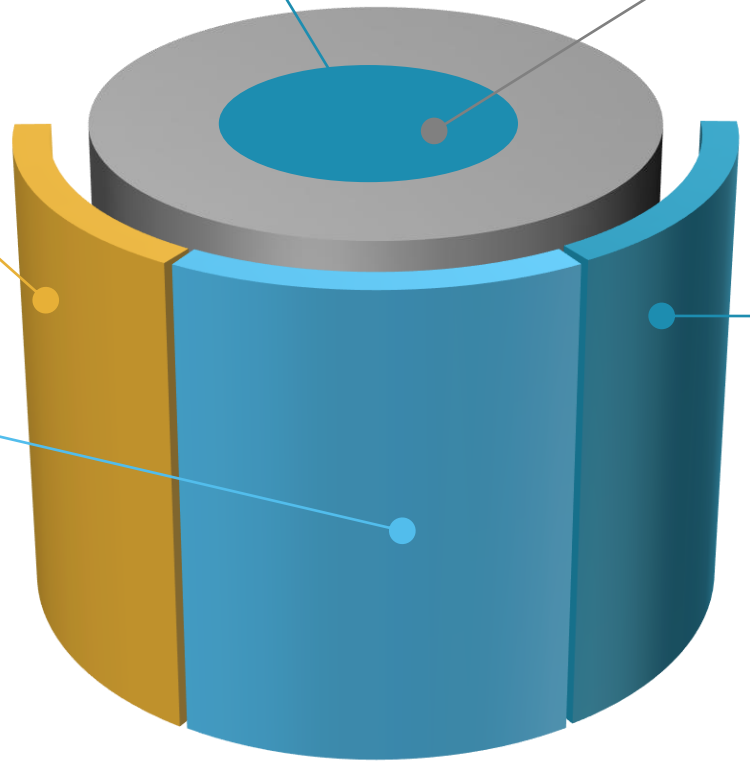
- Mathematical engineering

Applied research

- Systems modeling and control
- Digital signal processing, Computational biology,
- Data Science,
- Artificial intelligence, Decision support systems

Society

- Privacy and Security (privacy, security, ethics, encryption)
- Climate
- Music



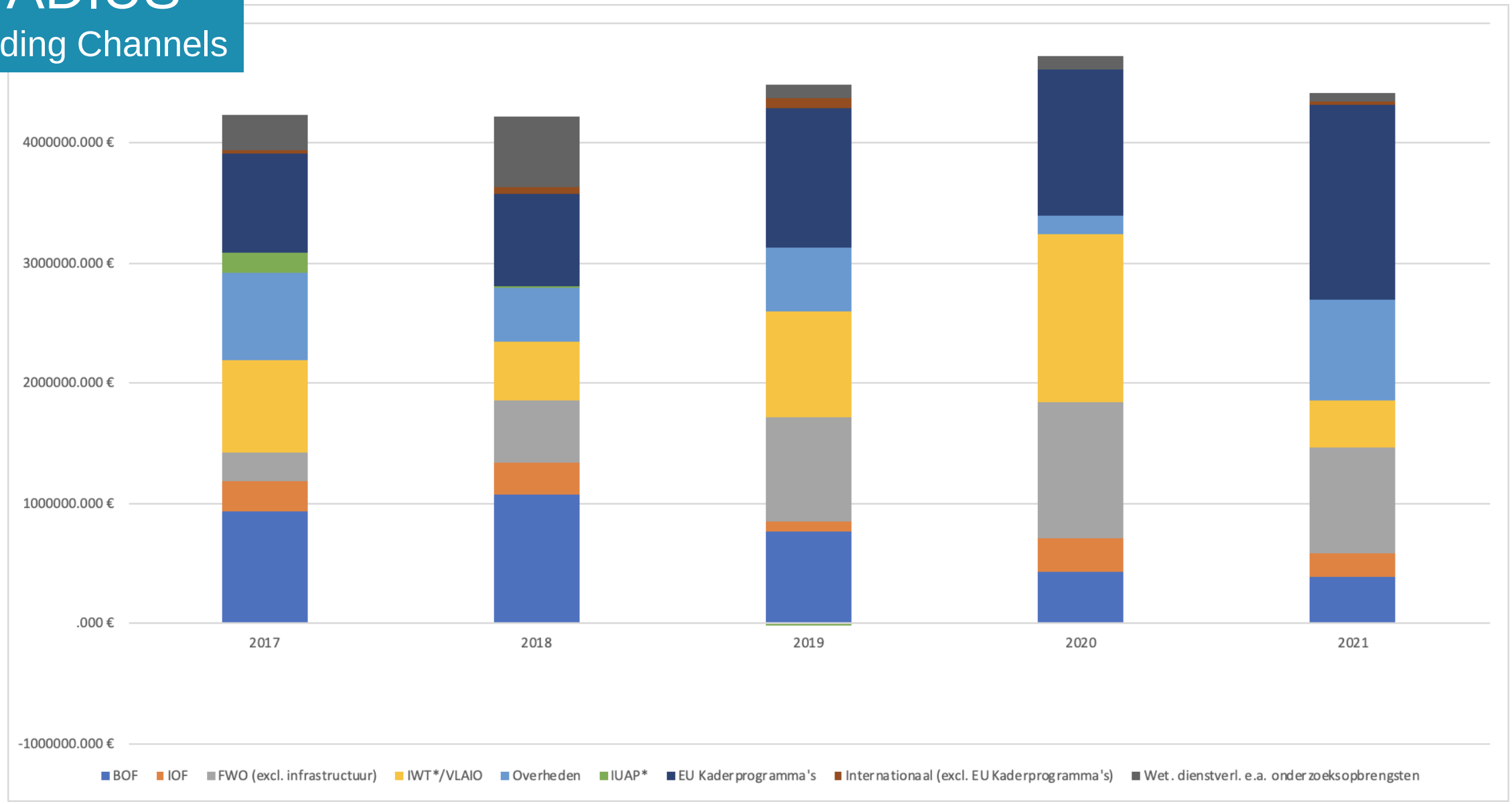
Health

- Health informatics
- Clinical decision support systems
- Precision medicine (genomics, multi-omics data mining, drug discovery, therapy design)
- Wearables and medical devices (epilepsy, neonatal Brain monitoring, EEG, hearing aids and cochlear implants, cardiorespiratory, sleep monitoring)

Industry

- Speech and audio processing, noise cancellation
- Autonomous systems
- Process industry
- Telecommunication (wireless and wireline modems)
- Utility networks (electricity, water, gas, …)

STADIUS
Funding Channels



STADIUS
Spinoffs

DATA4s
data4s
NORKOM TECHNOLOGIES

Payment fraud detection (2000)
(in 2004 acquired by Norkom Technologies ; in 2011 Norkom Techn. was acquired by Detica NetReveal , Bus. Division of BAE Systems Detica.
http://www.deticanetreveal.com/en/about-us.html

silicos

In silico drug discovery (2005)

TrendMiner

TrendMiner: Formerly Dsuare, is the Belgian big-data company that has been acquired by Software AG.

CARTAGENIA
Agilent

Data handling & mining for clinical genetics (2008).
Acquired by Agilent
https://www.agilent.com/

Aspect Analytics

https://www.aspect-analytics.com/

LINDACARE
Enjoy life more.

LindaCare makes patient tele-monitoring significantly more efficient and improves the quality of patient care, by providing healthcare professionals with a single integrated and unified vendor independent software platform.

TRANSPORT & MOBILITY LEUVEN

Transport & Mobility research & mgt (2002)
http://www.tmleuven.be/

VIPUN Medical
innovative nutrition devices

https://www.vipunmedical.com/

pyxima
SOCIAL CARE SOFTWARE

Social interest software (2009)
http://www.pyxima.com/

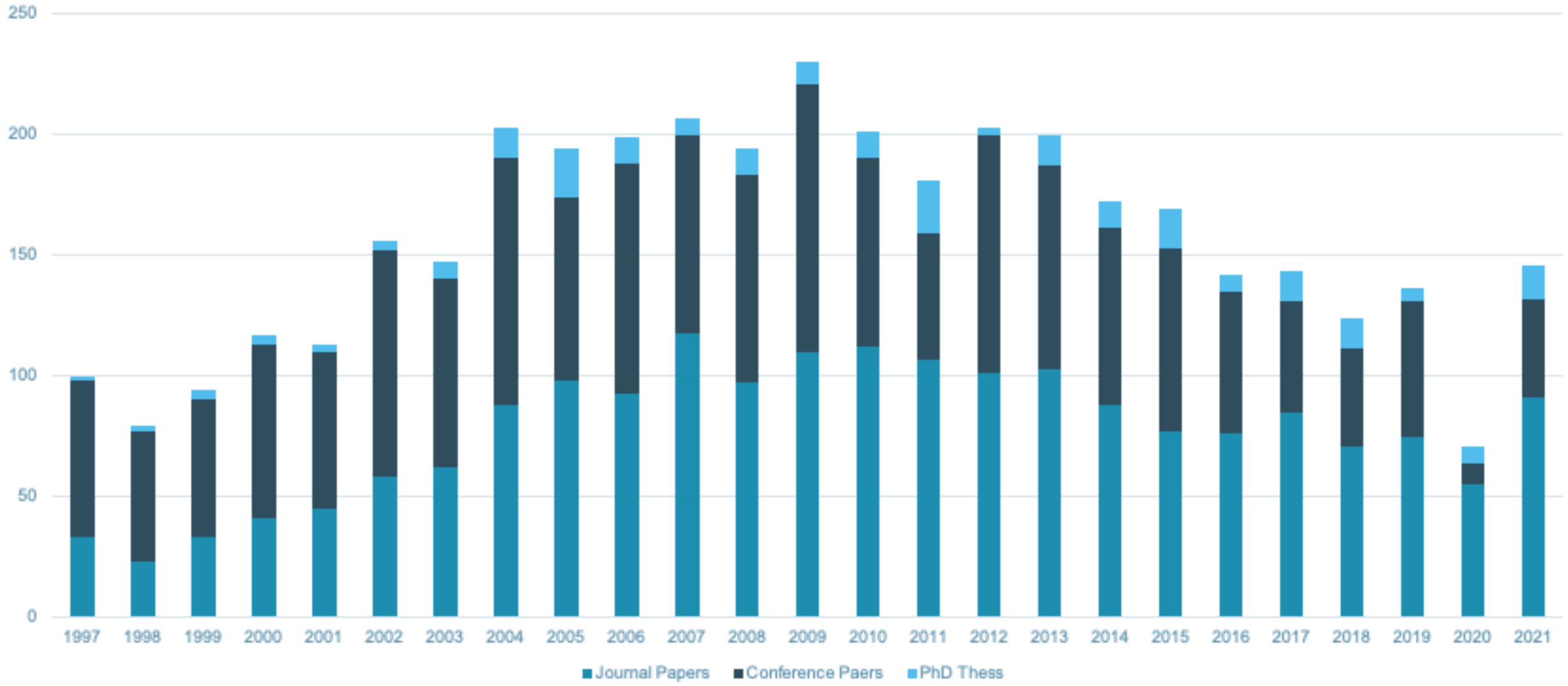
IPCOS

Modelling and control of multivariable industrial processes (chemical and power plants, oil exploration)
automation & optimization (1995)
http://www.ipcos.com/en

UgenTec

Intelligent software for laboratory technicians, molecular biologists and lab manager's

STADIUS
Publications



KU LEUVEN

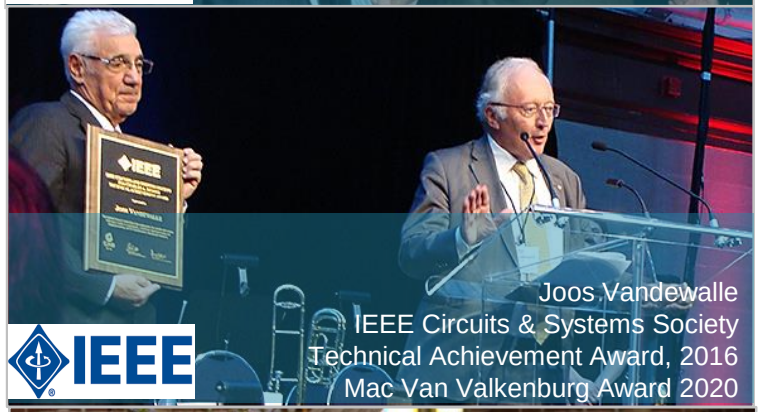
STADIUS
Awards and honors

ERC Starting Grant
2010 Moritz Diehl
2018 Alexander Bertrand

ERC Consolidator Grant
2017 Toon van Waterschoot

ERC Advanced Grant
2011 Johan Suykens
2013 Sabine Van Huffel
2017 Johan Suykens
2020 Bart De Moor

Bart De Moor
FWO Excellence Award
dr. De Leeuw-Damry-Bourlart, 2010



Joos Vandewalle
IEEE Circuits & Systems Society
Technical Achievement Award, 2016
Mac Van Valkenburg Award 2020

Sabine Van Huffel
Honorary doctorate
TU Eindhoven, NL, 2013

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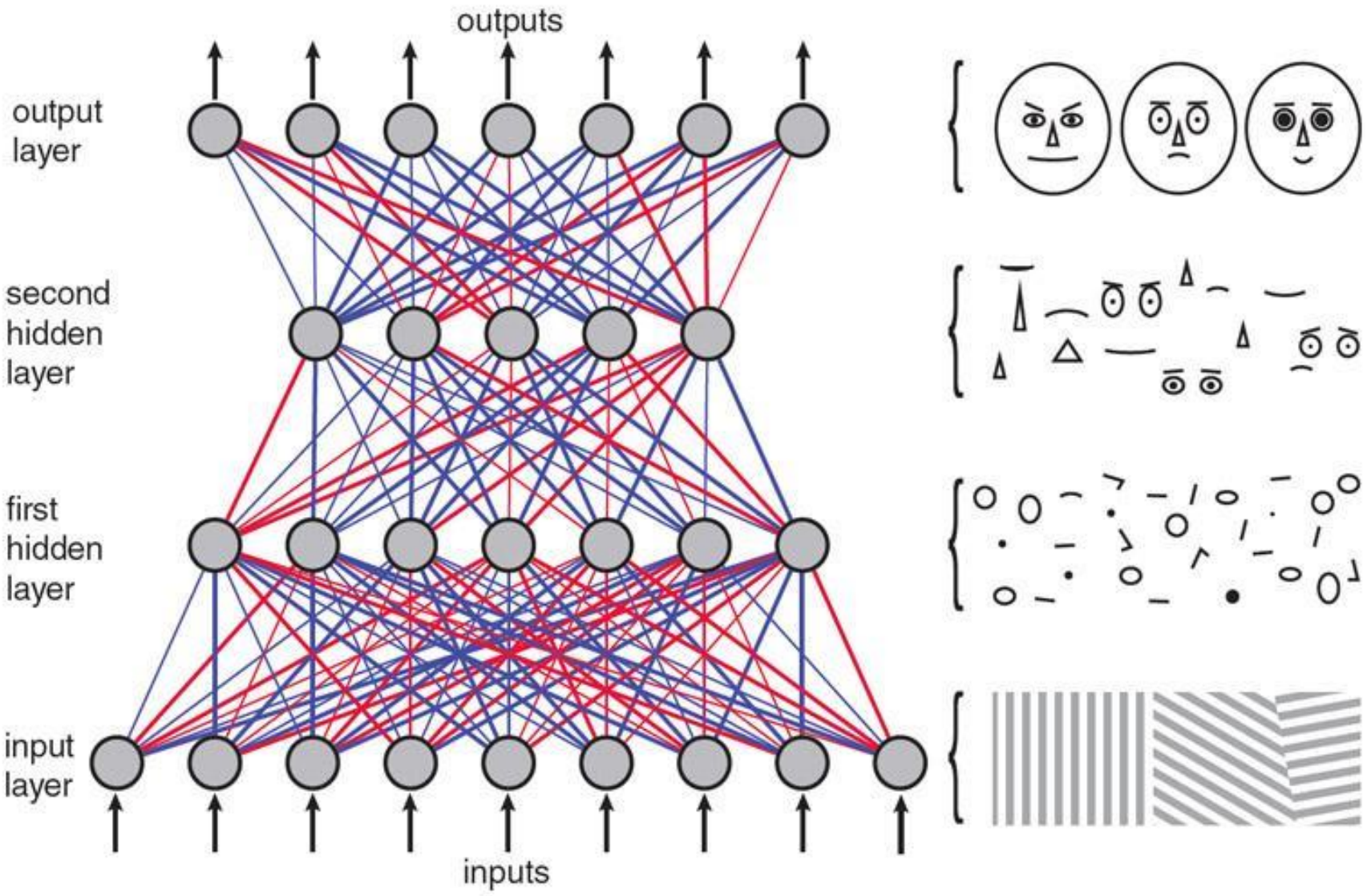
What is Artificial Intelligence and Machine Learning?

- Artificial intelligence
  - “Intelligence” as demonstrated by a machine unlike ‘natural (animal, human) intelligence’
  - Mimic the human mind in ‘cognitive functions’ and ‘problem solving’
  - Mimic = by massive computing power, exploiting tsunami of data
  - Interdisciplinary: mathematics, computer and information science, psychology, linguistics,…
  - Emotionality ? (Self-)consciousness ?

- Machine Learning
  - Computer algorithms that ‘improve’ their performance through experience/data processing
  - Supervised (e.g. by providing classification labels) or unsupervised (e.g. data reduction)
  - Interdisciplinary: mathematics, statistics, numerical optimization, …
  - Training and validation data
  - Generalization ? Transfer Learning ?

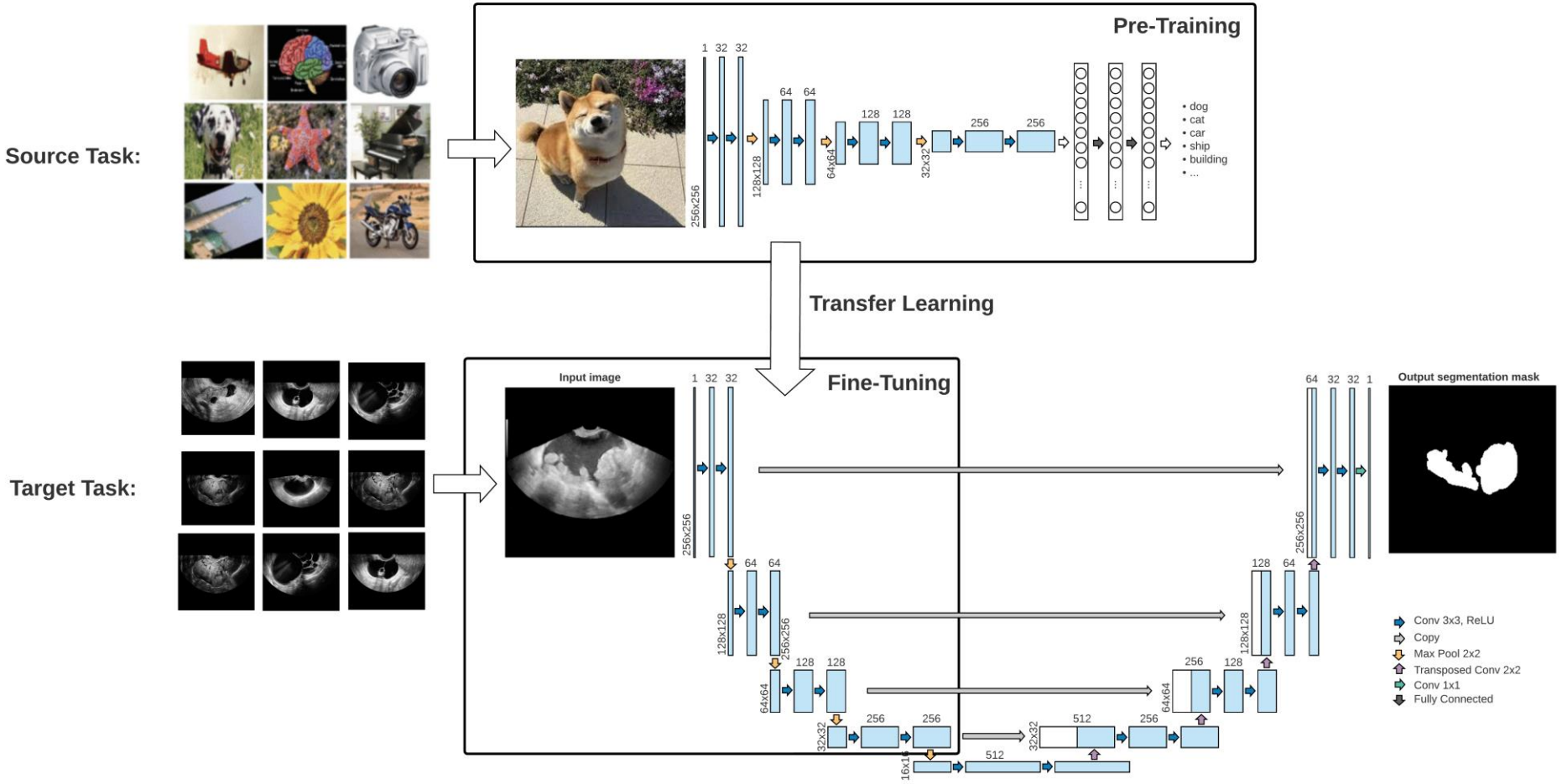
Deep Learning & Neural Networks



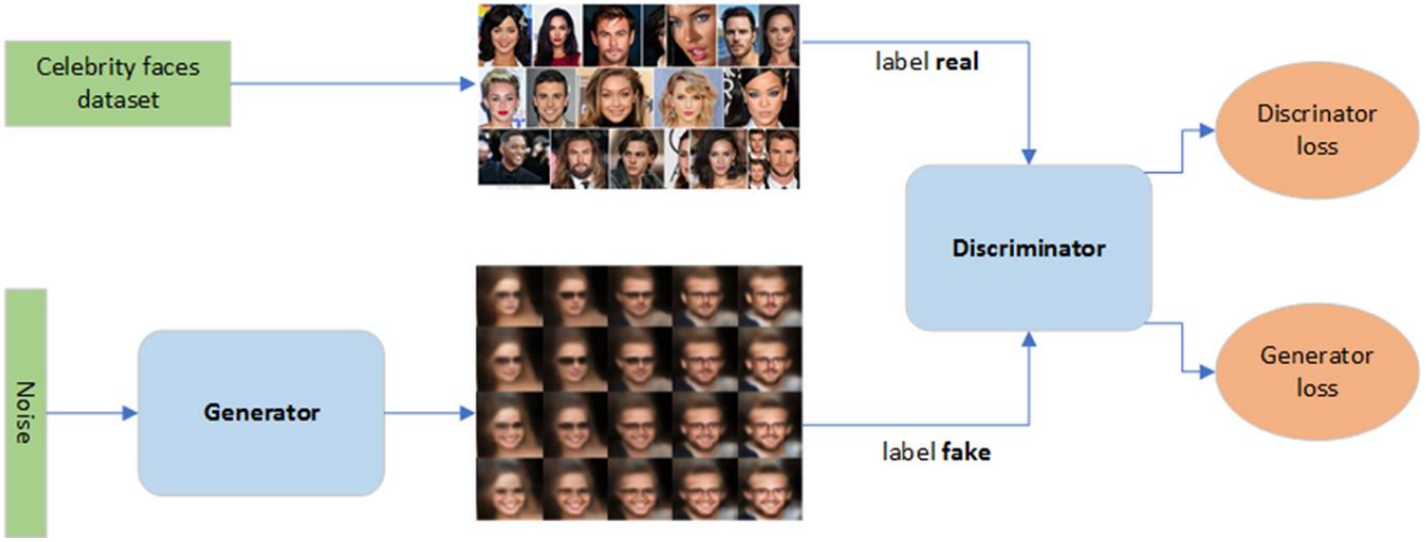
- Multiple layers on top of each other.
- Each layer learns a more complex representation.
- Learn feature hierarchies.

