Artificial Intelligence
Fact or Fiction ?

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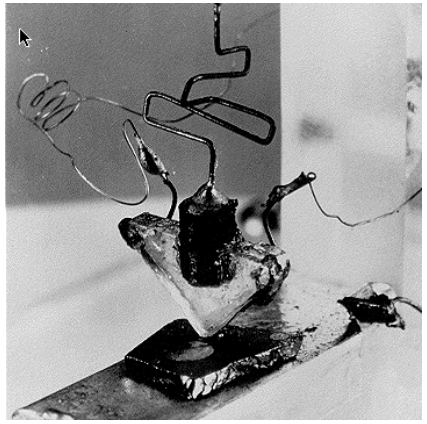
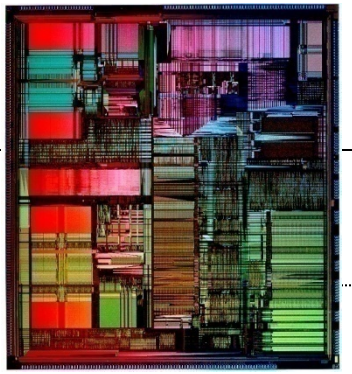
Center for Dynamical Systems, Signal Processing and Data Analytics

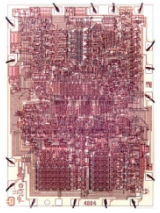
Outline

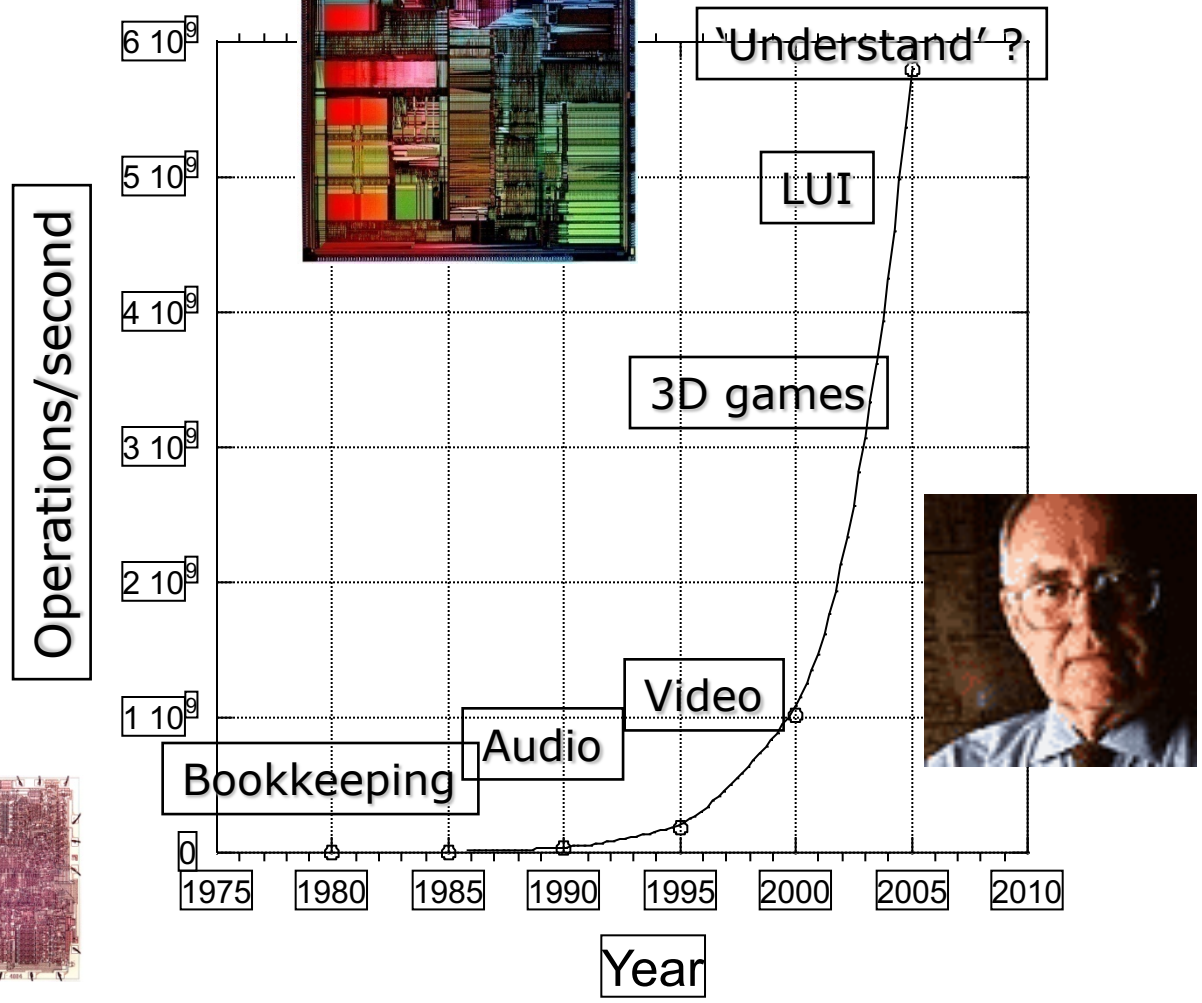
- AI: Why now ?
- Cases on time series
  - **Utility Networks**
  - **Process Industry**
  - **Health**
- The future of AI

Technology and Engineering Design:
The third industrial revolution (1945…)

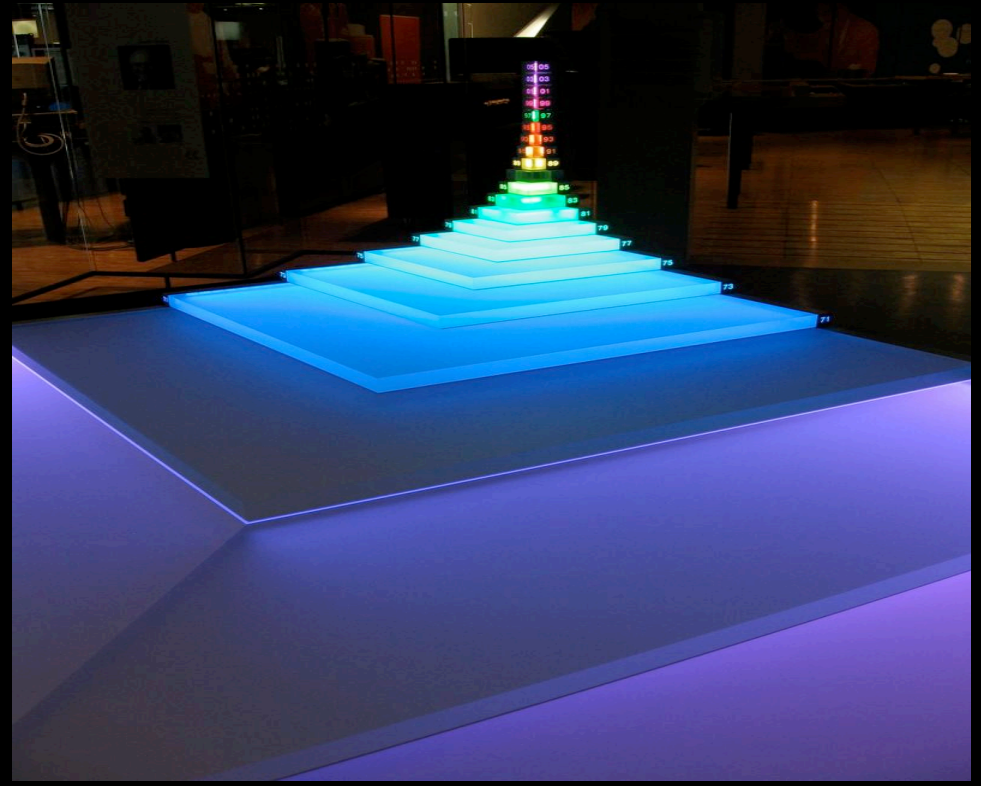






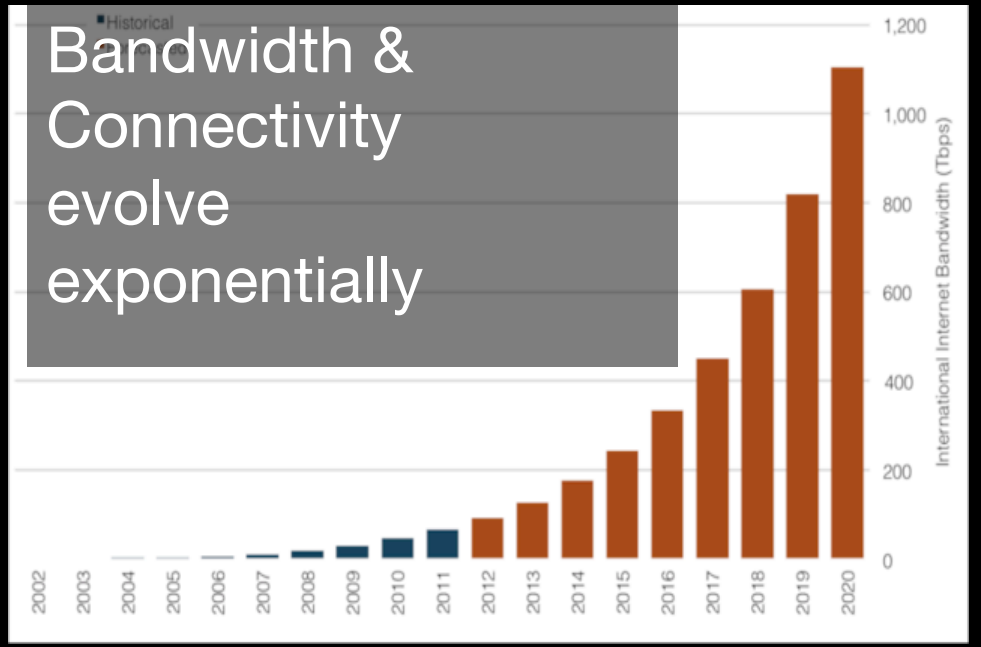