Convolutional Neural Networks (CNNs)

CNNs have a widespread use in computer vision tasks as its inductive bias allows for the preservation of the spatial structure present in an image (nearby pixels similar, big features made up of smaller features ...). Transfer Learning helps to increase performance for small dataset sizes and makes training go faster.



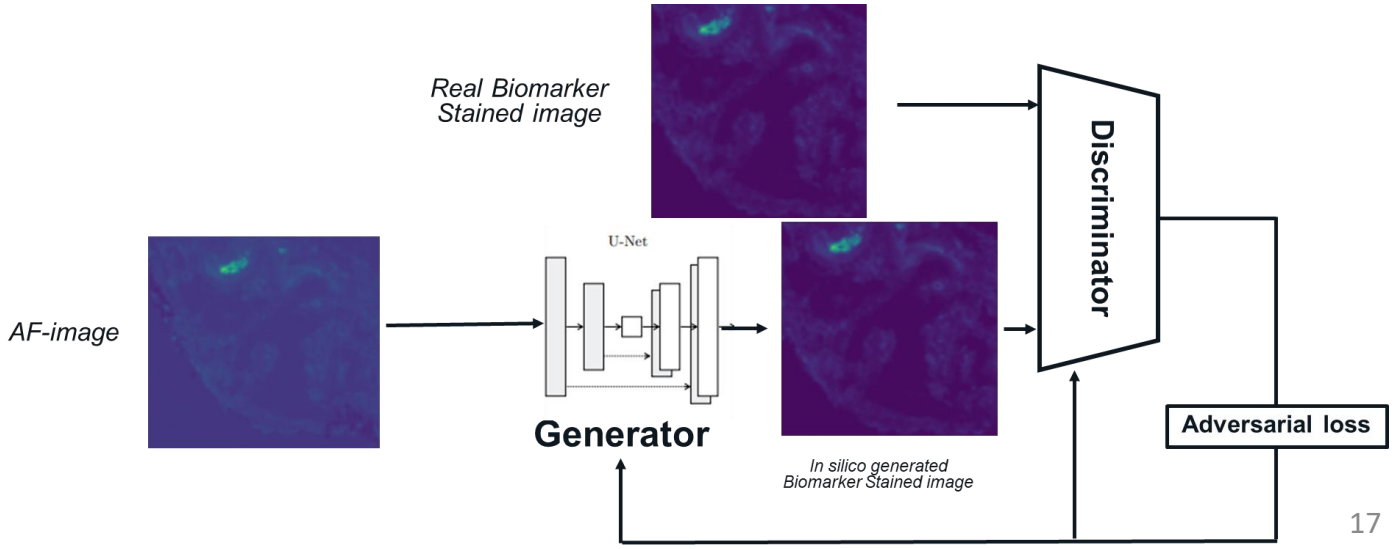
Generative Adversarial Networks (GANs)



A GAN consists of two competing Neural Networks:

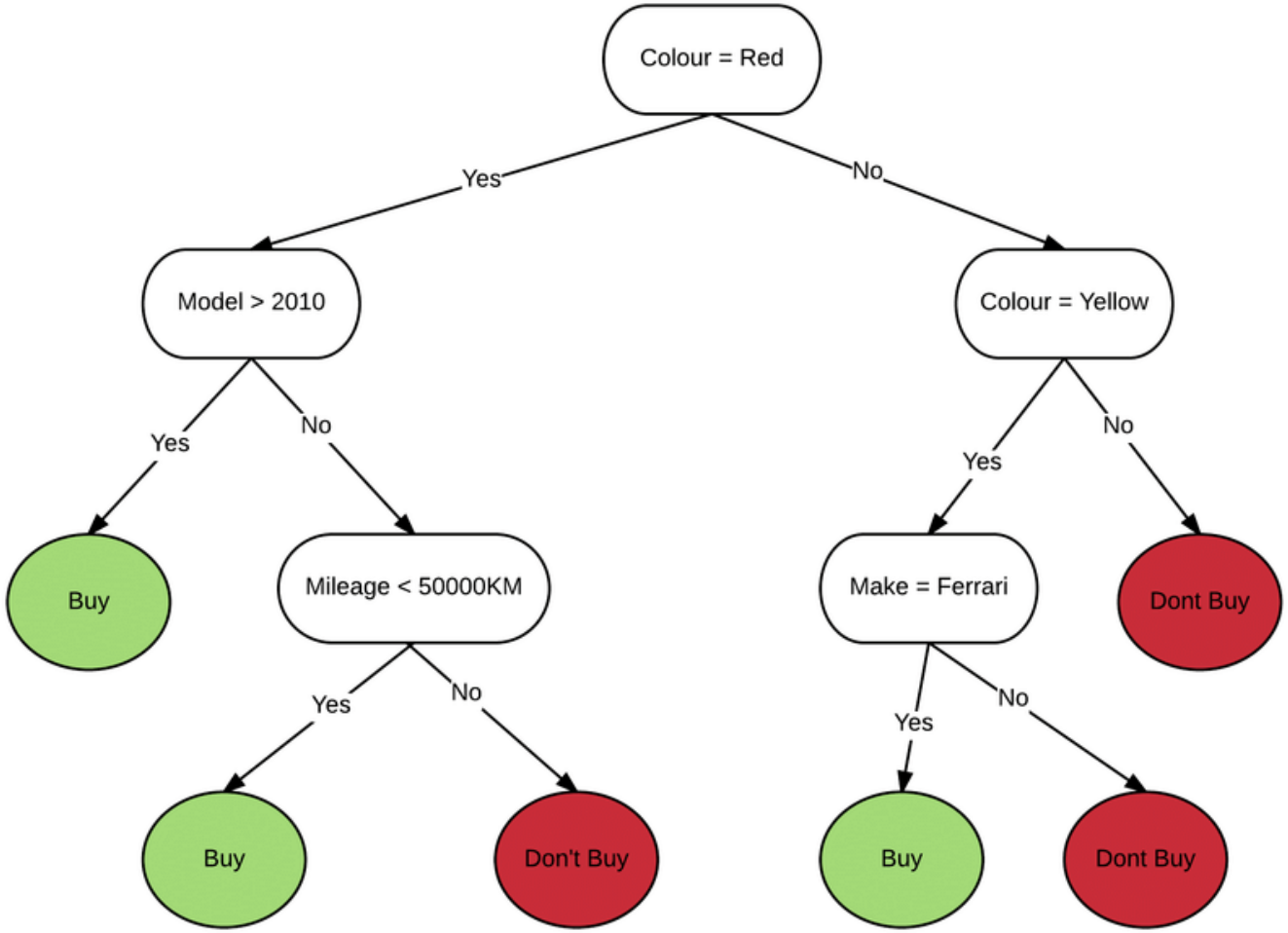
- **Generator**: creating a data sample based on a certain input (often noise)
- **Discriminator:** distinguishing real from fakes

Using GANs to generate **virtual stains** (e.g. H&E or fluorescence imaging).



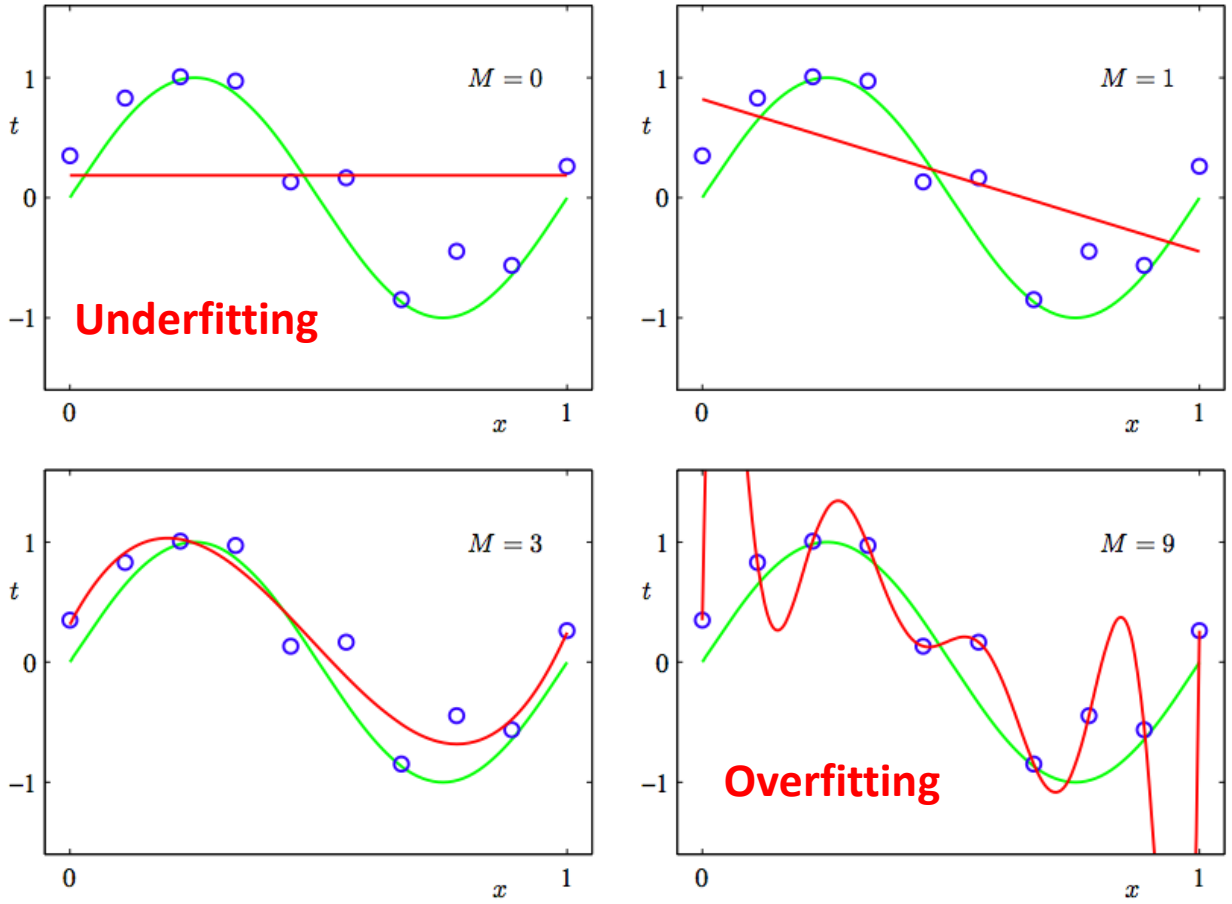
Decision trees

Decision nodes are trained according to a labeled set of data points. A new instance is given as an input and run through the tree, which then produces the most likely output.



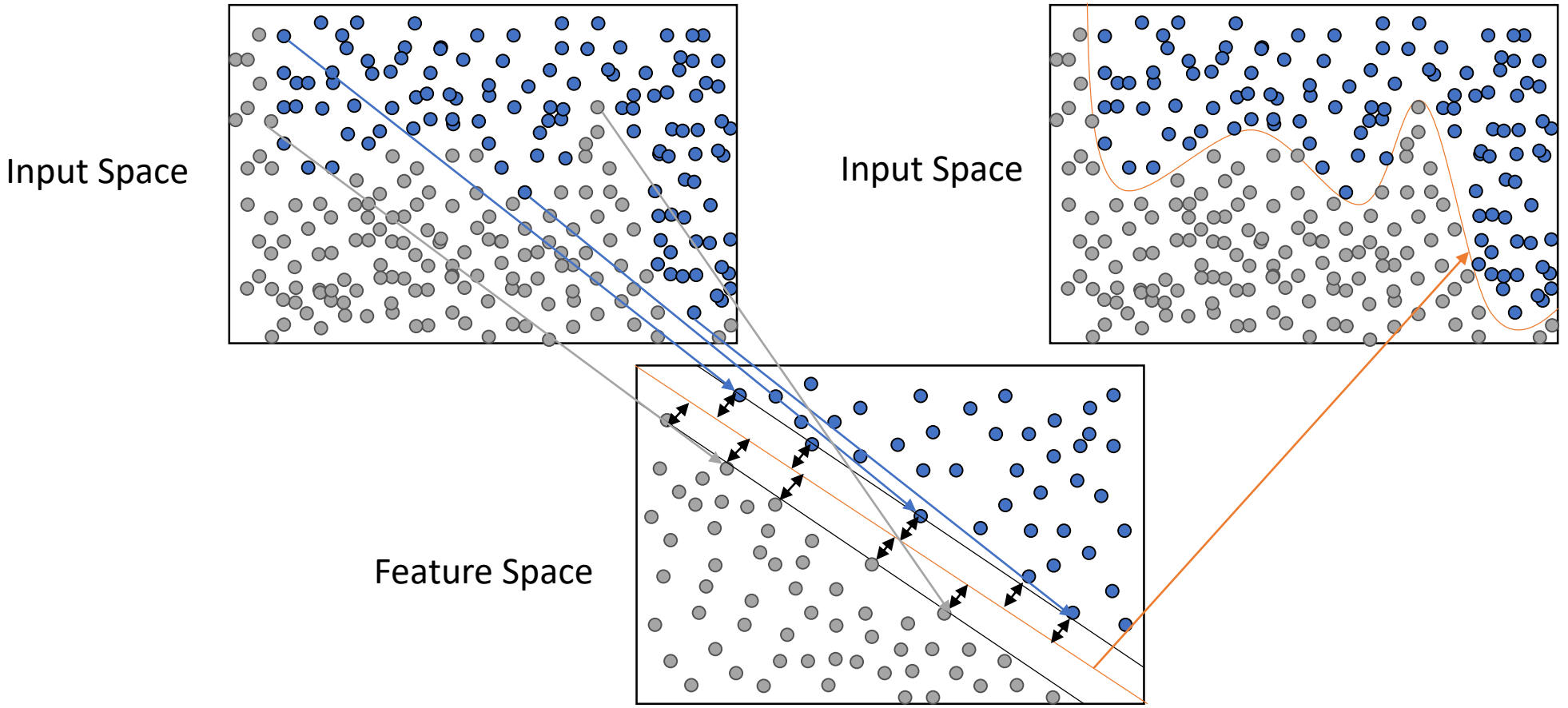
Regularized Regression

Fitting a regression function on a data set can result in overfitting: the regression fits to the data, but not to the general trend. The regression is thus not generalizable! A solution is to punish the learner for creating a model with high complexity.



Support Vector Machines (SVMs)

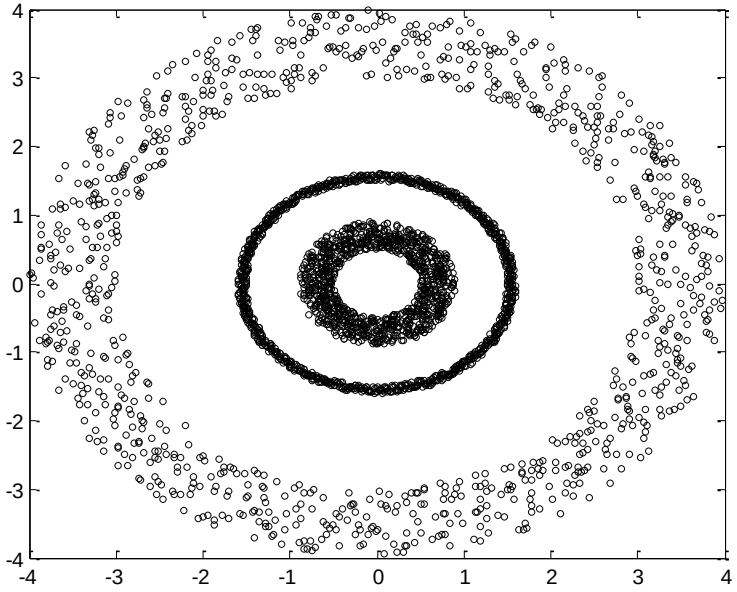
First transform the problem to a high-dimensional form, where the solution is easily found, through the so-called ‘kernel trick’. Then, transform the decision boundary back to the original form.



Spectral Clustering

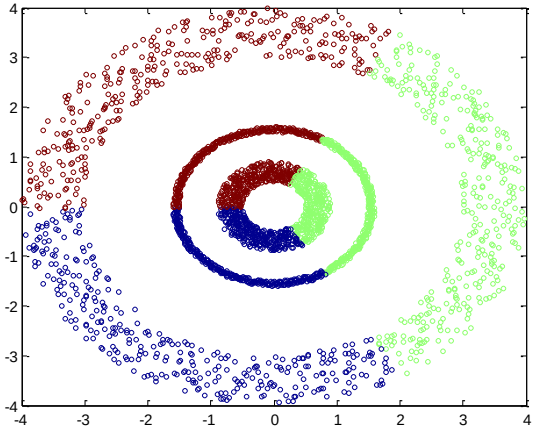
Goal of data clustering: to discover the natural grouping of a set patterns, points, etc. Although widely used, K-means can fail in some scenarios

Input data

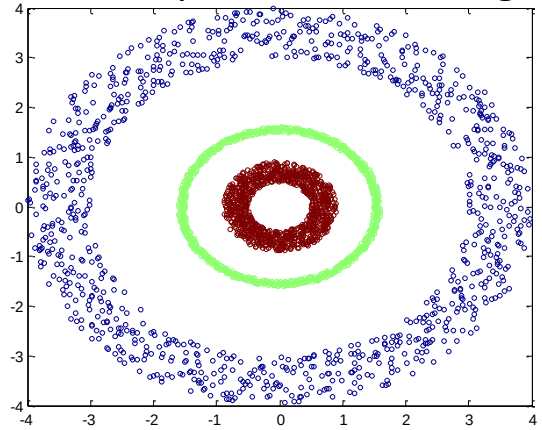


Clustering Algorithm

K-means

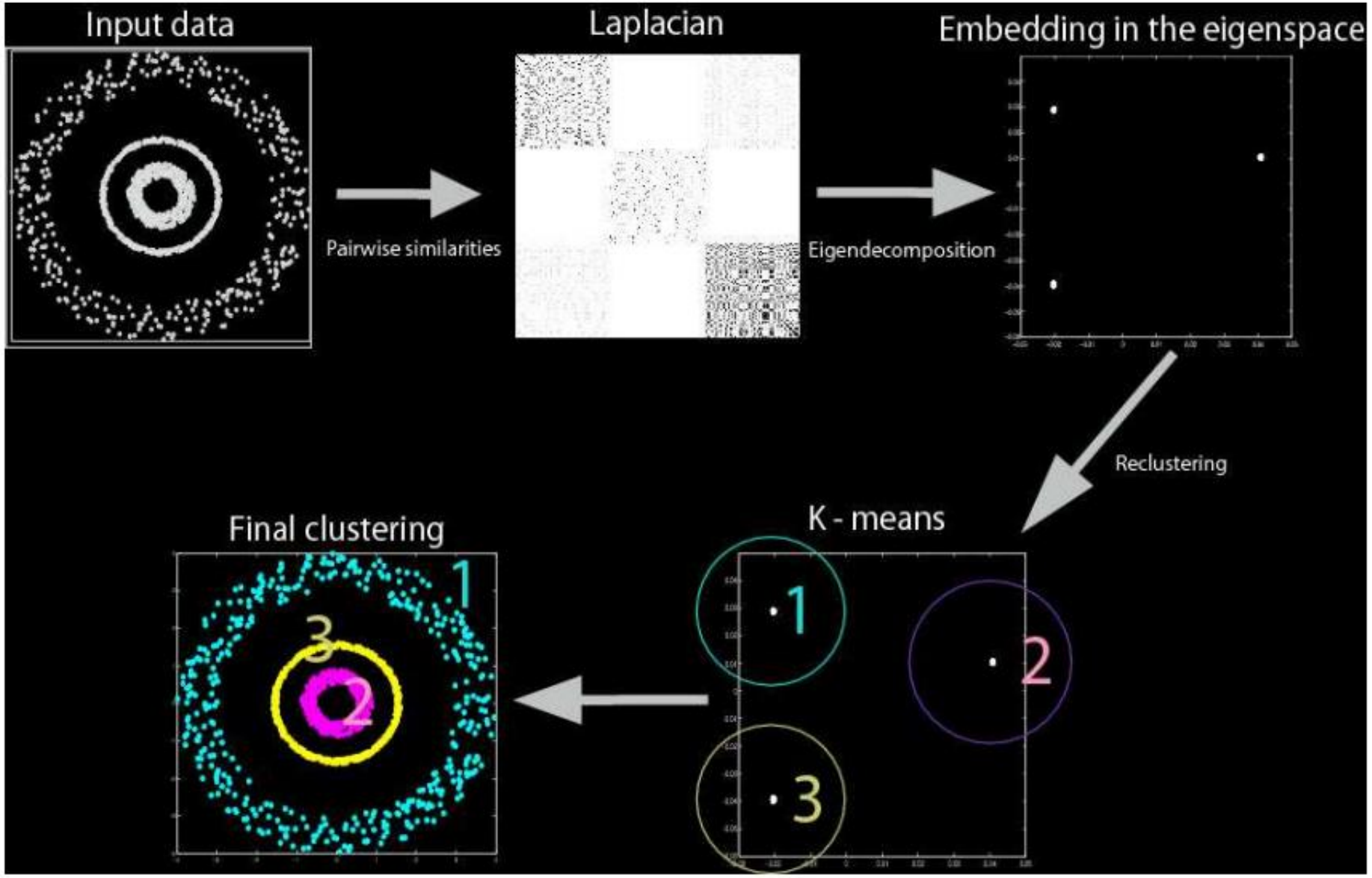


Spectral Clustering
Kernel Spectral Clustering*



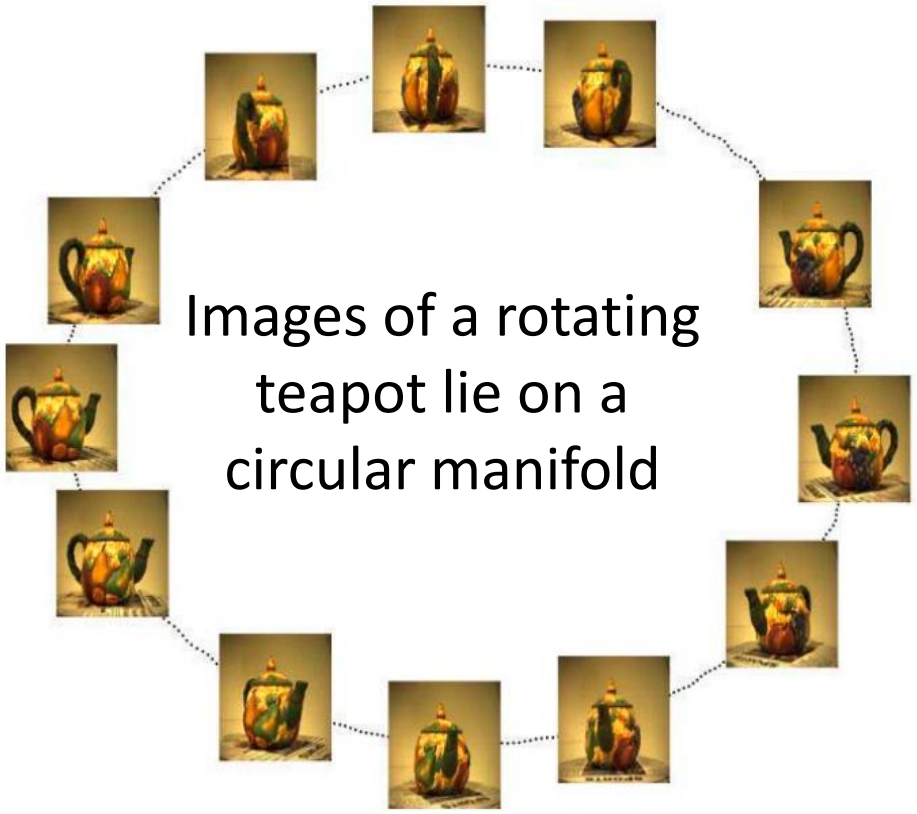
* Developed at STADIUS. [Alzate & Suykens, IEEE TPAMI 2010]