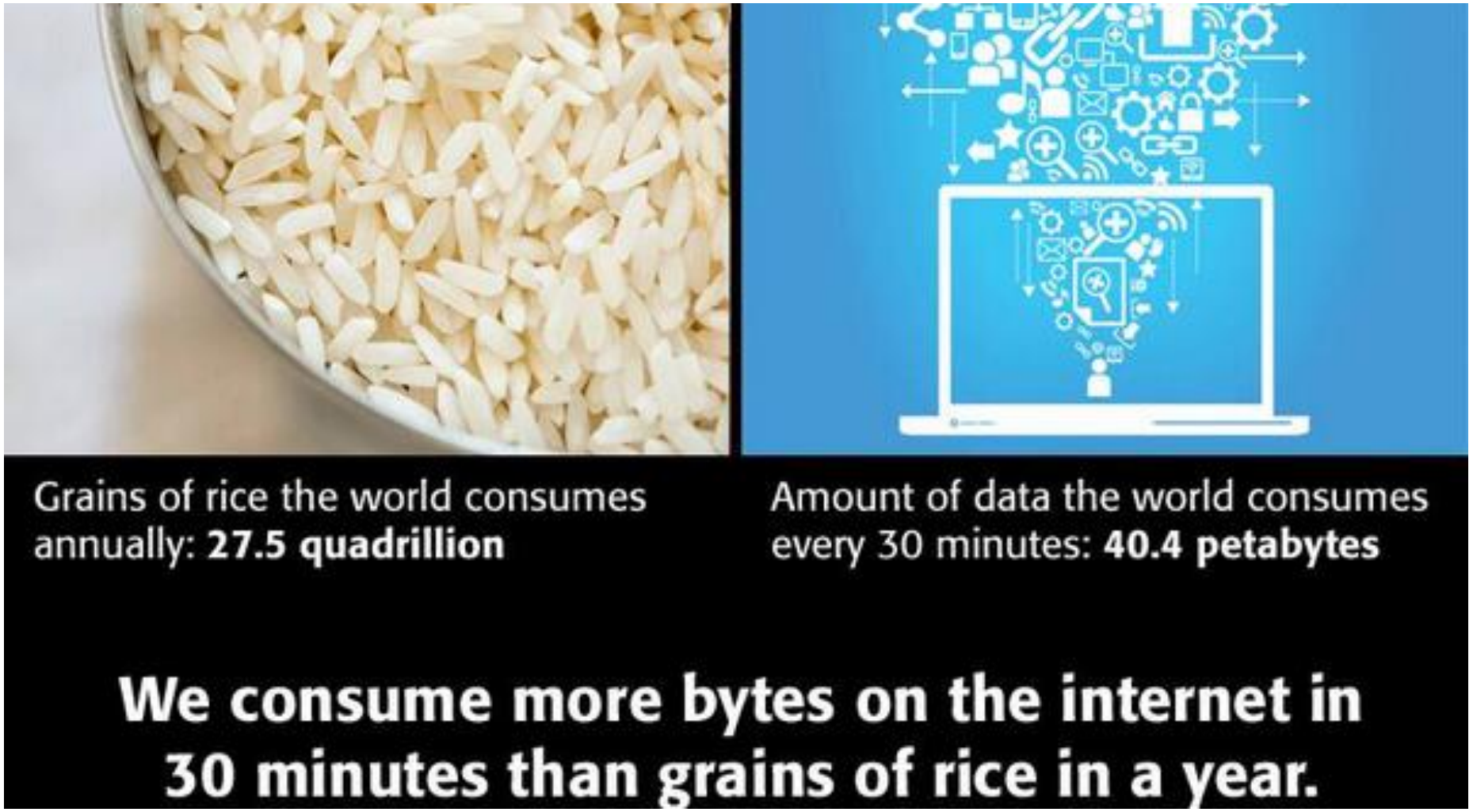
Computational power x 2 every 18 months



Moore's law:
computing power
doubles
every 18 months

Bandwidth &
Connectivity
evolve