Spectral Clustering

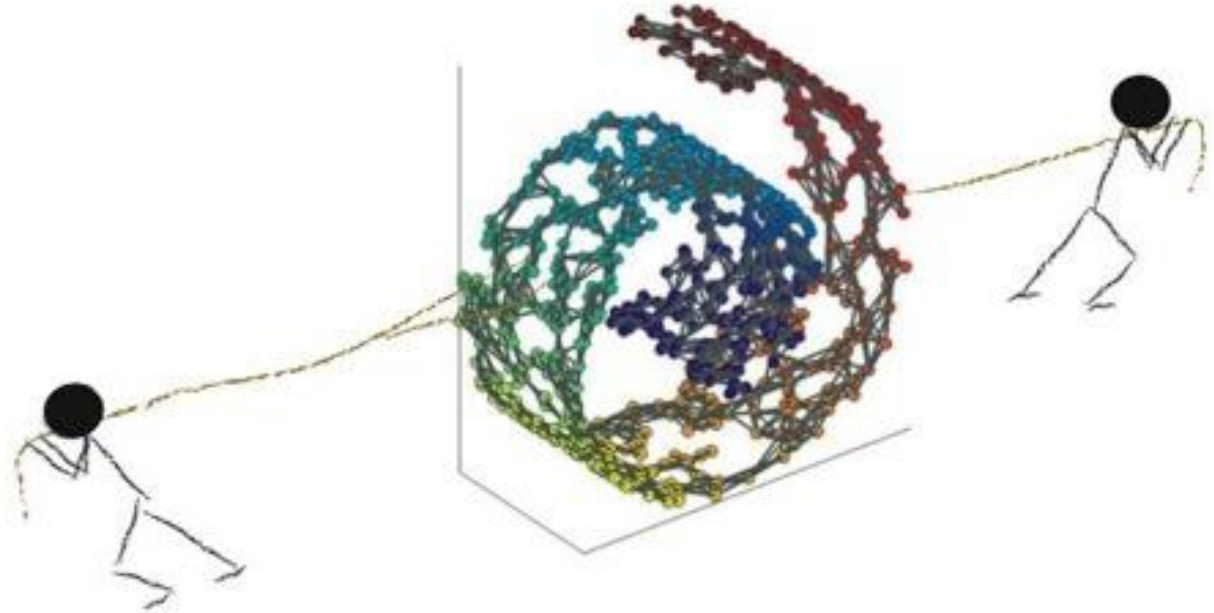


Manifold Learning

A lot of datasets live on a low dimensional manifold.



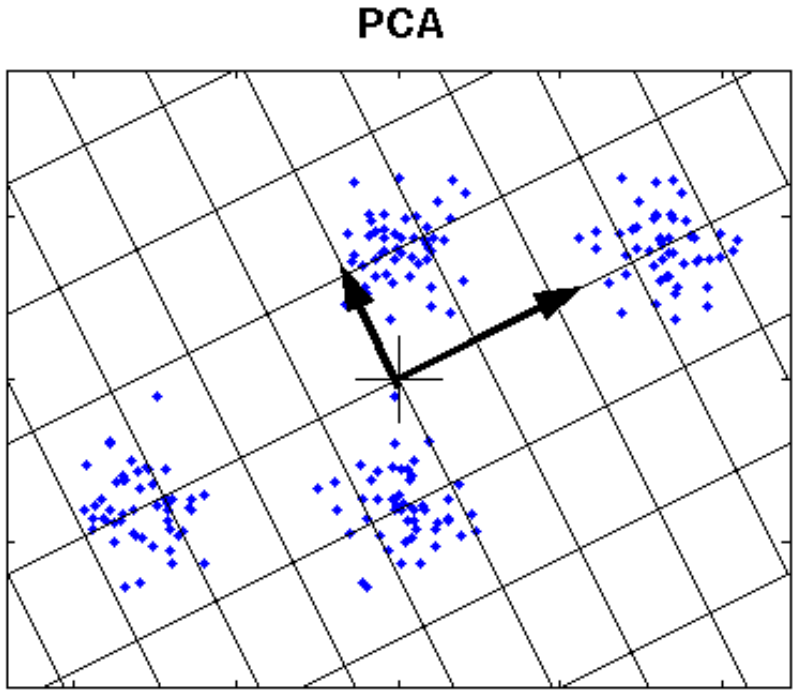
Images of a rotating teapot lie on a circular manifold

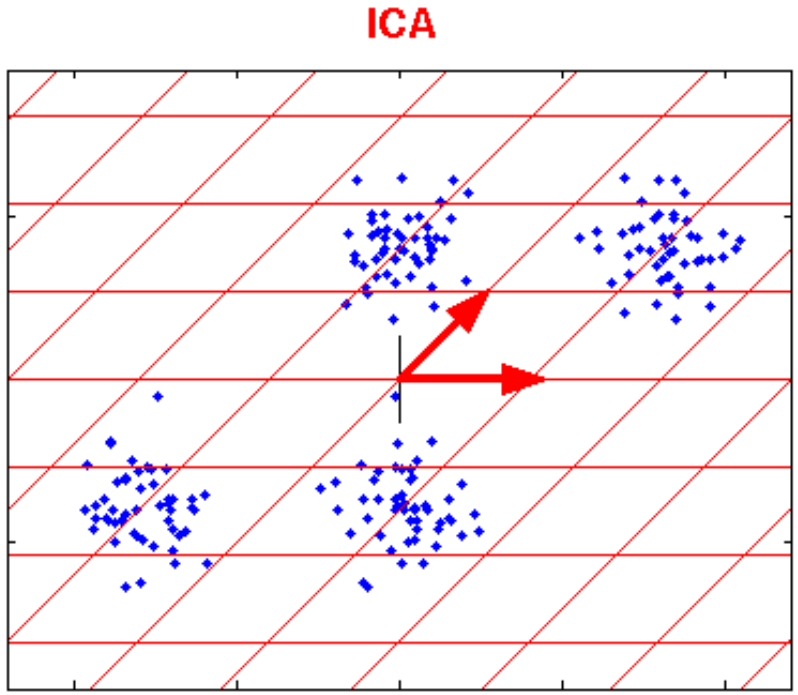


Goal: Find a low-dimensional basis for describing the high-dimensional data

Component Analysis

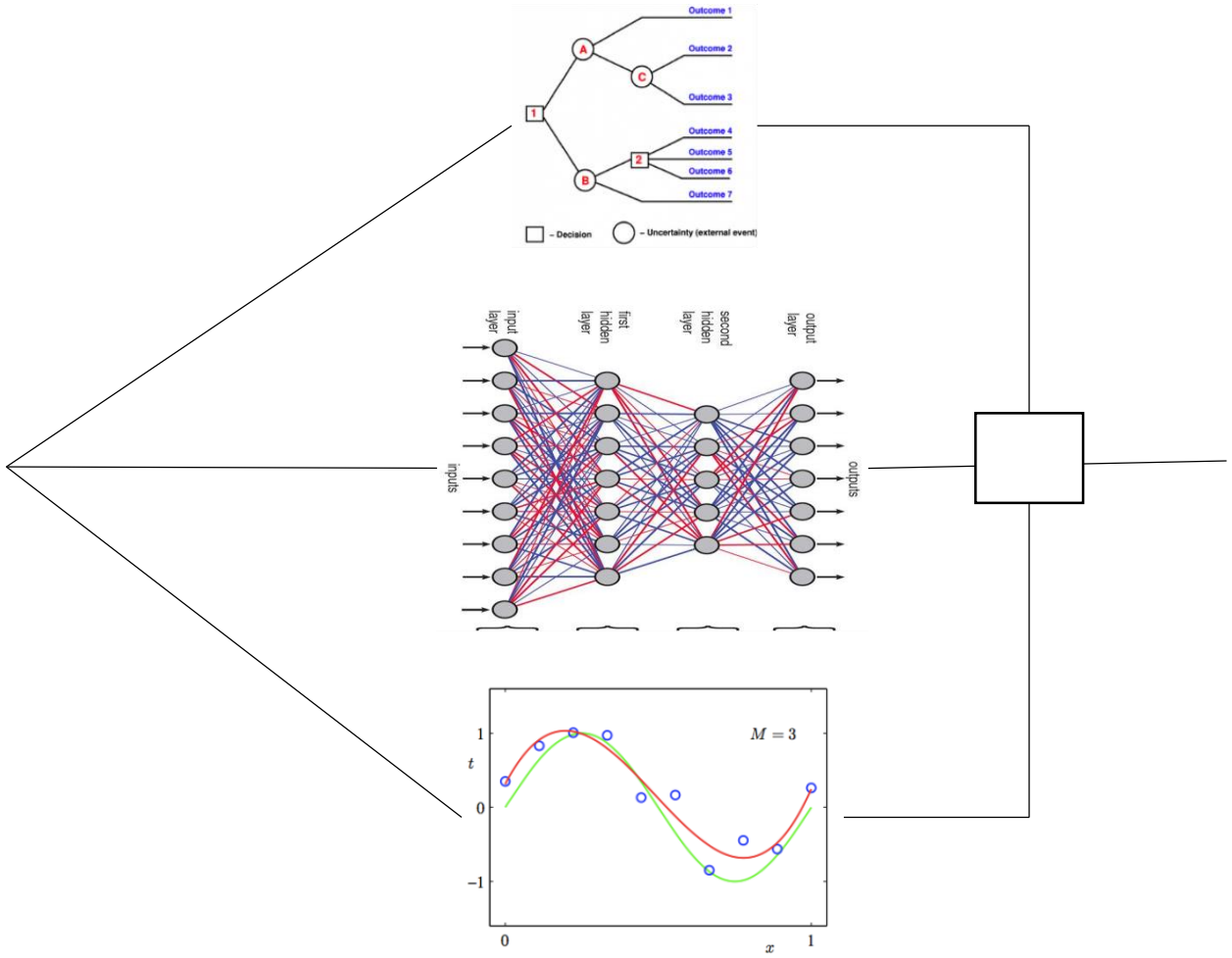
The data dimensionality is reduced by dividing the data set into smaller, relevant components. This can be done by maximizing the variance (principal component analysis), or by finding independent sources of data (independent component analysis).



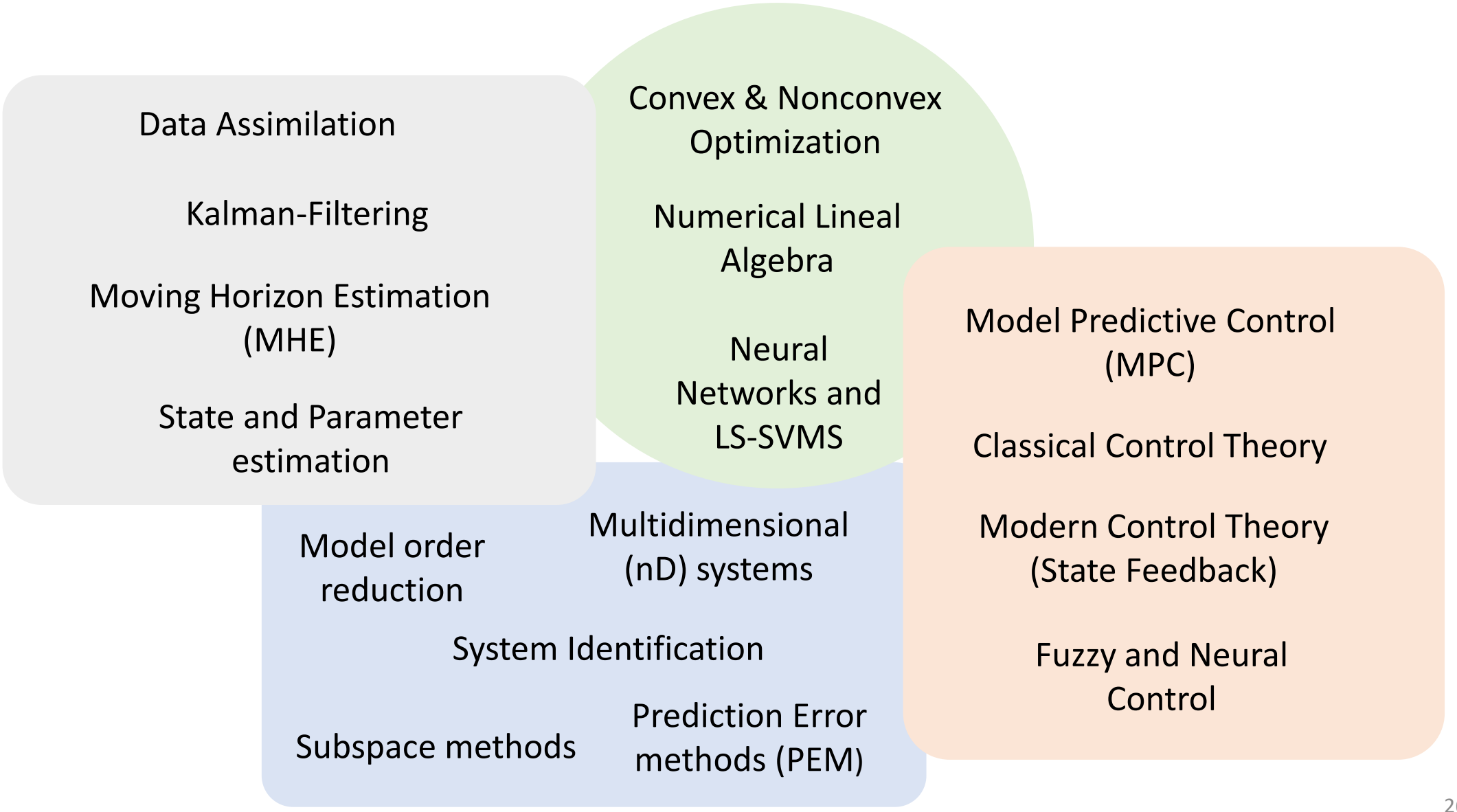


Ensemble Methods

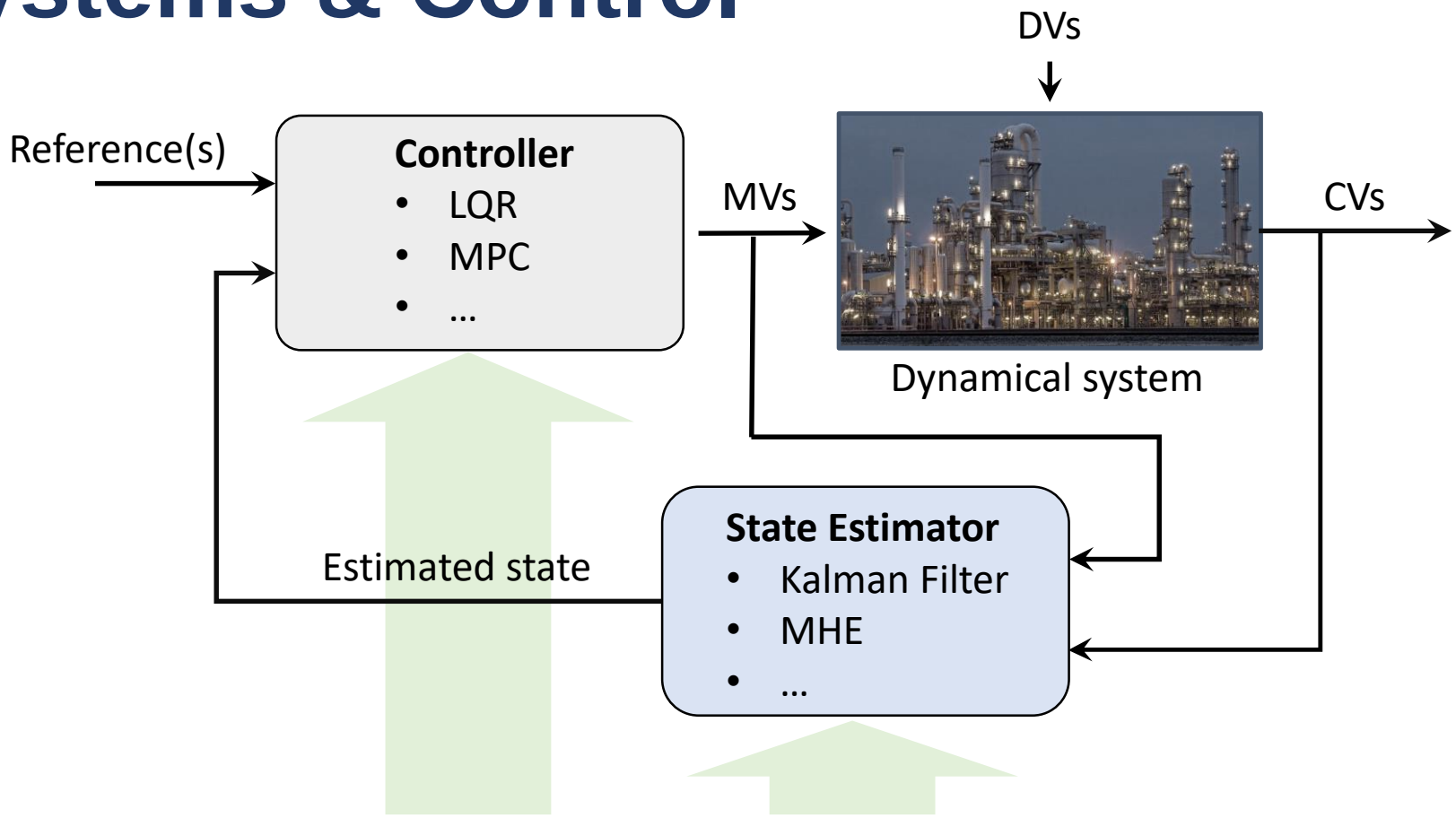
Several machine learning algorithms are implemented in parallel to each other. A decision on the outcome is then made, based on some decision rule (e.g., majority voting).



AI and Systems & Control



AI and Systems & Control



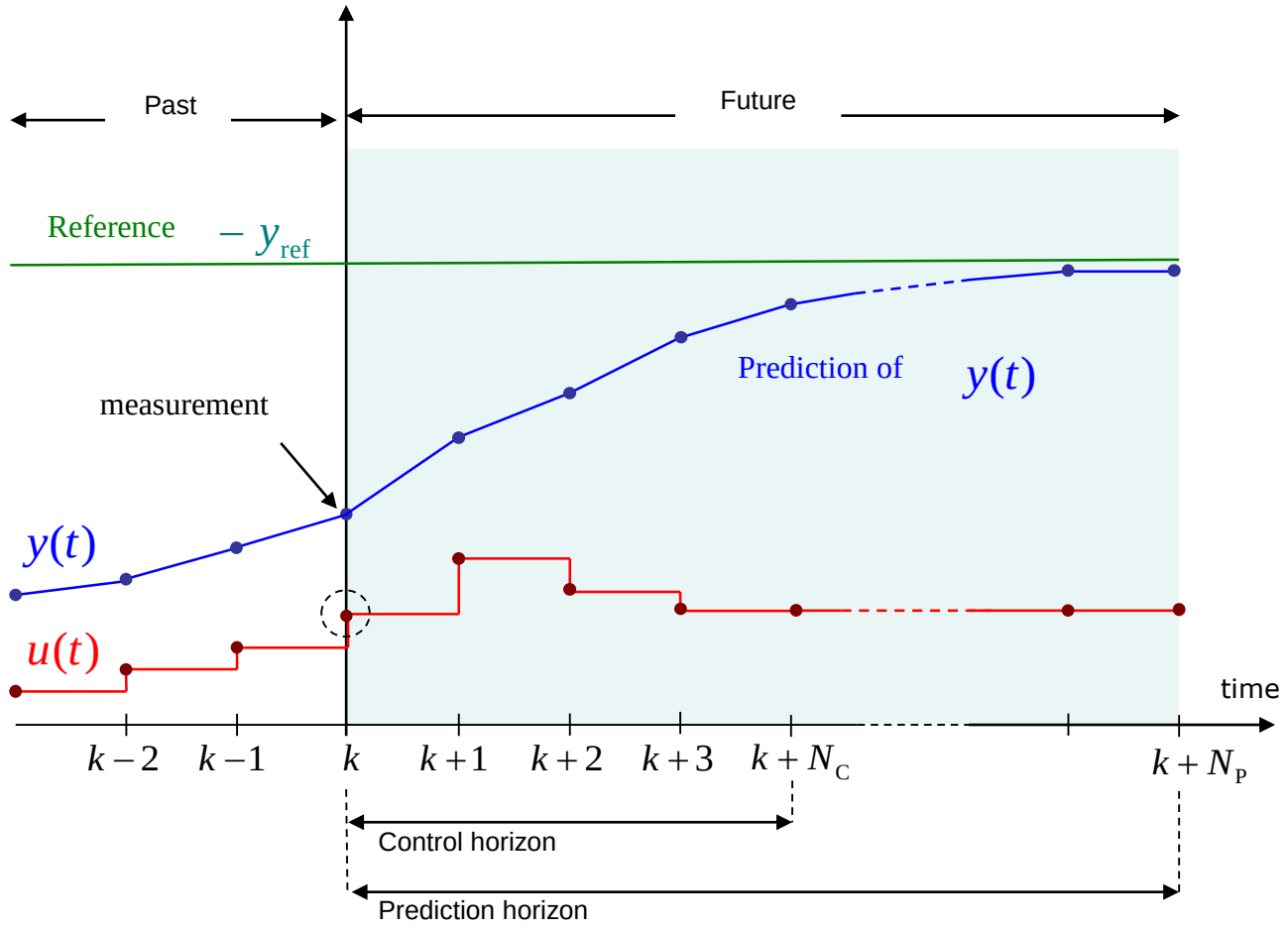
Mathematical model

- Physical modelling
  - ODEs
  - PDEs + discretization + Model reduction
- System identification

Model Predictive Control (MPC)

Control method for handling input and state constraints within an optimal control setting.

Principle of predictive control



$$\min_{u(k),\ldots,u(k+N_c-1)} \sum_{i=1}^{N_p} \left(y_{\text{ref}} - y(k+i)\right)^2$$

subject to

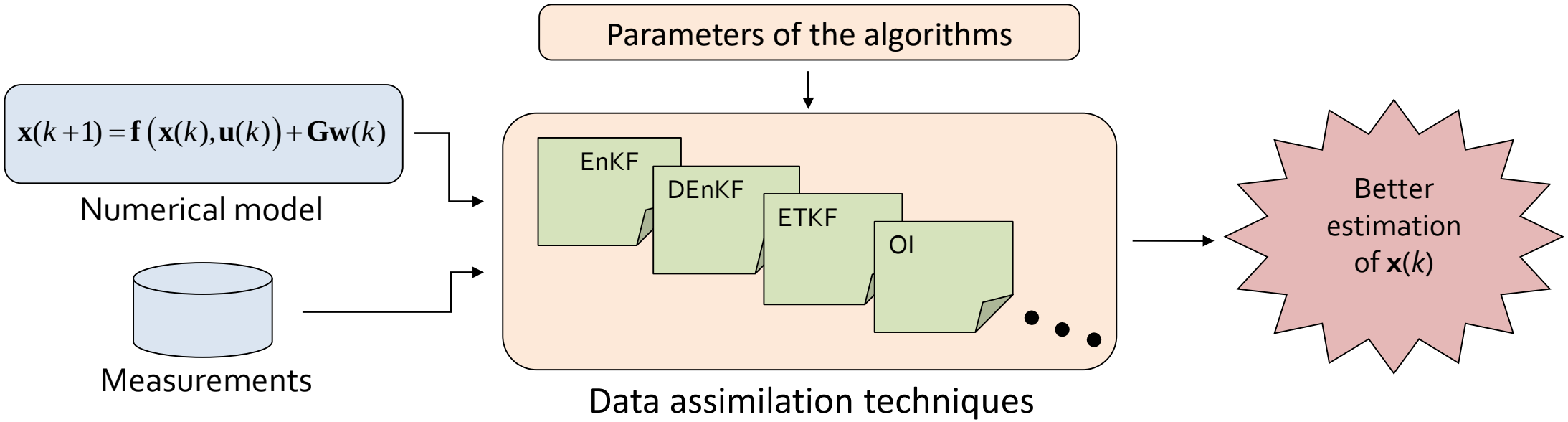
- model of the process
- input constraints
- output / state constraints

Why MPC ?

- It handles multivariable interactions
- It handles input and state constraints
- It can push the plants to their limits of performance.

Data Assimilation

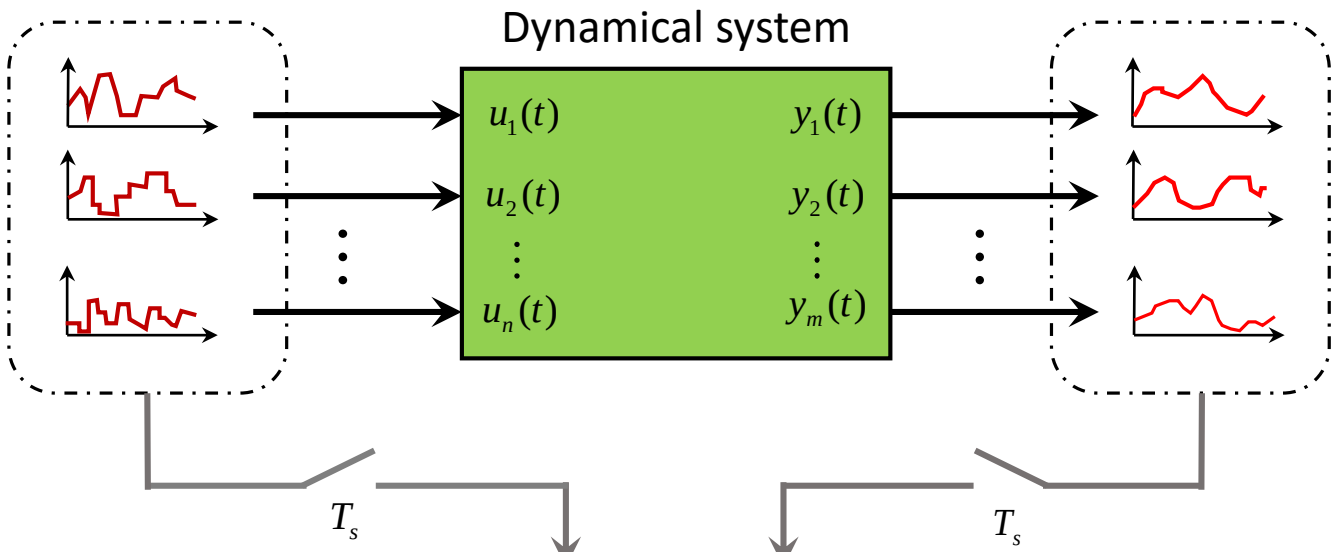
Data assimilation is the common name given to several numerical techniques that combine **the outputs of a numerical model** with **observational data** in order to improve the quality of the model predictions.



Some data assimilation techniques: 3DVAR, 4DVAR, Ensemble Kalman Filter (EnKF) and its variants, Optimal Interpolation (OI), particle filters, etc.

System Identification

It consists of developing models from observed or collected data.



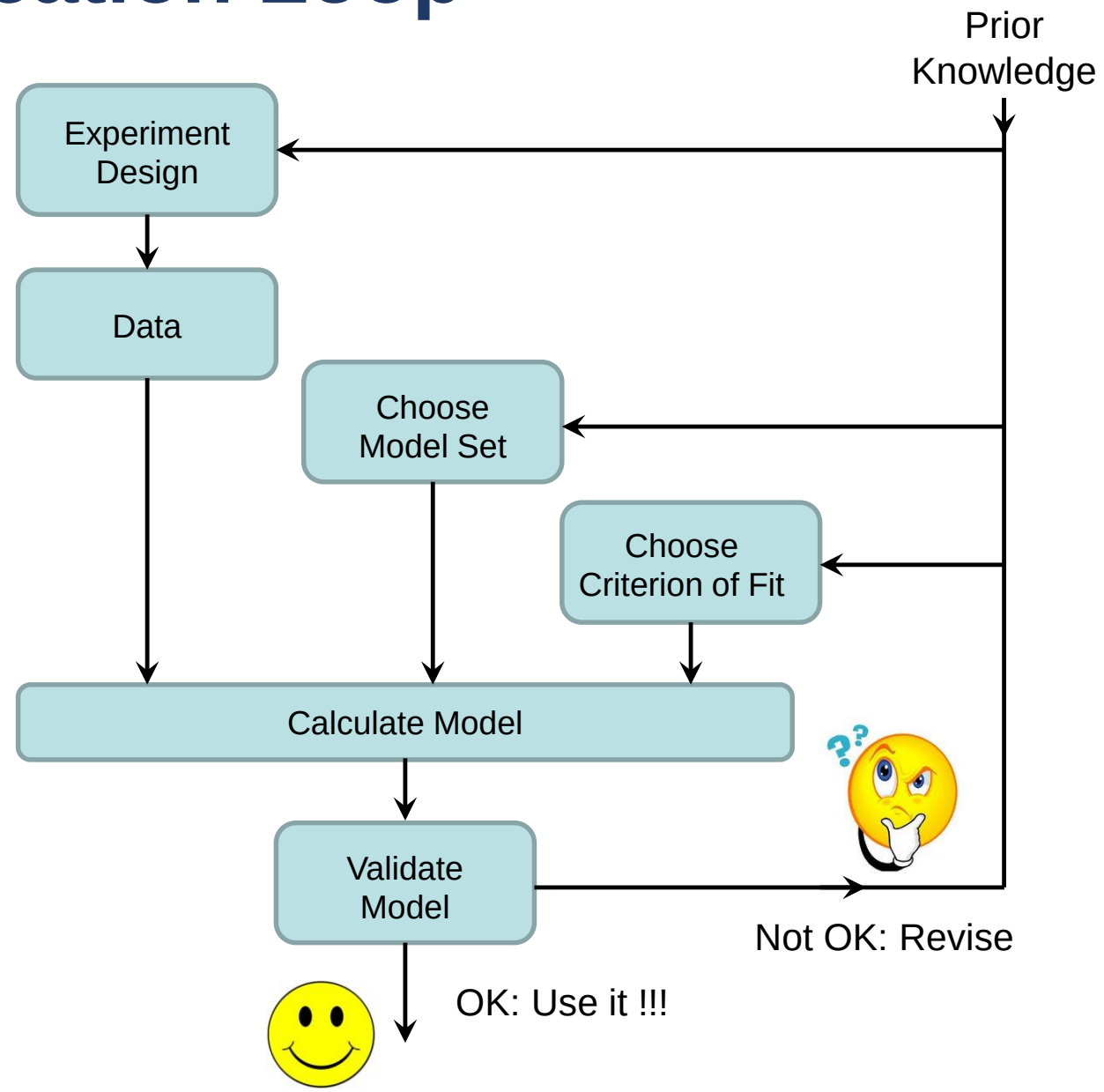
E.g., N4SID (Subspace Method)

For example:

$$\mathbf{y}(t) = \mathbf{f}\left(\mathbf{y}(t-1), \mathbf{y}(t-2), \ldots, \mathbf{u}(t), \mathbf{u}(t-1), \ldots\right)$$

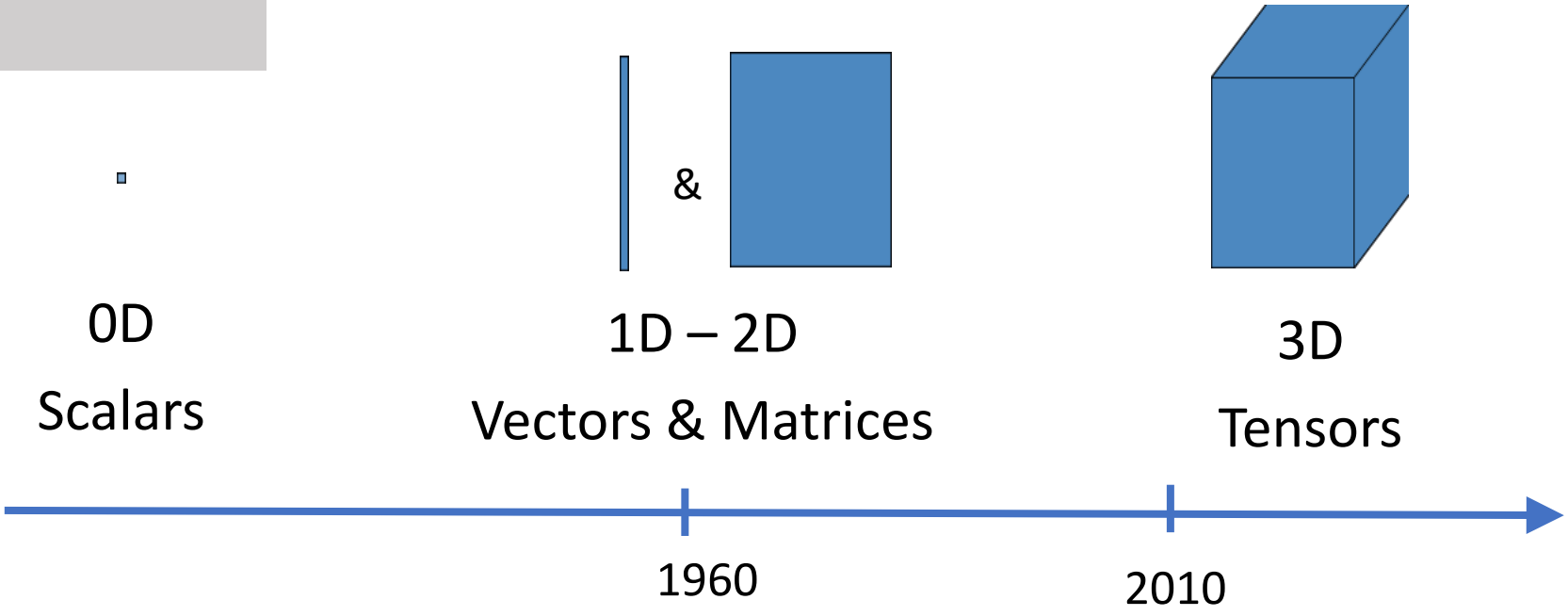
System Identification Loop

"System Identification is an Iterative procedure"

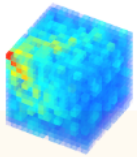


From Matrices To Tensors

Tensors are generalizations of Matrices



- Exciting new possibilities in tensor framework
- Shift of paradigm



Tensorlab

A MATLAB package for tensor computations.

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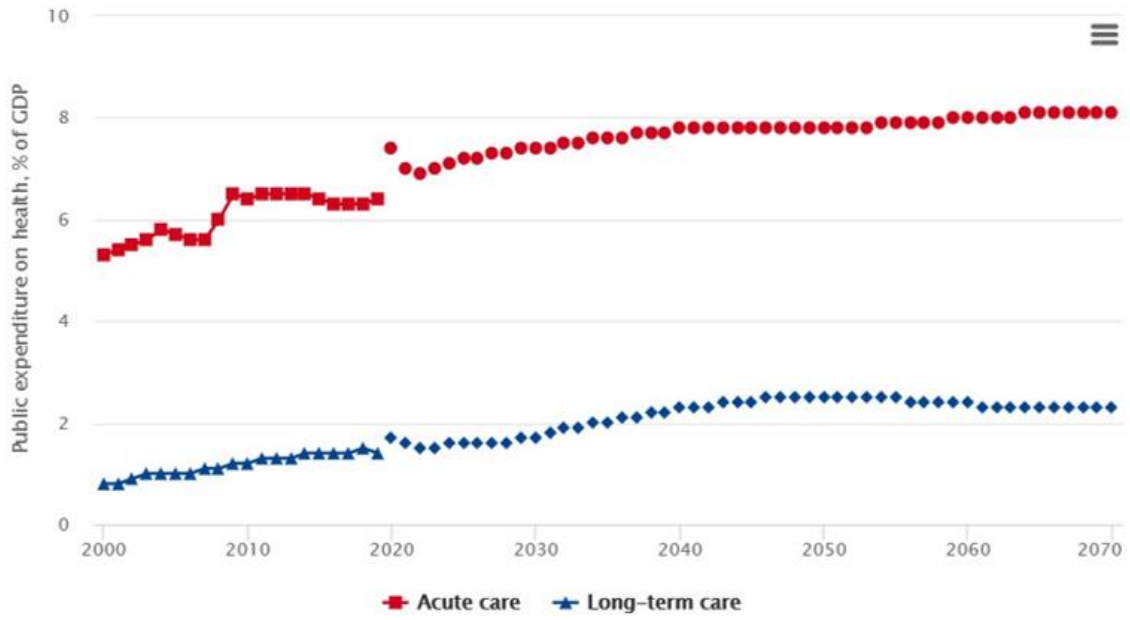
Detection of wasteful expenditure in health care

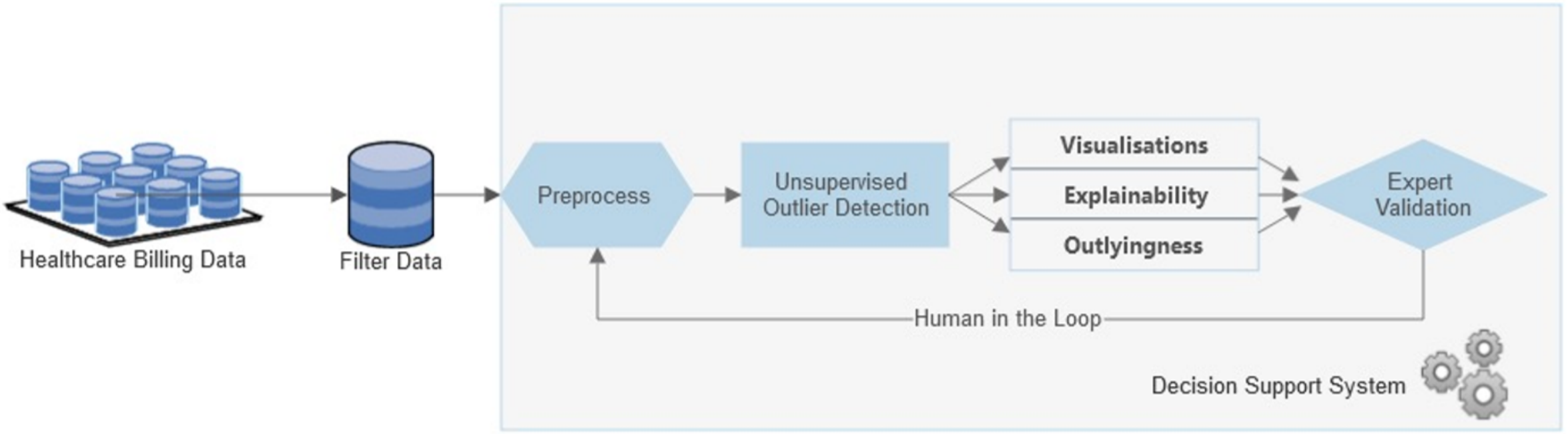


Projected healthcare expenditure in Belgium

The public expenditure on healthcare is on the rise. This rising expenditure poses a real risk to provide compassionate, accessible, and high quality care. Approx. €56 billion are lost annually due to fraud in healthcare in Europe.

Types of waste in healthcare

Detection of wasteful expenditure in health care



In an ongoing collaboration with CM, the largest healthcare provider in Belgium, we are creating **unsupervised outlier detection methods** to detect fraud or waste in healthcare using large scale data (>400 million records/yr).

Length of Hospital Stay Prediction

Early and dynamic predictions of inpatient length of stay (LoS) can help maintain optimal patient flow, reduce wait times, improve working conditions for medical professionals while improving patient outcomes.

Methods

1. Imputation: by forward filling and augmenting the input matrix with $\tilde{X}$ s.t, Inputs $(\hat{X}) = \text{concat}(X; \tilde{X})$, $|X| = |\tilde{X}| = \frac{m}{2}$

with, $\tilde{X} = \begin{cases} 0, if\ X\ is\ recorded \\ 1, if\ X\ is\ imputed \end{cases}$ [5]

2. Transfer learning – OUR PROCEDURE:

- Given the source domain with m= 33
- Train LSTM model on source domain S,
- If $\hat{X}_T \equiv \hat{X}_S$,

  Full Transfer of weights :

  Set $w_{hS} := w_{hT}$

  OR

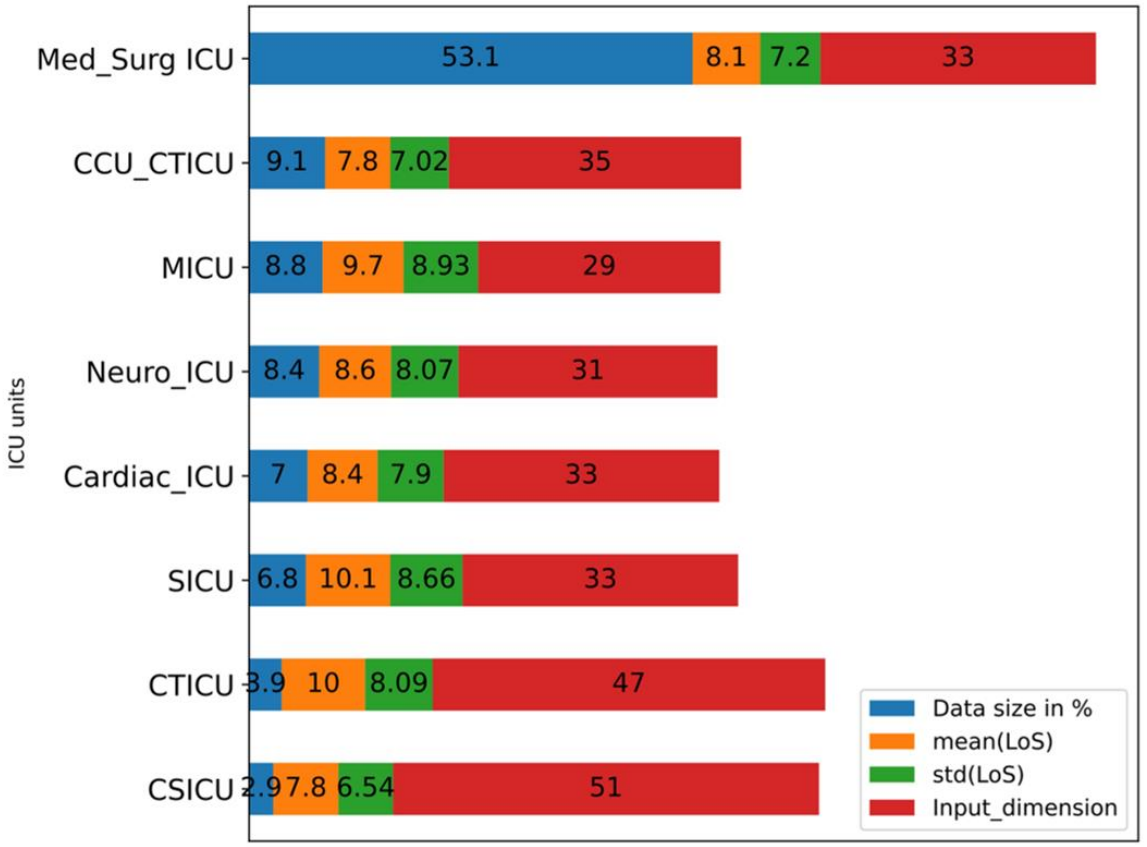
  Full transfer of model structure: transfer of weights and optimizer state.

- Else if $\hat{X}_T \neq \hat{X}_S$,

  Partial weights transfer:

  Set $w_{hS} := w_{hT}\ for\ \hat{X}_T \cap \hat{X}_S$ and

  $w_{hS} := random\ weights\ for \hat{X}_T \setminus \hat{X}_S$



Source (S-Medical Surgical ICU)) and Target domains (T-all 7 others) with their specificities. Some T have very few patients.

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Length of Hospital Stay Prediction

We have developed an efficient LoS prediction algorithm that can be deployed within the hospitals at low-cost, and accounts for different patient specific characteristics.