exponentially





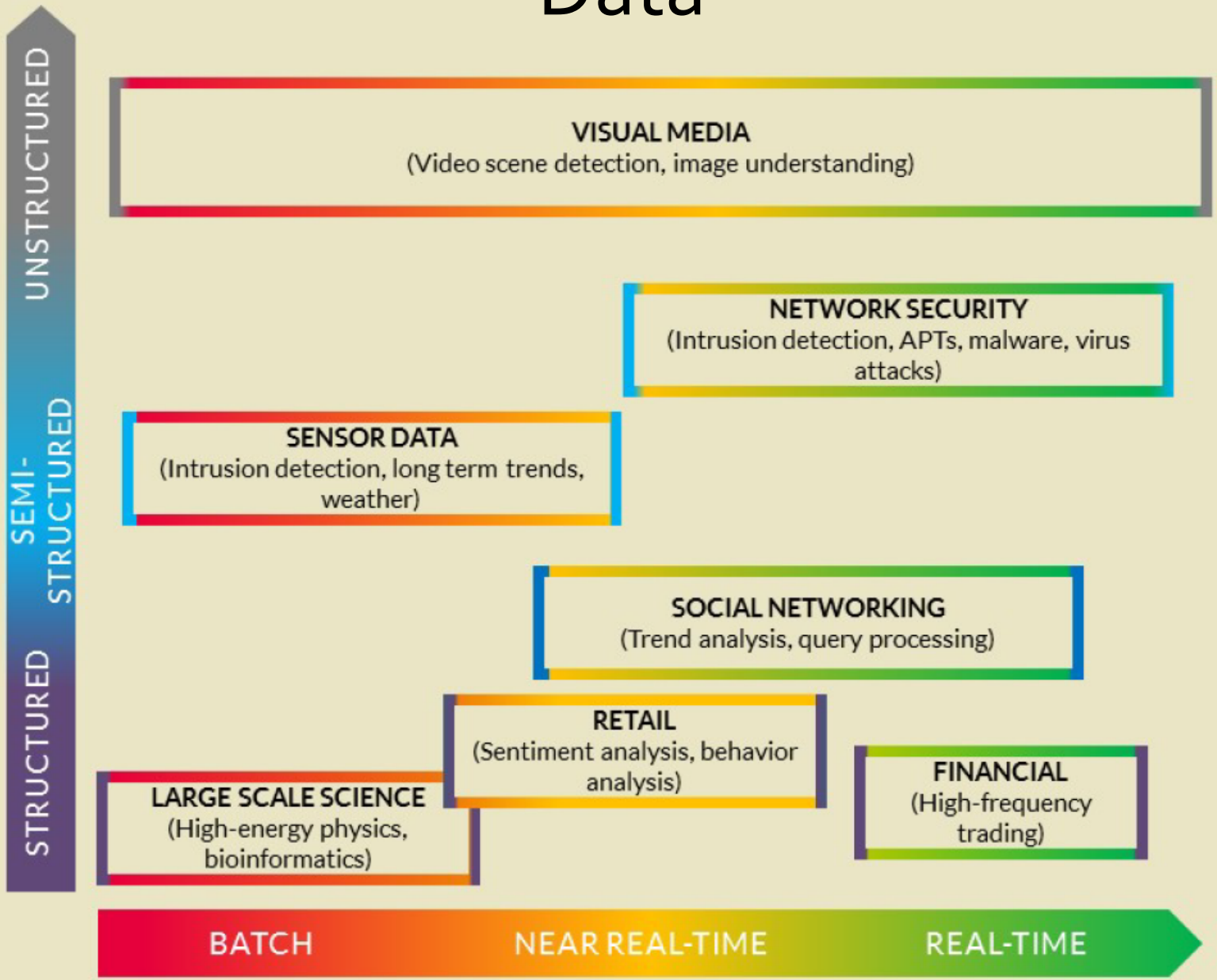
1 million = 1 000 000
1 billion = 1 000 000 000
1 trillion = 1 000 000 000 000
1 quadrillion =
1 000 000 000 000 000