Our method can providing error measures for the predictions dynamically during an inpatient stay, allowing updating the predictions for better hospital management.

The model uses transfer learning techniques, resulting in faster convergence and on average more accurate predictions.

Figure 5: Distribution of the number of epochs without and with transfer learning on Seven target domains

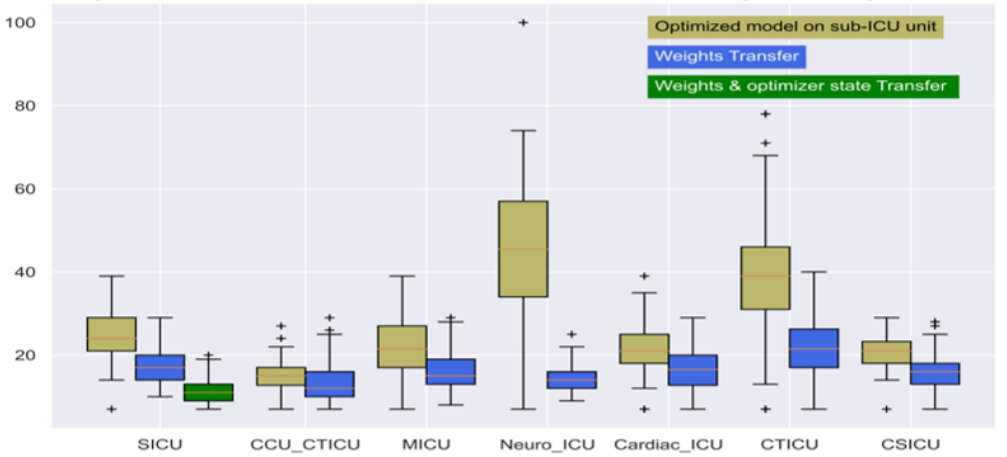
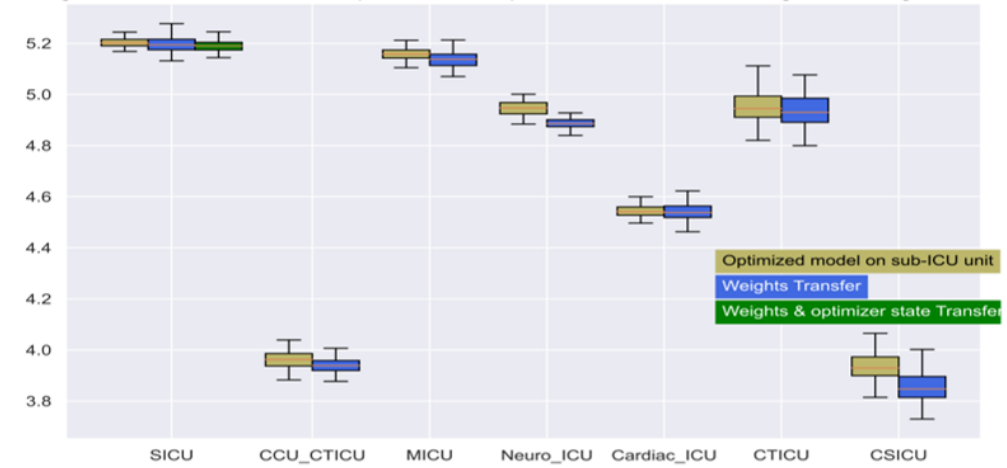


Figure 6: Distribution of the Test MAE (outliers not shown) without and with transfer learning on Seven target domains



Secure and privacy preserving data handling

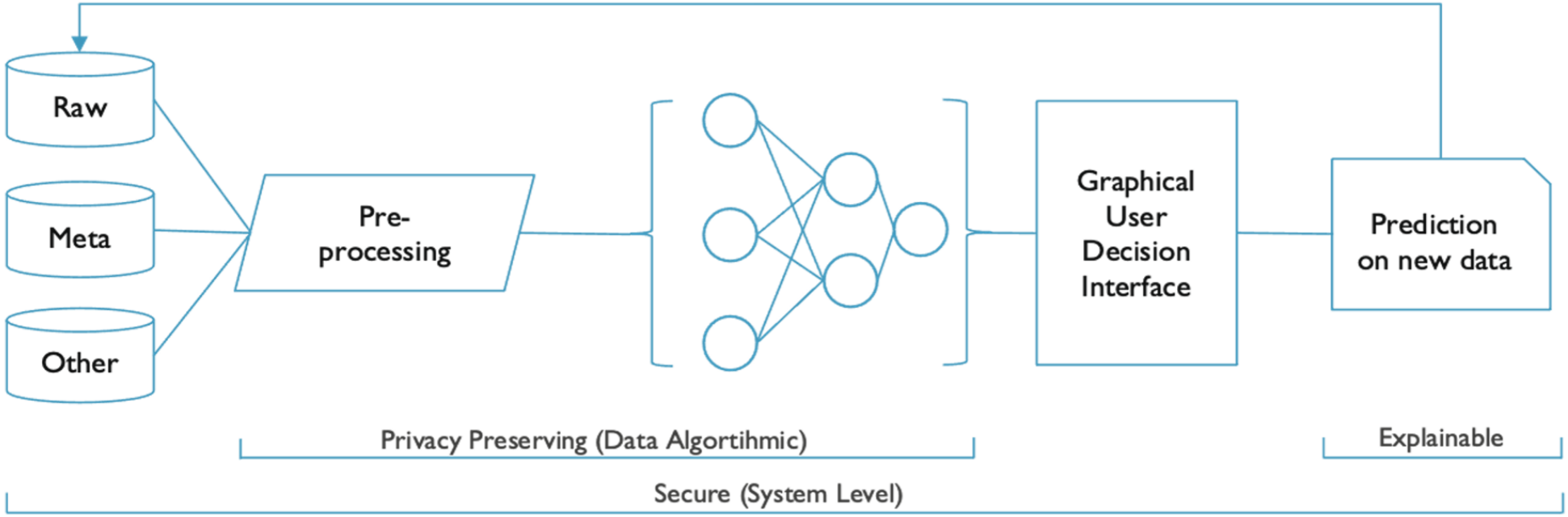
Secure AI by Design

An ever increasing need and (legal) requirement for **security and privacy** guarantees for AI applications dealing with **privacy sensitive information** as a driver for security and privacy preserving ML research.

Securing the **AI-driven decision pipeline** with security considerations borrowed from Cyber Security at the system level

Privacy Preservation at the data-algorithmic level whilst maintaining interpretability and exploring novel setups and models for federated learning

Facilitating **multi-institutional learning** with decentralized data silo's and obtaining on par performance with novel or unexplored techniques **compared to centralized learning** on aggregated data



Secure and privacy preserving data handling

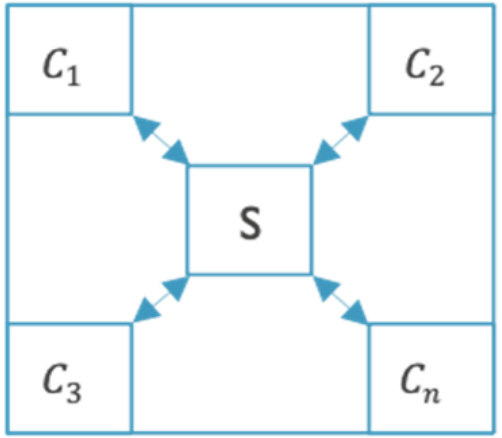
Data Algorithmic

Protecting proprietary information and preserving privacy

Hub – Spokes (multi-insitutional) Federated Learning

Differential Privacy: Privacy-Utility benchmarks

Computations on encrypted data and benchmarking algorithms within FL



Robustness against adversarial attacks

1. Gradient based membership inference
2. Model reconstruction, …

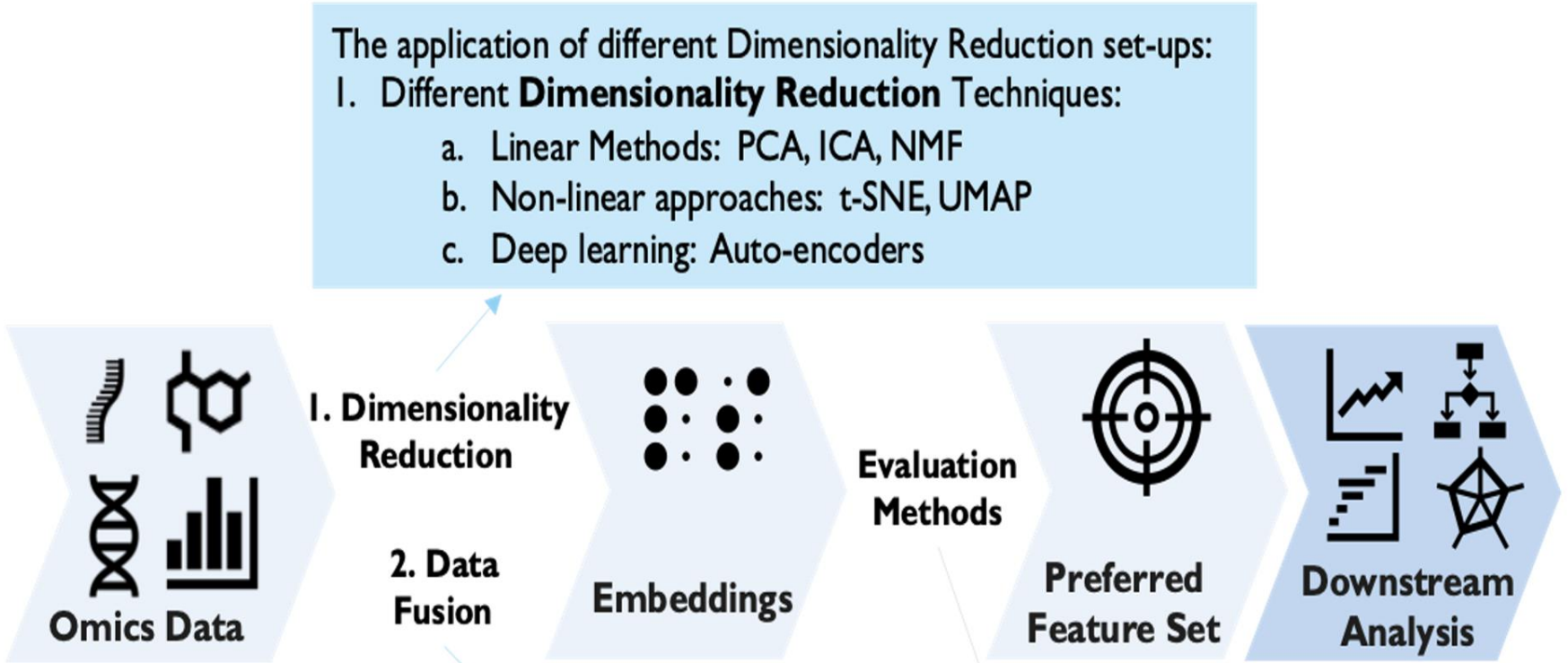
System Level

Securing the DSS building blocks end-to-end

Identifying and securing the **building blocks** of the decision support systems

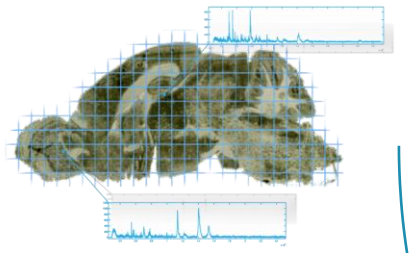
Developing the concept of **Security by Design for AI** driven decision pipelines

Benchmark dimensionality reduction for multi-omics data

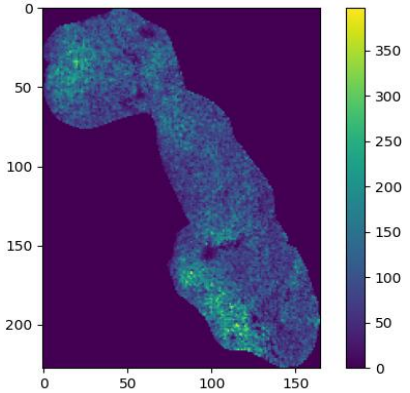


Mass spectrometry imaging data analysis using topological data analysis techniques

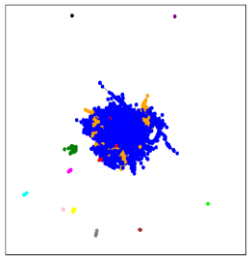
MSI



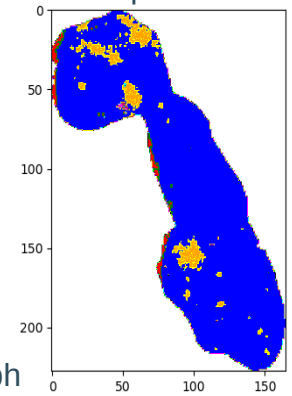
Mouse pancreatic tissue



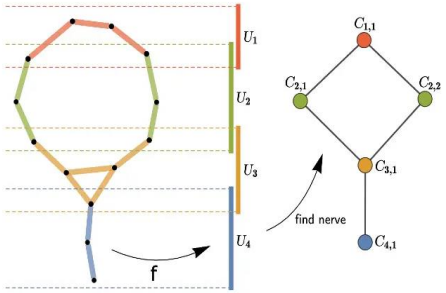
Mapper graph



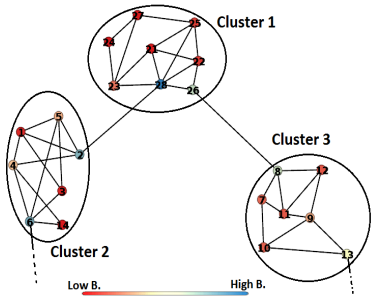
Connected components



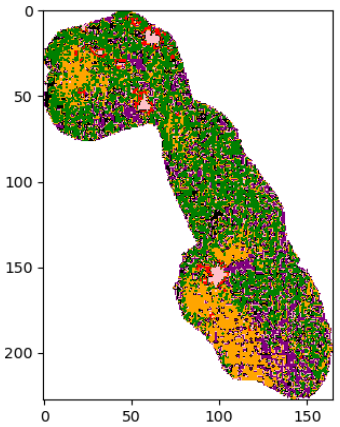
Construct Mapper graph



Spectral clustering



Final clustering



- Mapper creates a low dimensional representation of high dimensional input data
- Spectral clustering is used to cluster the connected components of the Mapper graph
- Resulting clusters represent separate tissue types

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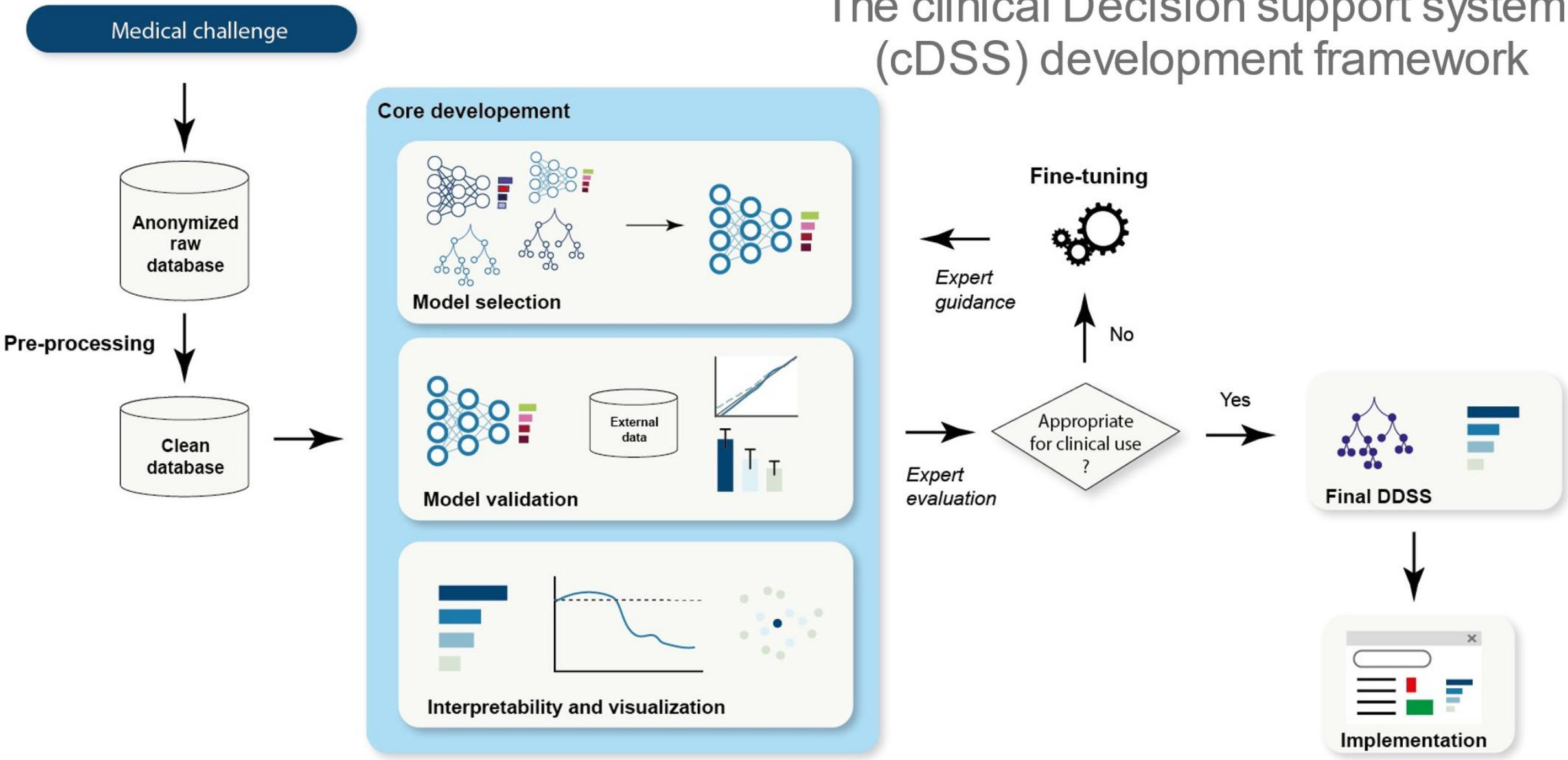
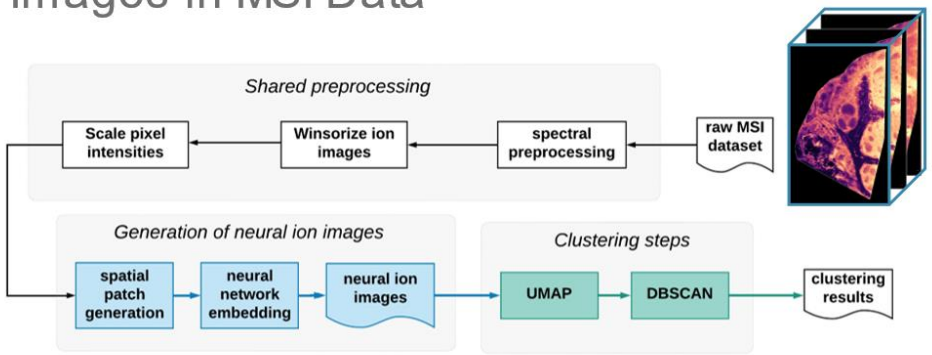
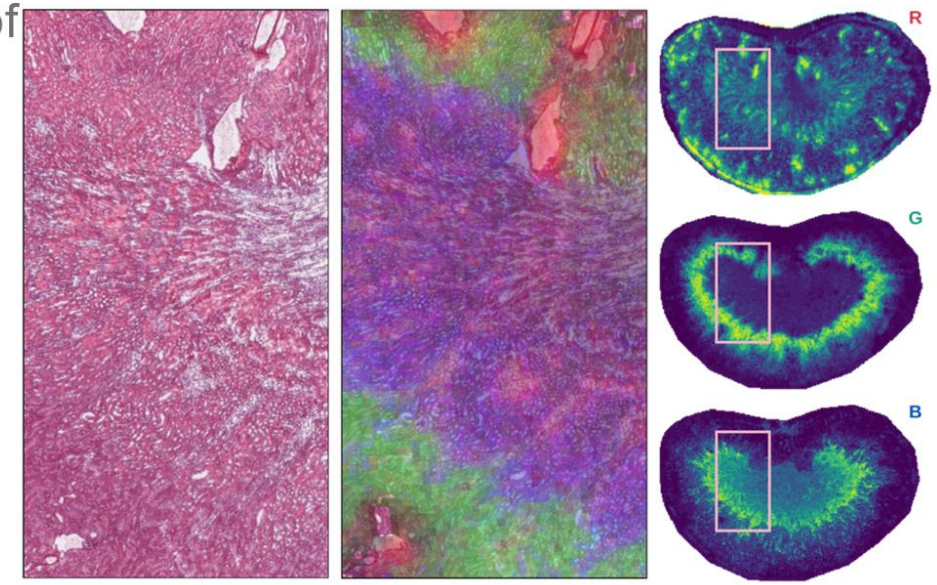
The clinical Decision support system (cDSS) development framework



cDSS for enhanced interpretation of Mass Spectrometry Imaging data using Deep Learning

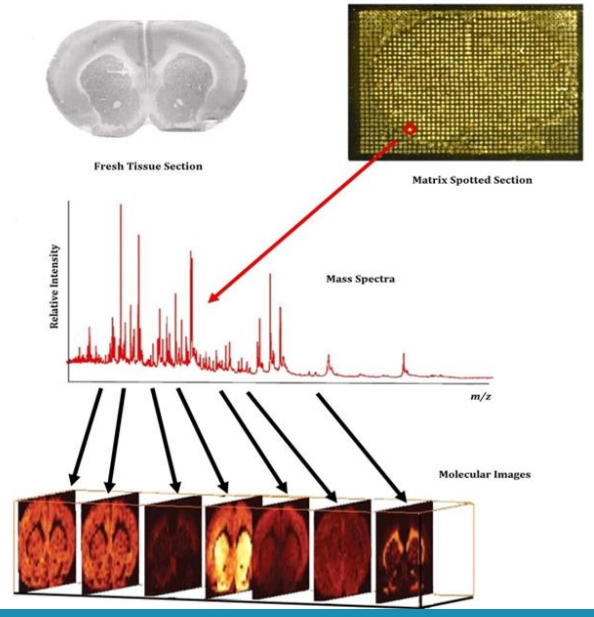
Deep Learning Enables Spatially-aware Clustering of Ion Images in MSI Data

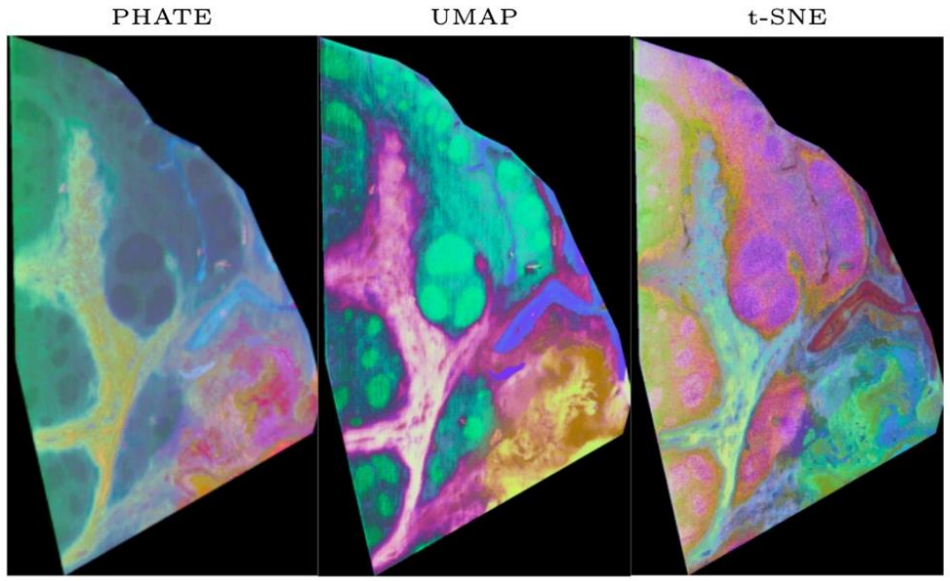




Neuron ion images using pre-trained neural networks enabled direct incorporation of spatial expression patterns, improving clustering of similar ion images, making them readily available as inputs for any downstream machine learning pipeline

Mass Spectrometry Imaging Data Analysis Using Unsupervised Machine Learning

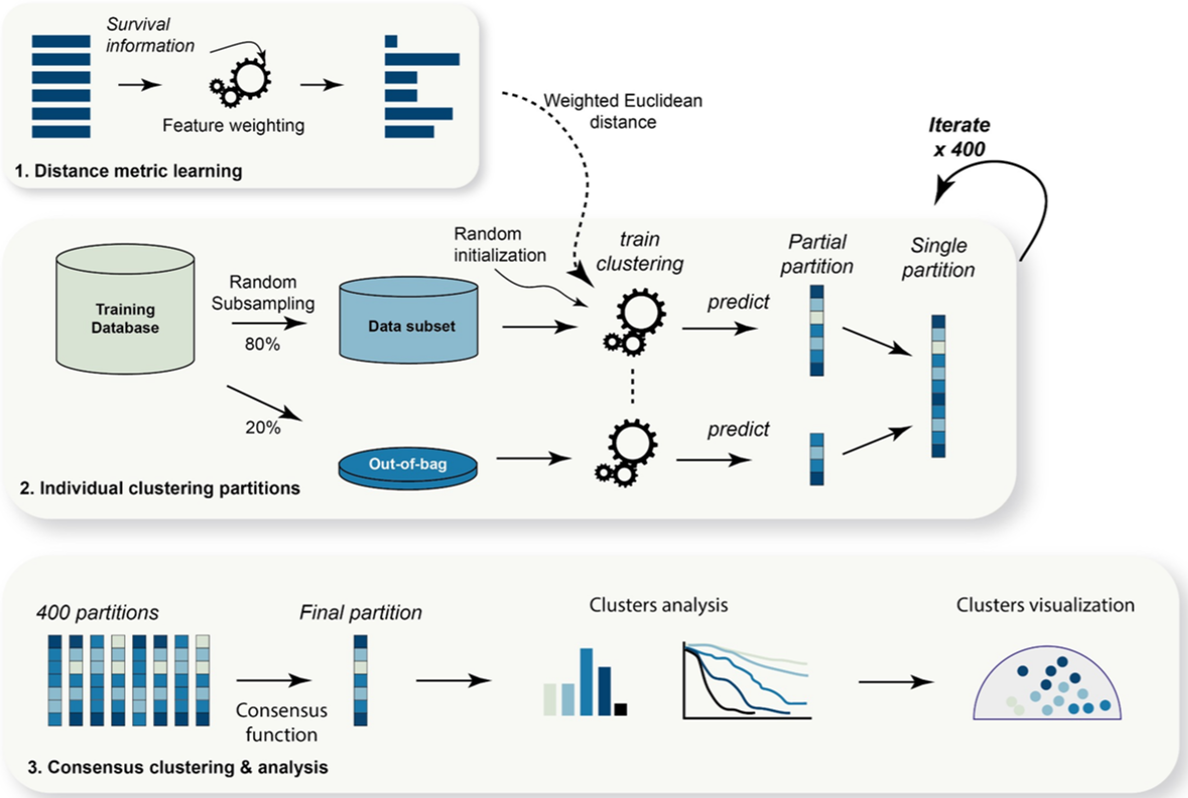




UMAP, with it's very memory efficient GPU implementation, outperforms the other methods in computational time, and gives the most intuitive visualisations on our datasets available.

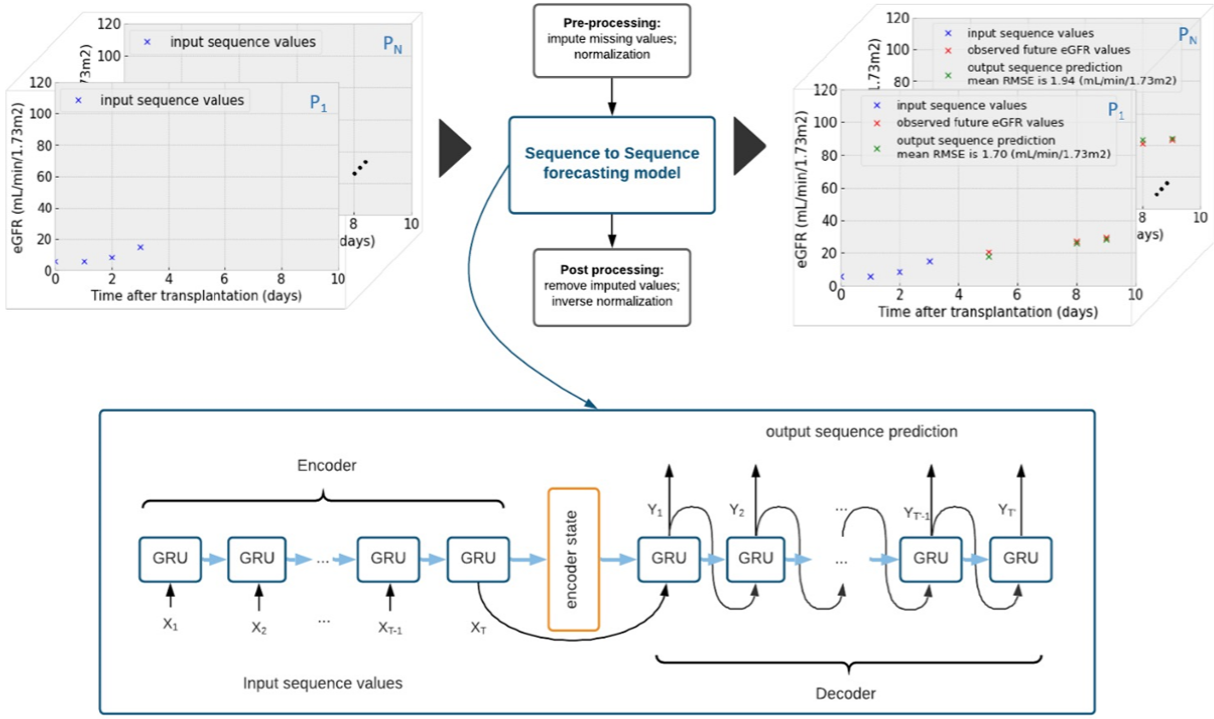
A cDSS for kidney transplant function evaluation

Reclassification of kidney transplant biopsies

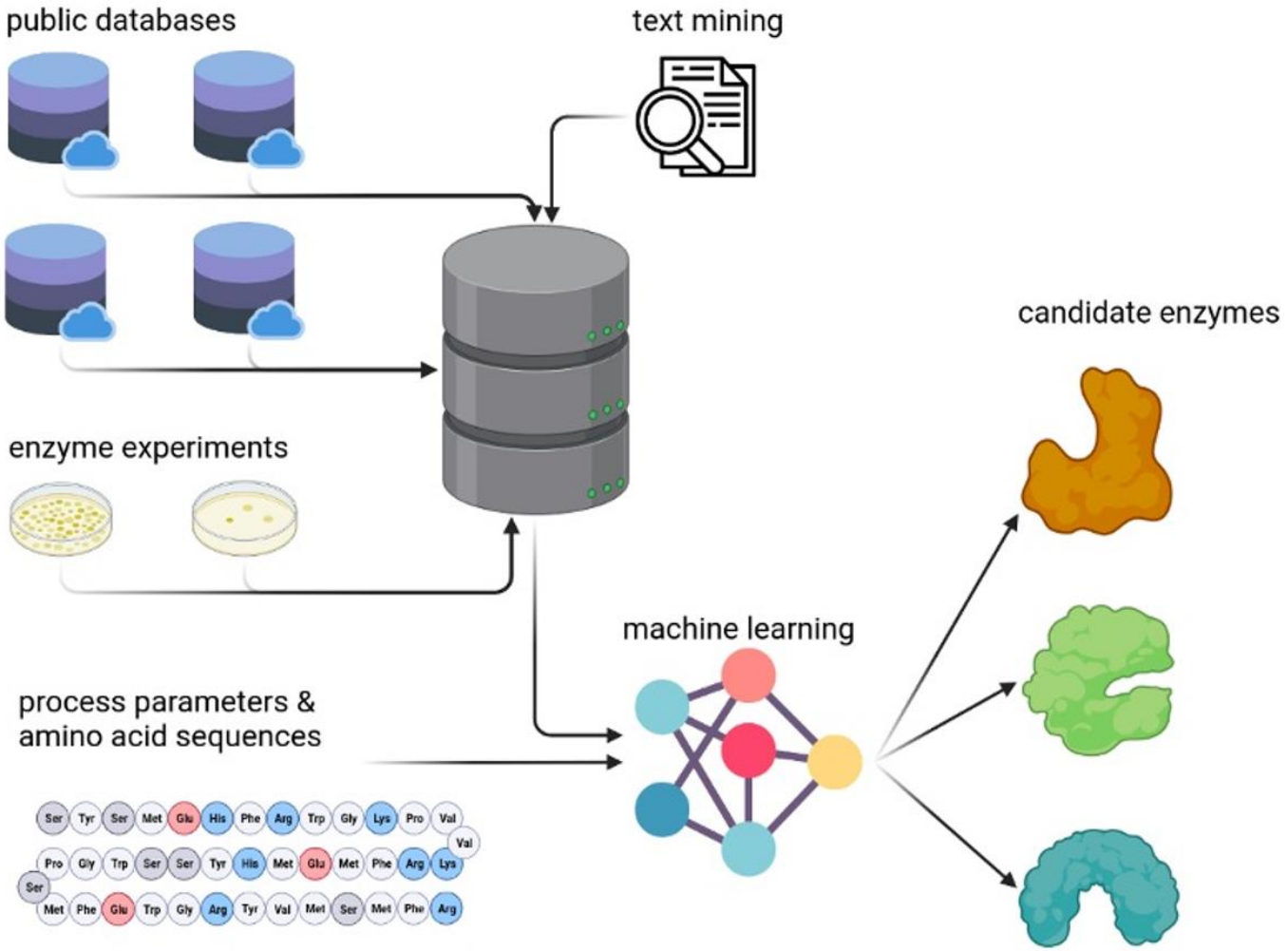


Six novel clinically meaningful phenotypes discovered, Each of them significantly associates with graft failure and overcomes the current limitations of intermediate and mixed Banff phenotypes.
Intuitive visualization tool to assess the rejection phenotype + severity (figure)

Patient-specific kidney transplant function with a sequence-to-sequence deep-learning model



Seq2Seq models accurately predicted future patient-specific eGFR trajectories within the first 3 months after transplantation, outperforming the the conventional ARIMA prediction model with low overall error.



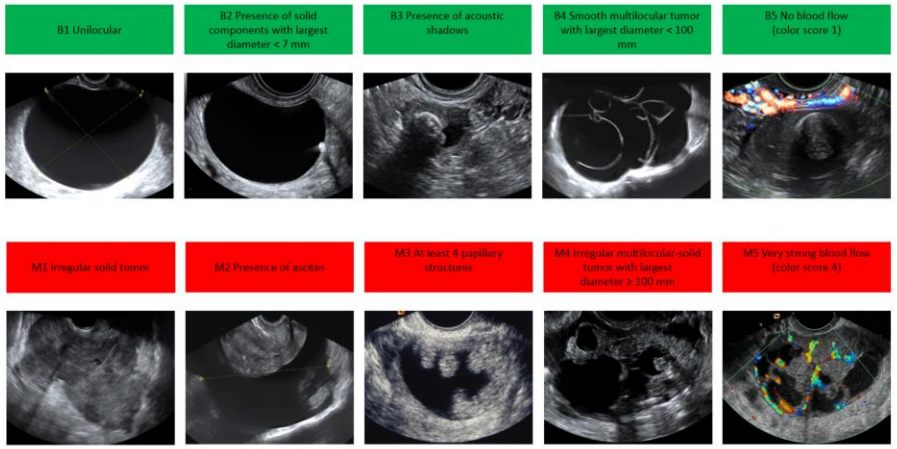
Enzymares Enzyme discovery platform

In this project, we are developing a toolbox for discovering unique enzymes. This enzyme discovery toolbox integrates public databases, text mining and novel AI methods for prediction of enzyme function such as substrate specificity, thermostability and halostability, and to identify candidate mutations for protein engineering

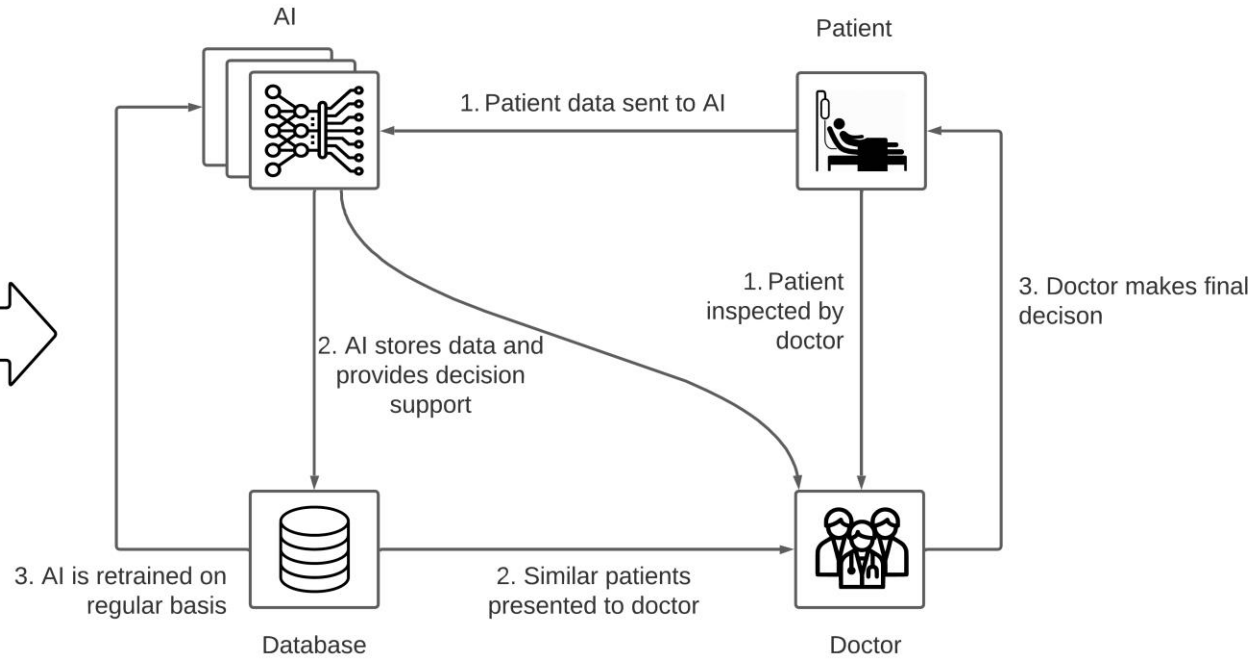
A cDSS for ovarian cancer evaluation using ultrasound

Global objective: To go from a rule-based cDSS to an intelligent cDSS using ML

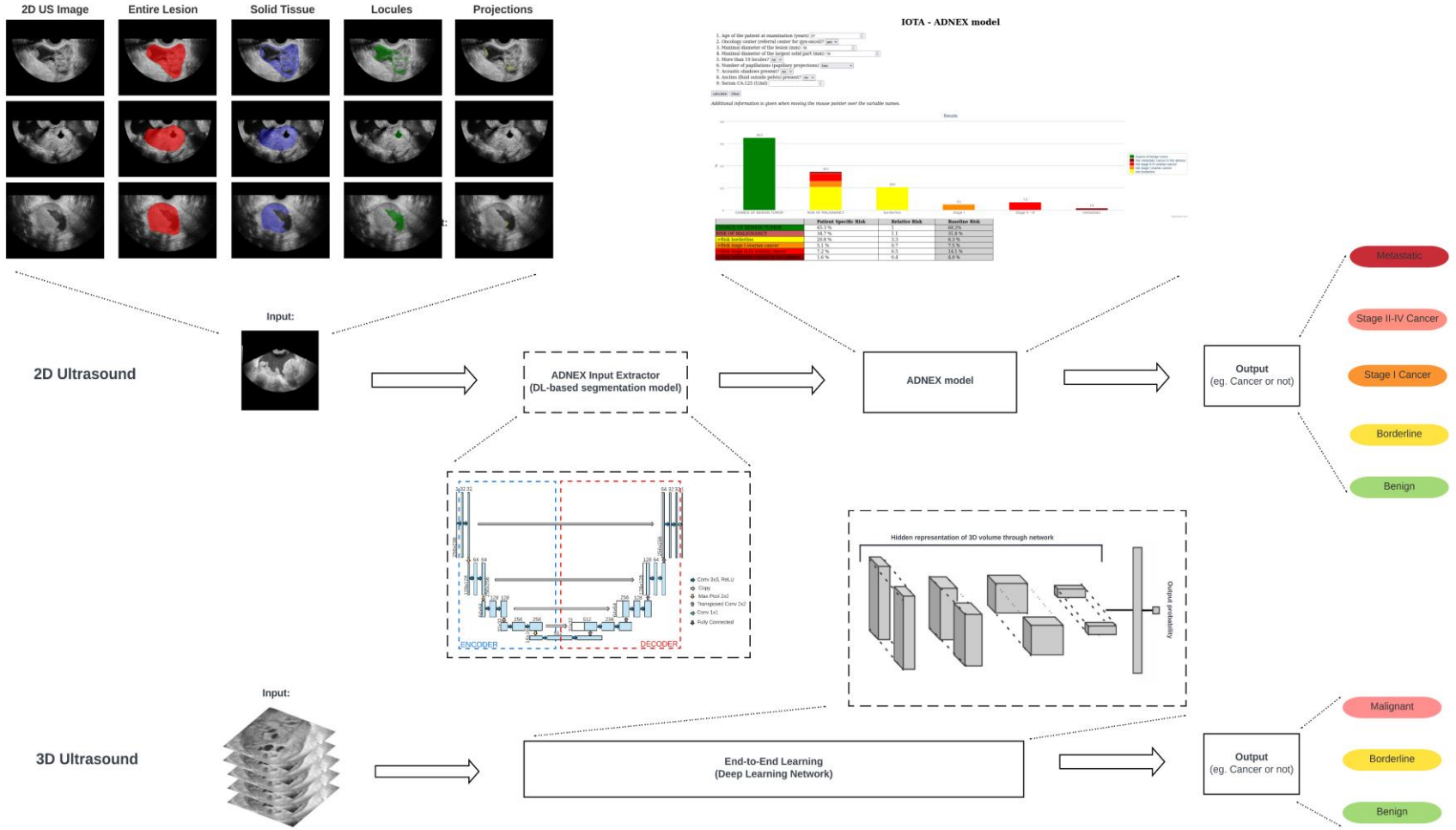
Rule-Based CDSS



Intelligent CDSS

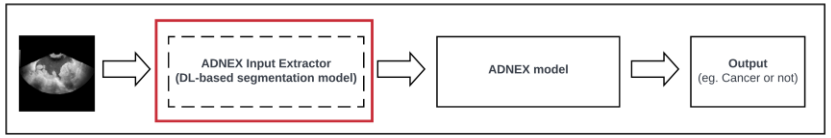


A cDSS for ovarian cancer evaluation using ultrasound

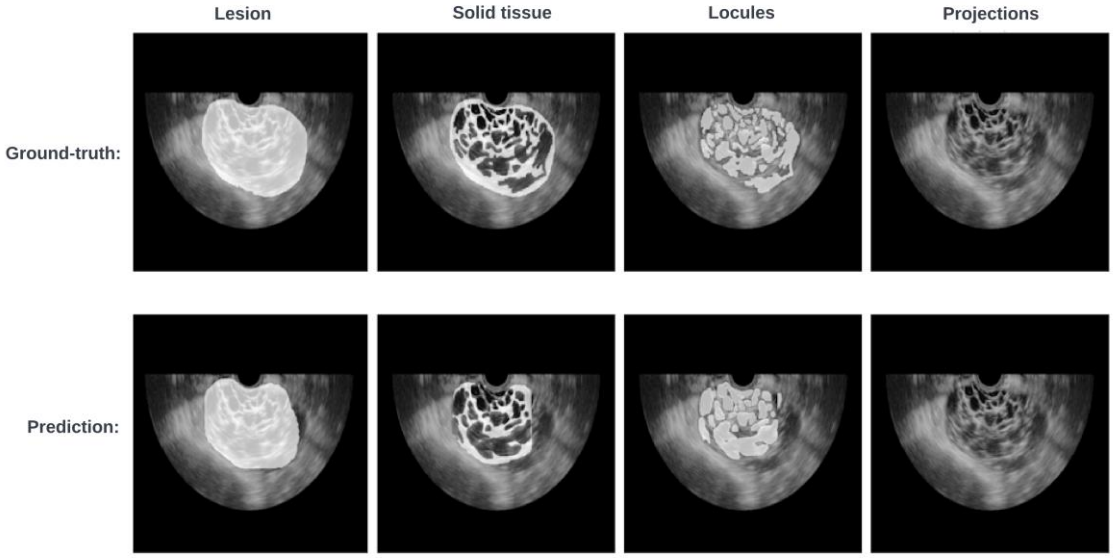


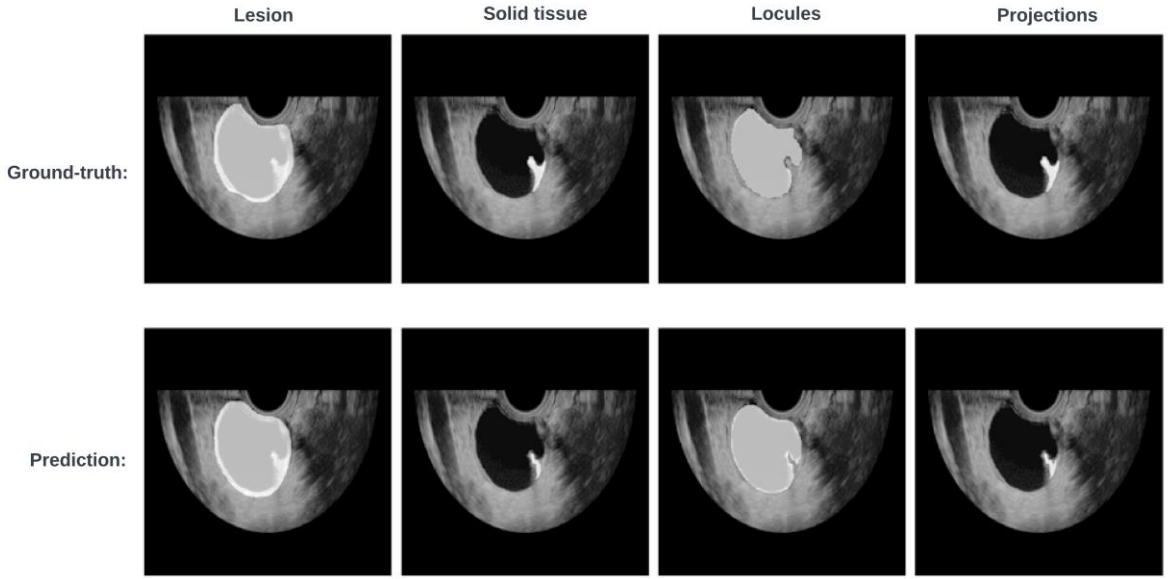
Implementation cDSS: Design of 2 complementary pipelines using both 2D & 3D ultrasound data