1 kB = 1 000
1 MB = 1 000 000
1 GB = 1 000 000 000
1 TB = 1 000 000 000 000
1 PB = 1 000 000 000 000 000

1 TB
= large university library
= 212 DVD discs
= 1430 CDs
= 3 year music CD quality

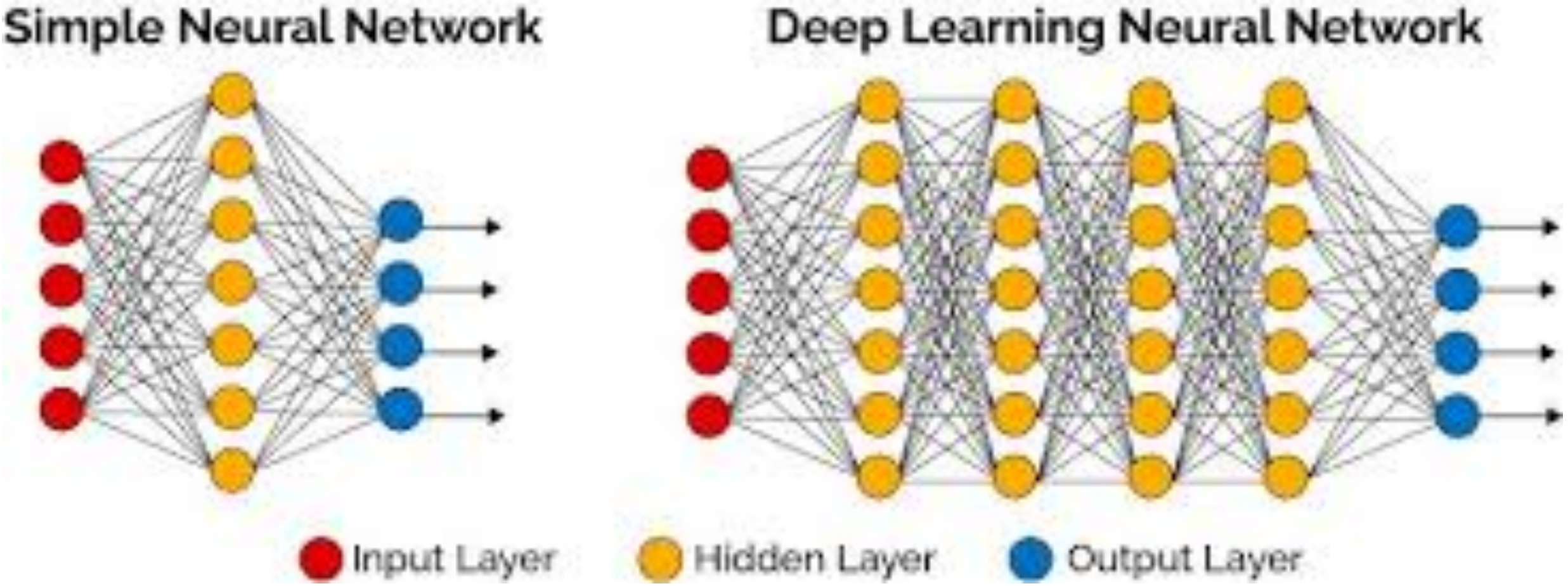
1
Data
2
Compute Infrastructure
3
Storage Infrastructure
4
Analytics
5
Visualization
6
Security & Privacy
Big Data

Data


UNSTRUCTURED
SEMI-STRUCTURED
STRUCTURED
VISUAL MEDIA
(Video scene detection, image understanding)
NETWORK SECURITY
(Intrusion detection, APTs, malware, virus attacks)
SENSOR DATA
(Intrusion detection, long term trends, weather)
SOCIAL NETWORKING
(Trend analysis, query processing)
RETAIL
(Sentiment analysis, behavior analysis)
FINANCIAL
(High-frequency trading)
LARGE SCALE SCIENCE
(High-energy physics, bioinformatics)
BATCH
NEAR REAL-TIME
REAL-TIME

Generic data processing tasks

- Data preprocessing, denoising, normalization
- Clustering and classification; feature detection; profiling;
- Relevance detection, ranking
- Dynamic modelling, time series, longitudinal modelling
- Decorrelation, modelling, (Kalman) filtering
- Predictive analytics
- Vizualisation
- Heterogeneous data fusion
- Prediction, processing and monitoring



Universal approximation

A mostly complete chart of

Neural Networks

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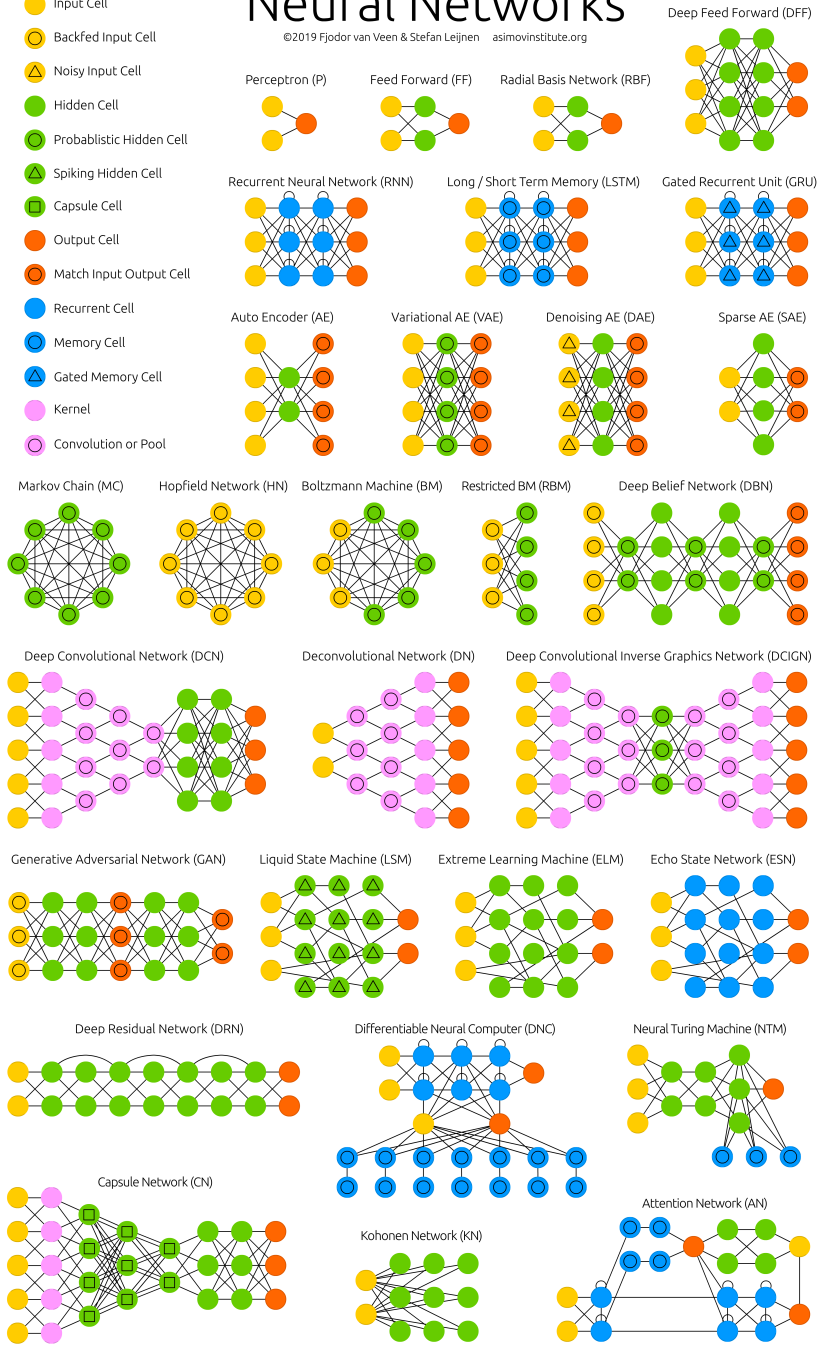
- Input Cell
- Backfed Input Cell
- Noisy Input Cell
- Hidden Cell
- Probablistic Hidden Cell
- Spiking Hidden Cell
- Capsule Cell
- Output Cell
- Match Input Output Cell
- Recurrent Cell
- Memory Cell
- Gated Memory Cell
- Kernel
- Convolution or Pool