A cDSS for ovarian cancer evaluation using ultrasound

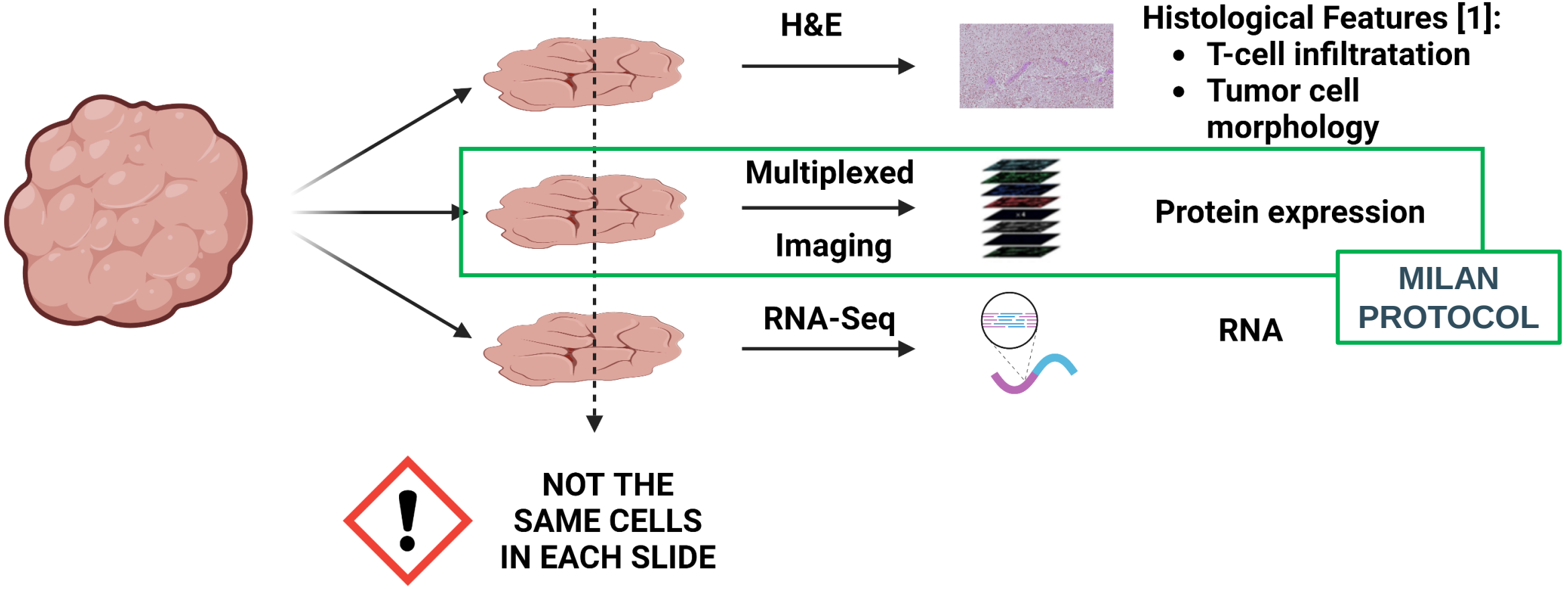


Results 2D ADNEX feature segmentation (2 cases): Comparison Ground-truth & Prediction

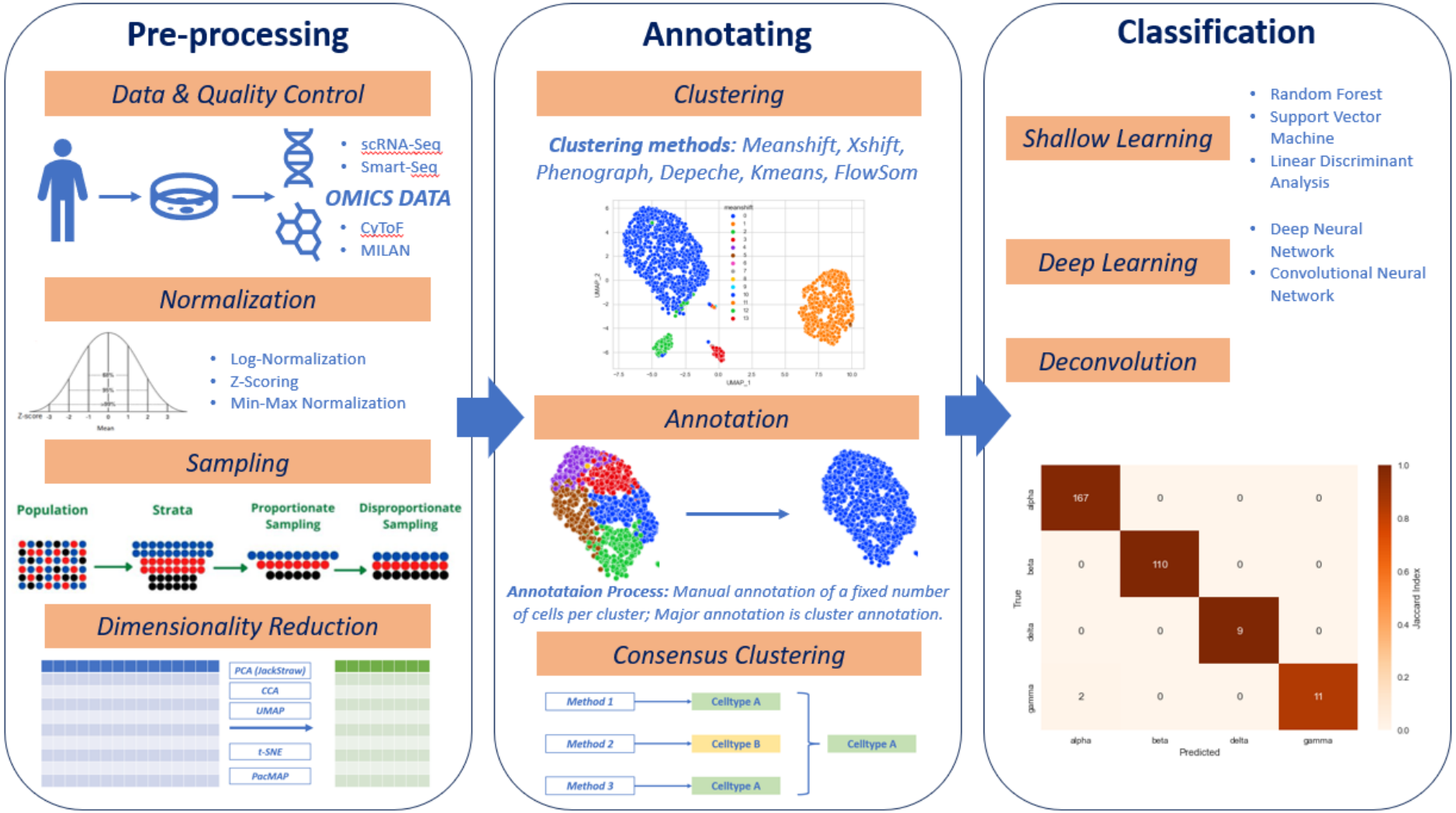




MILAN project: From Tumor to Data



From Data to Information: Annotating



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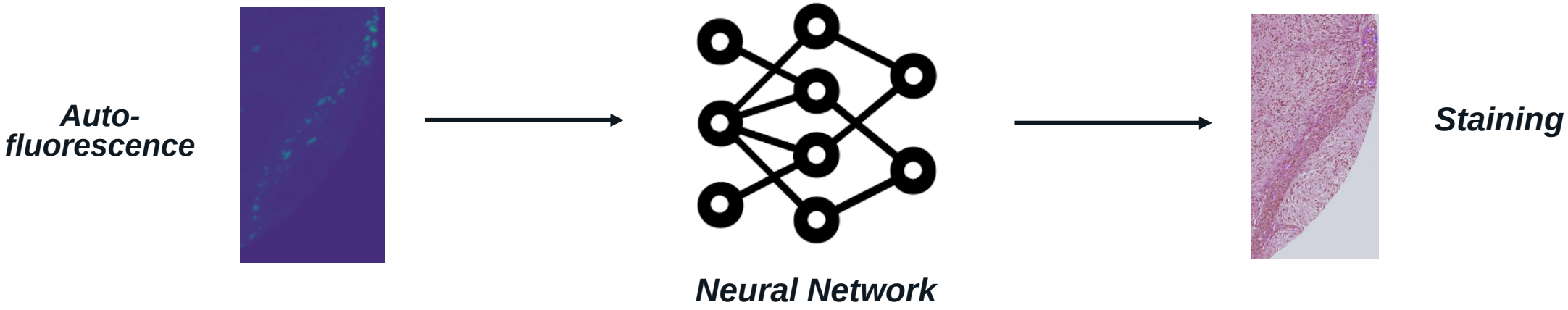
Multiple Analysis: AI to the rescue?

Can artificial intelligence create a stain virtually based on auto-fluorescence so we can apply other analysis on the same tissue slide?

- **Auto-fluorescence (AF):** natural emissions of cells when excited by UV or visible light
- Training a **neural network** transforming AF images into stained image (H&E or MILAN)



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KU LEUVEN LEUVEN.AI

Leuven.AI

The KU Leuven Institute for Artificial Intelligence

Leuven.AI

Prof. Luc De Raedt

Director

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Dr. Jens Bürger

Coordinator

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What is AI?

Data Science

Autonomous driving

Facial recognition

Chatbots

Recommendations

Robotics

Decision-making

Health applications

Fraud detection

Learning analytics

And many more…

Nobel prize winner Herbert Simon:

"Machines that exhibit behaviors that would be regarded intelligent if they were exhibited by human beings."

Many questions concerning AI (AI is interdisciplinary):

- What is regarded as intelligent behaviour?
- How can we make such machines?
  - for general AI?
  - for specific applications?
- What are the limitations?
- What are the implications for our society?
- Should we make such machines?

AI at KU Leuven

Advanced Master in Artificial Intelligence

- Since 1988
- 300+ students annually

Research excellence in all areas of AI

- 13 active ERC grants
- 800+ publications in 2020

Vibrant student and research community

- 100 professors
- 100s of PhD Students
- 500 Master Students in AI

But together, we could do more and be more united !

The idea for a KU Leuven Institute for AI was born in 2018 and on January 1, 2020 we officially started.

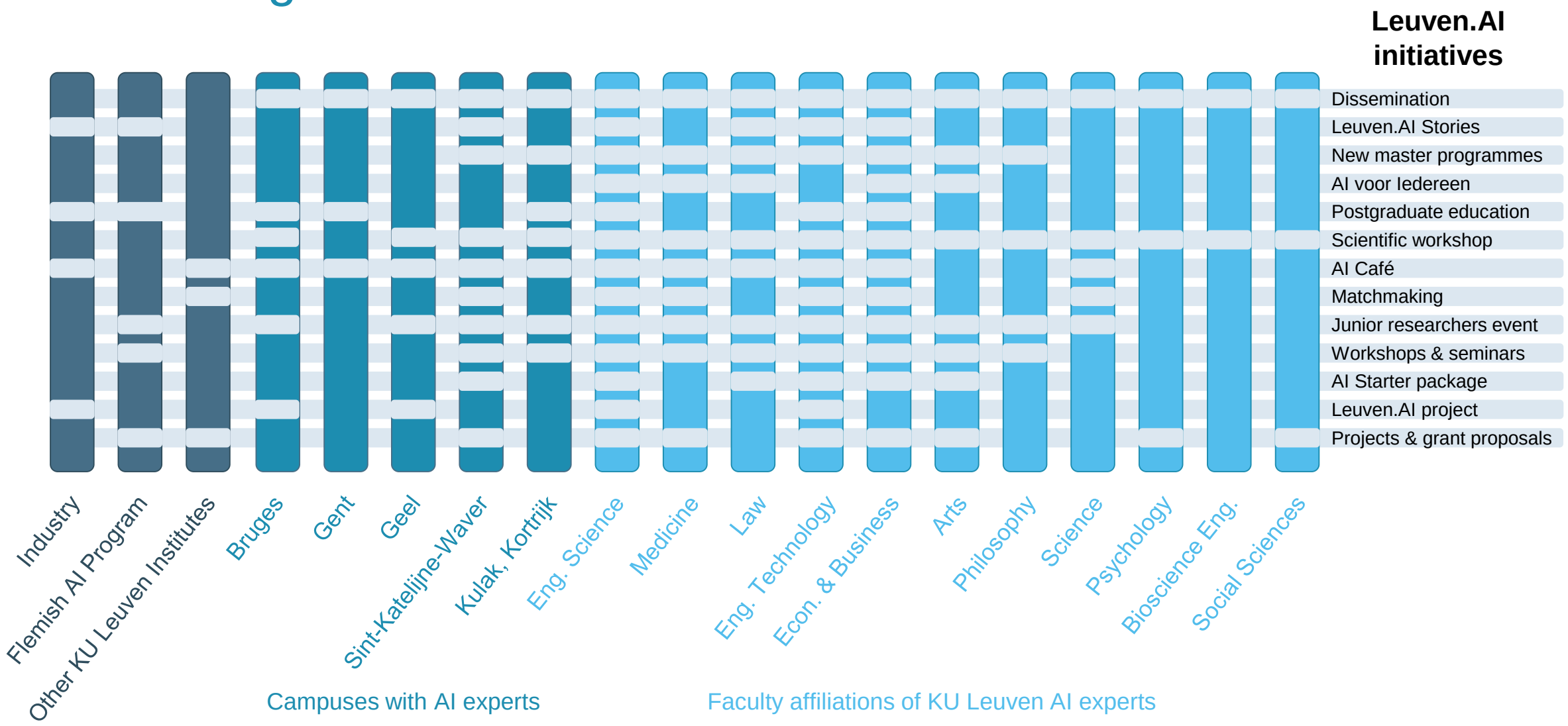
"For the University, the Leuven Institutes are a way to highlight certain focal points in research – a strategic instrument, in other words."

-- Rector Luc Sels

Mission of Leuven.AI

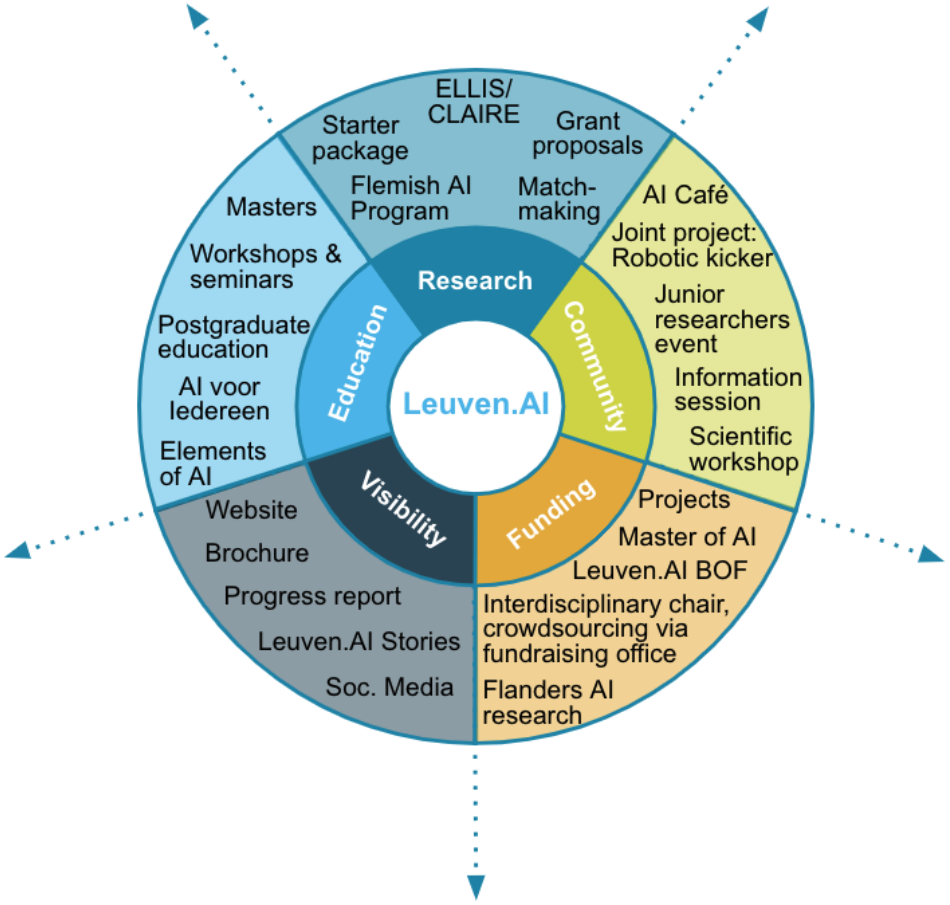
- **Unite AI** and its renowned **AI experts at KU Leuven** in an interdisciplinary institute.
- **Foster AI education** by offering courses and contributing to education programmes.
- **Foster AI research** by providing a forum for exchanging ideas and for initiating projects and collaborations on AI.
- **Offer expertise on all aspects of AI**, including on the possibilities and limitations of AI and its implications from an ethical, legal and societal perspective.
- **To promote and represent the Leuven AI community** both internally and to the outside world
- **To obtain sustainable funding** for organising and supporting all this.

Positioning of Leuven.AI



Five pillars of activity

- Research
  - Leuven.AI aims to foster more (interdisciplinary) research collaborations
- Education
  - Leuven.AI supports the coordination and communication of new programmes
- Community
  - Leuven.AI develops opportunities for researchers to meet and expand their networks
- Visibility
  - Leuven.AI creates a unified representation for AI @ KU Leuven
- Funding
  - Leuven.AI supports funding applications and explores new routes to finance interdisciplinary research and education



Leuven.AI at a glance

- **100+** senior and **100s** of junior researchers from across **11 faculties and 6 campuses**
- Over **800 publications** in 2021
- **63 PhD defences** with Leuven.AI (co-)promoters during 2021/22
- The advanced **Master of Artificial Intelligence** with **300+** students annually and new, specialised master programmes to be rolled out.
- Overall, **500+** active Master students
- Leuven.AI members are currently holding **12 prestigious ERC grants**.
- Leuven.AI members play a prominent role in the **Flemish AI Action Plan**.
- Leuven.AI members are involved in two important EU initiatives for excellence in AI research: **ELLIS and CLAIRE**
- Leuven.AI members participating in 3 out of 4 **H2020 ICT-48 projects**: ELISE, TAILOR, AI4MEDIA
- Leuven.AI members regularly drive the creation of **spin-off companies**.

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Leuven.AI

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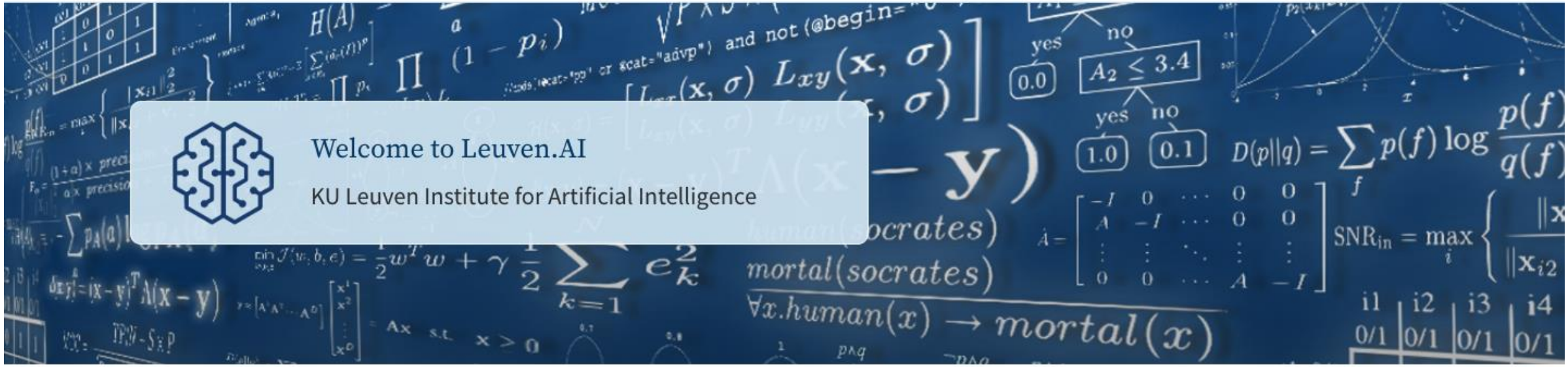


Leuven.AI - KU Leuven Institute for Artificial Intelligence

Leuven.AI is one of the first four "KU Leuven Institutes" bringing together KU Leuven's world-class AI experts from diverse disciplines in an interdisciplinary research network with societal relevance. The articulation of Leuven.AI as an institute is important to all interested in AI at the KU Leuven, as it will result in many new activities and even more interdisciplinary AI research.

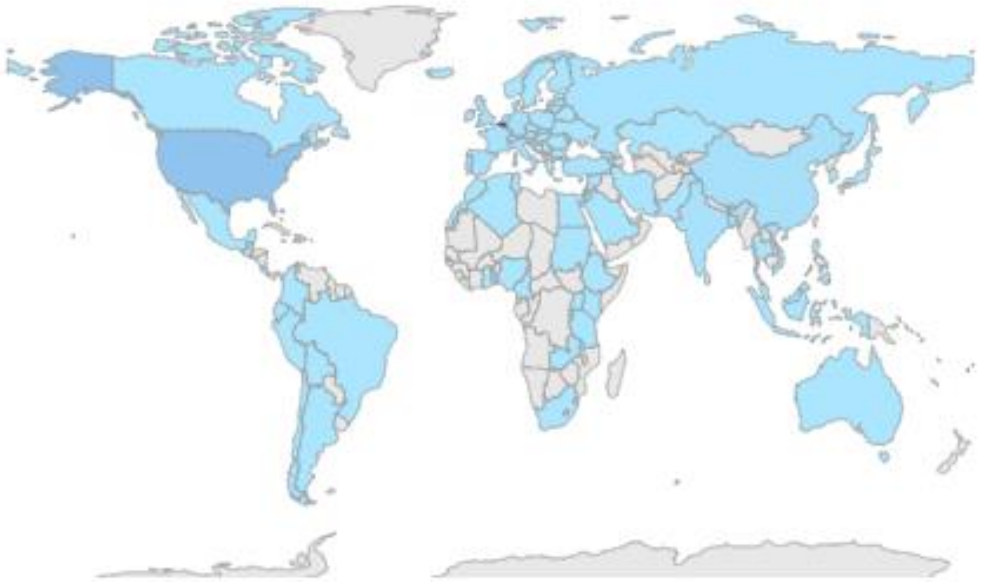
According to Rector Luc Sels

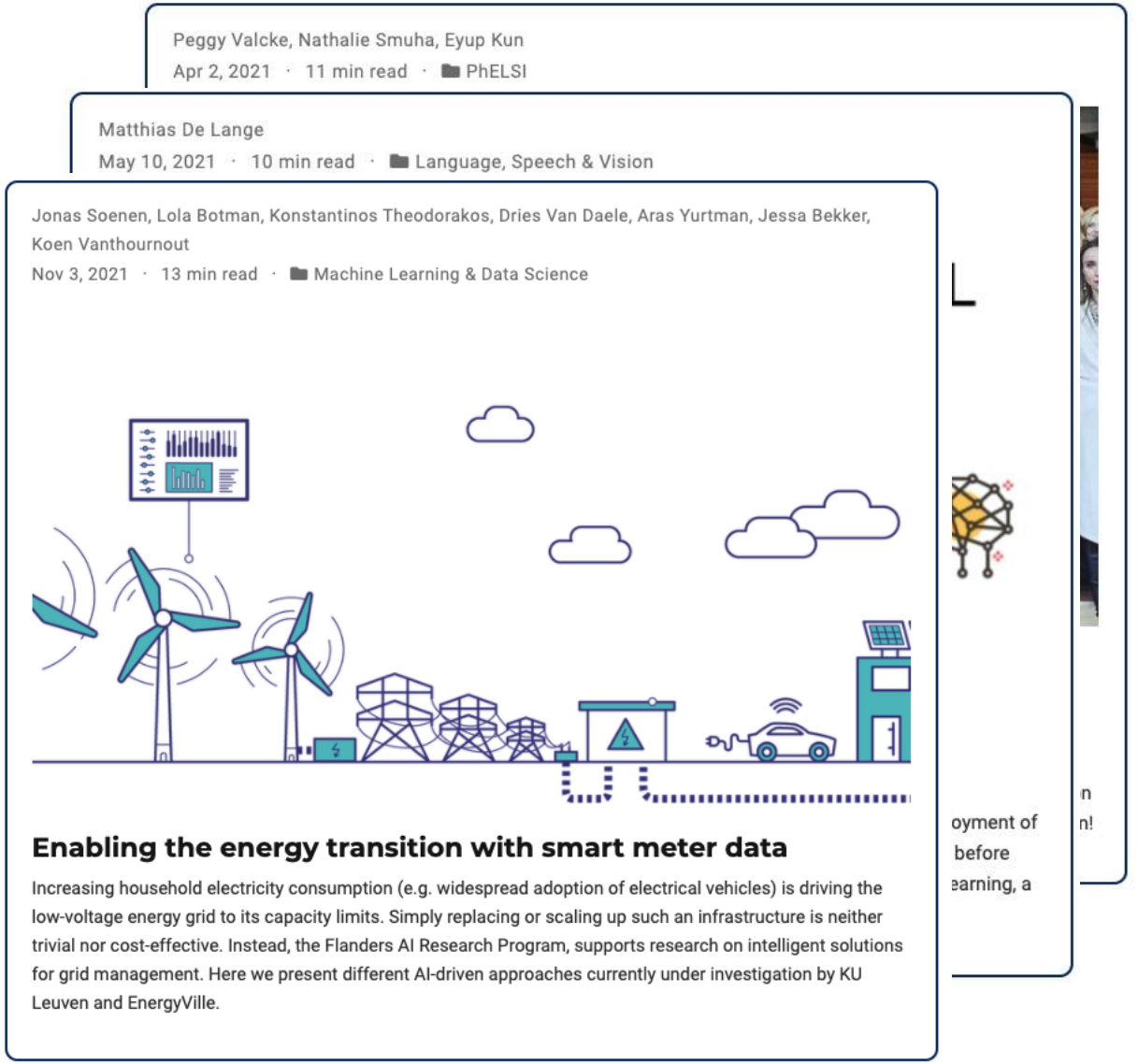
"For the University, the Leuven Institutes are a way to highlight certain focal points in research – a strategic instrument, in other words." (Read full interview here.)

Leuven.AI Stories

Leuven.AI science communication project.

Making AI research results accessible and tangible to more people, from all over the world.





AI Starter Package - Fostering new applications

Education

TAKE THE "ELEMENTS OF AI" MOOC

Elements of AI is an introductory text-based course on AI, that is accessible to all. It was developed by the University of Helsinki and Reaktor in Finland, and has already been followed by over 500.000 people.

The course is structured in 6 modules, walking you through the basics of AI, its different flavours, practical considerations and more. Elements of AI was also made available in Dutch language by Leuven.AI.

DUTCH VERSION | ENGLISH VERSION

Collaboration

IDENTIFYING EXPERTISE

Uniting more than 90 senior researchers, we are active in almost all areas of AI research and education. To foster collaborations, to explore synergies, and to drive applications of AI, we aim to connect Leuven.AI members and KU Leuven researchers based on shared interests and matching expertise.

Regardless if you already are an AI expert or only getting started with AI, we will help you in searching and identifying colleagues with the right AI expertise for your ideas and projects.

CONTACT US

Research

WRITING A PROJECT DESCRIPTION

Reaching out to potential collaborators is best done with a concise description of your project idea, giving a good grasp on all relevant AI-related aspects.

We support KU Leuven researchers in communicating their ideas to Leuven.AI colleagues via the development of 3-page project descriptions, which can be communicated and made accessible to Leuven.AI members.

CONTACT US

Funding

LEUVEN.AI AS PROJECT PARTNER

Besides identifying expertise and helping to inititate collaborations, Leuven.AI can also act directly as a partner for any internal, national or international project.

As such, we can provide specific feedback during project definition or execution, co-organise project events, or disseminate AI-related project outcomes via our networks, among others.

CONTACT US | EXAMPLES

Community

Junior researchers event

Nov 2020

130 participants

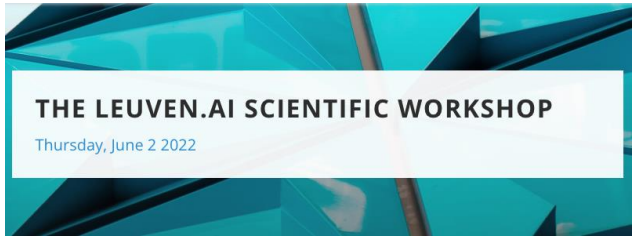
Applications matchmaking event

May 2021

12 video contriutions, 30 participants

Scientific Workshop + General Assembly

Jun 2, 2022



AI Café: Recurring networking events for junior AI researchers

Started in July 2021

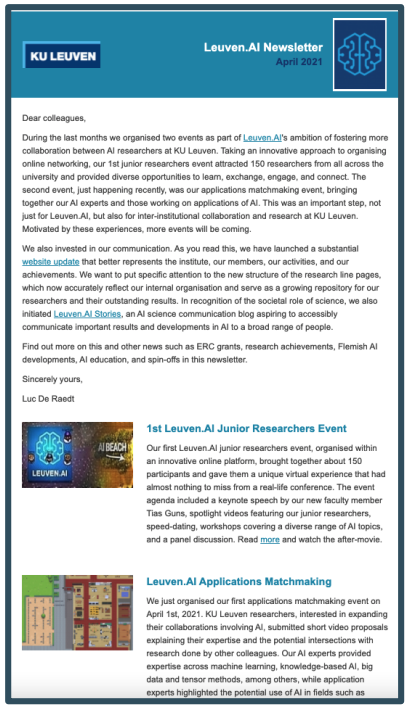
30-60 participants per event

Visibility

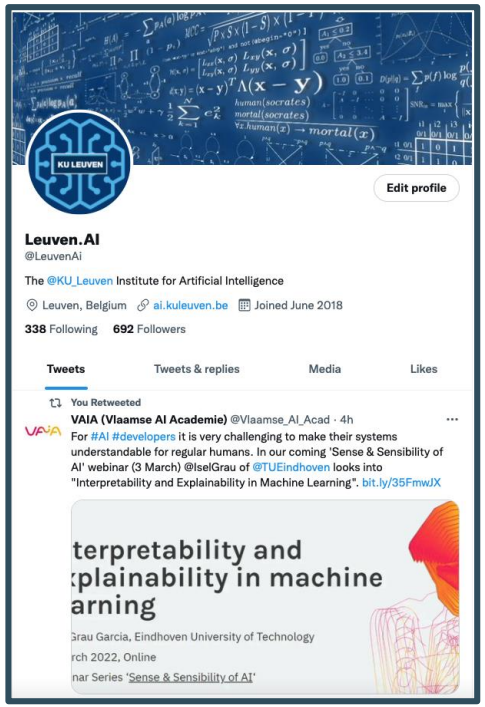
Website

https://ai.kuleuven.be/

Newsletter

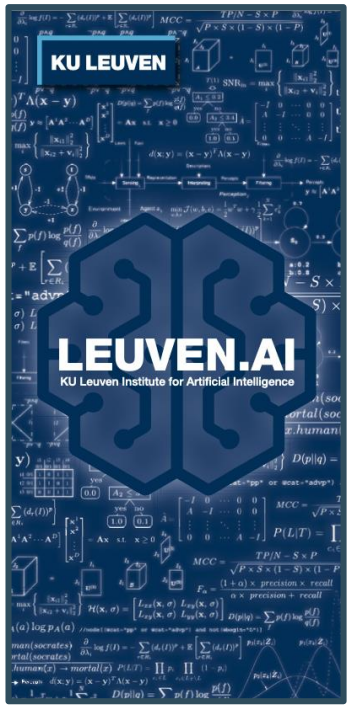


Twitter

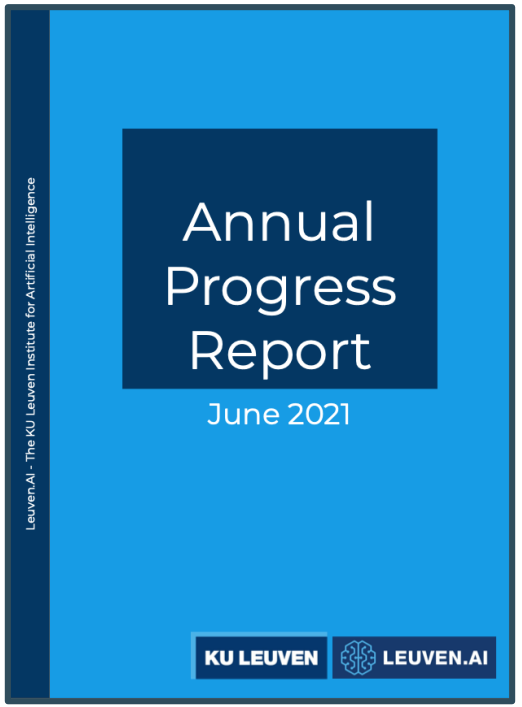


@LeuvenAI

Brochure



Progress report



Educational programs at KU Leuven

Advanced Master in Artificial Intelligence

(Since 1988; 300+ students annually)

Advanced Master in AI for Business and Industry

Master of Engineering: Computer Science

Master of Mathematical Engineering

Elements of AI (Dutch)

University-wide course AI for Everyone

Postgraduate Studies: Big Data & Analytics in Business and Management

Many more programmes with AI courses

Research lines

Machine Learning & Data Science

Find out more

Language, Speech & Vision

Find out more

Reasoning, Acting & Decision-Making

Find out more

Philosophical, Ethical, Legal and Societal Implications of AI (PhELSI)

Find out more

Applications of AI

Find out more

Agents | AI in education | Autonomous systems | Big data | Biomedical applications | Business applications | Computational linguistics | Computer vision | Data protection | Data science | Deep learning | Engineering applications | Ethics of AI | Evolvable Hardware | Explainable AI | Fairness | Knowledge representation | Language and speech | Liability | Logic | Machine Learning | Machine Learning on chip | Mathematical engineering | Multilinear algebra | Natural language processing | Philosophy of AI | Privacy | Reasoning | Regulation | Robotics | Speech recognition | Statistical relational learning | Sociality of AI

Content

- Research division STADIUS

- AI and machine learning

- AI in Health Care – Projects/Cases/Examples

- Clinical Decision Support Systems

- Leuven.AI KU Leuven Institute

- Flanders AI Program

Flanders AI Research Program

Groundbreaking AI research enabling a meaningful impact on people, industry and society

AI FLANDERS

BUILDING OUR DIGITAL FUTURE

1 RESEARCH

FAIR 1.0

Flanders AI Research Program

Vlaams AI Onderzoeksprogramma

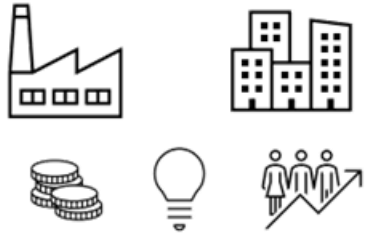
www.flandersairesearch.be

Director: Sabine Demey, imec

DEPARTMENT OF ECONOMY SCIENCE & INNOVATION

€ 12 M

2 IMPLEMENTATION



www.digitaletoekomst.be

(Site in Dutch, for companies)

AGENTSCHAP INNOVEREN & ONDERNEMEN

€ 15 M

3 SUPPORTING Activities

Education & Training

VAIA

Vlaamse AI Academie

www.vaia.be

Voorzitter: Bart De Moor, KU Leuven

Citizen Projects

Ethical & Legal

Knowledge Centre Data & Society

data-en-maatchappij.ai/en

€ 5 M

DEPARTMENT OF ECONOMY SCIENCE & INNOVATION

AGENTSCHAP INNOVEREN & ONDERNEMEN

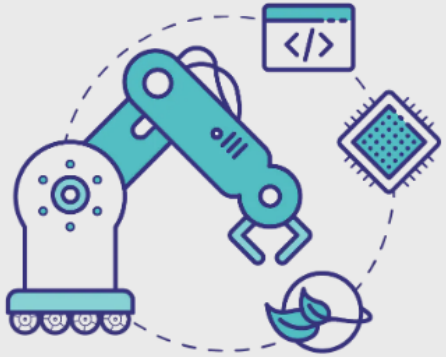
Flanders AI Research Program (FAIR 1.0)

2019 - 2023

Research Challenges:

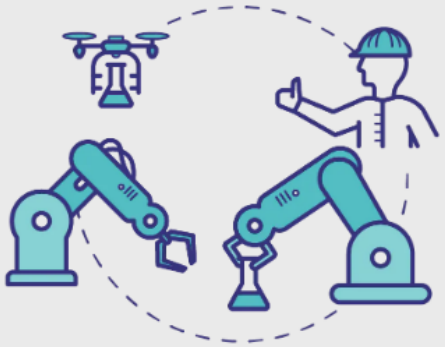
AI-Driven Data Science

Making data science hybrid, automated,trusted and actionable



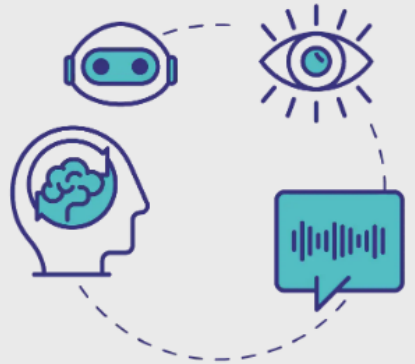
AI in the Edge

Real-time and power-efficient AI in the edge



Multi-agent Collaborative AI

AI systems that interact autonomously with other decision-making entities



Human-like AI

AI-systems that communicate and collaborate seamlessly with humans

Some Use Cases in FAIR 1.0

Health

- Single-cell technologies
- Multiple Sclerosis
- Epilepsy Monitoring
- Medical Imaging
- Length-of-stay prediction

Energy

- Smart Energy Distribution - Low Voltage Grid
- Improved Energy Production of Wind Turbines
- …

Industry

- Industrial production processes:
  - Smart Maintenance
  - Adhesive Bonding
  - Additive Manufacturing
- Prognostic Health Management of Industrial Assets
- …

Government and Citizens

- Public Employment Services

Flanders AI Research Program (FAIR 2.0)

2024 - 2028

NEW

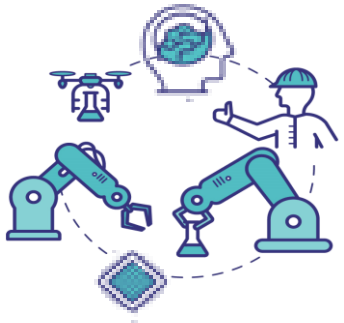
Research Challenges:

AI-driven data science

Supporting complex decision making and actionable insights creation with AI Systems unlocking the value of data,

in a responsible, resilient and performant, human-centred, sustainable and productive manner,

enabling a meaningful impact on people, industry and society



Situated AI

Support complex task execution in a **dynamic environment** with (semi-)autonomous AI systems, collaborating in **real-time** with each other and with people in a **human-centered**, **trustworthy**, **safe**, **sustainable** and **data-efficient** manner

Use Cases in FAIR 2.0

HEALTH

- Monitoring @ Home
- Real-world Evidence
- Medical imaging
- Single cell technologies
- Digital twin Cardio
- Intensive Care Units
- Personalized dermatology
- AI for Sports
- Epidemic decision making
- Fitness on the Edge

INDUSTRY

- Straight-Through-Digitalization
- Monitoring & Control of Production & Machine
- Production-Design optimization
- Prognostic Health Management for assets
- Refurbishment
- Usage driven smart machines
- Autonomous Systems
- Human-machine Flexible Production
- Robotics in Agrifood

PLANET & ENERGY

- Smart grid
- Geo-Platform urban
- Natural environment
- Energy building
- Renewable Energy Production

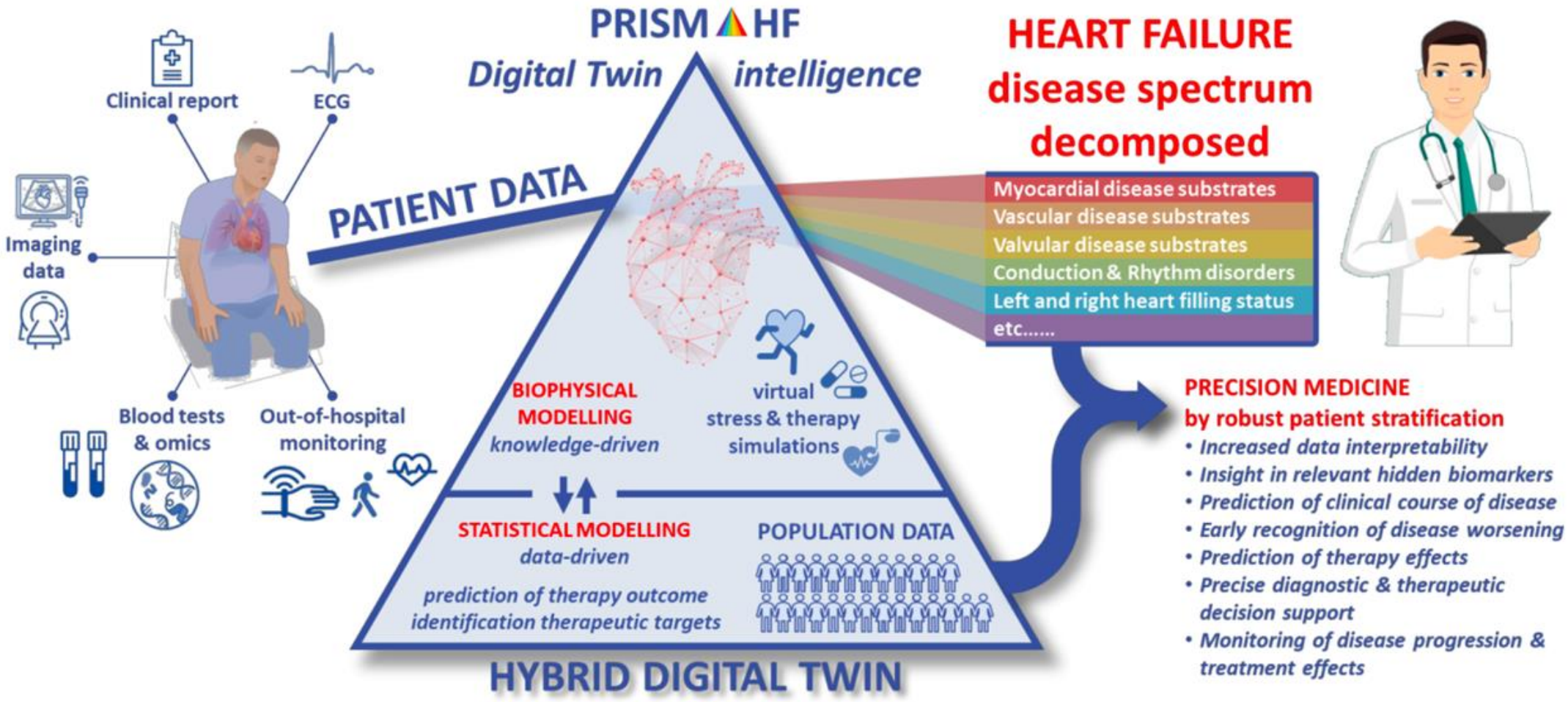
SOCIETY

- Public Employment
- Digital Humanities
- Education & Training
- Collaborative Learning
- Conversational XAI
- Intelligent intersections

Monitoring @ home

The overarching goal is to reliably and robustly **learn from time series data collected outside of traditional hospital environments** (e.g., at home through the use of wearable monitoring), which will enable a more realistic view and the continuous follow-up of neurological disorders and ultimately lead to better self-management of the disease.

Digital Twin Cardio



The **objective** of this use case is **to provide disease-tailored treatments for each individual patient at the right time according to their individual pathophysiological disease spectrum** by harvesting multimodal and heterogeneous data and allowing to dynamically update those predictions when additional data becomes available.

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