The Fourth Paradigm

Paradigm	Time Ago	Method
First	A millenium	Empirical
Second	A few centuries	Theoretical
Third	A few decades	Computational
Fourth	Today	Data-driven

Evolution

From

I have a hypothesis

⇩

I need data to check it

⇨

To

I have data

⇩

Which hypotheses can I check?

⇨ Data first!

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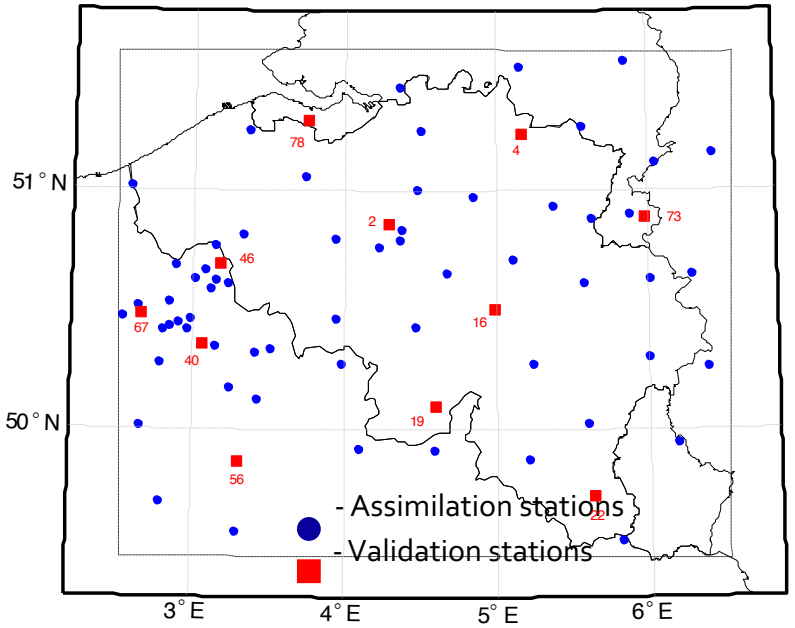
  - **Process Industry**
  - **Health**
- The future of AI

- Cases on time series

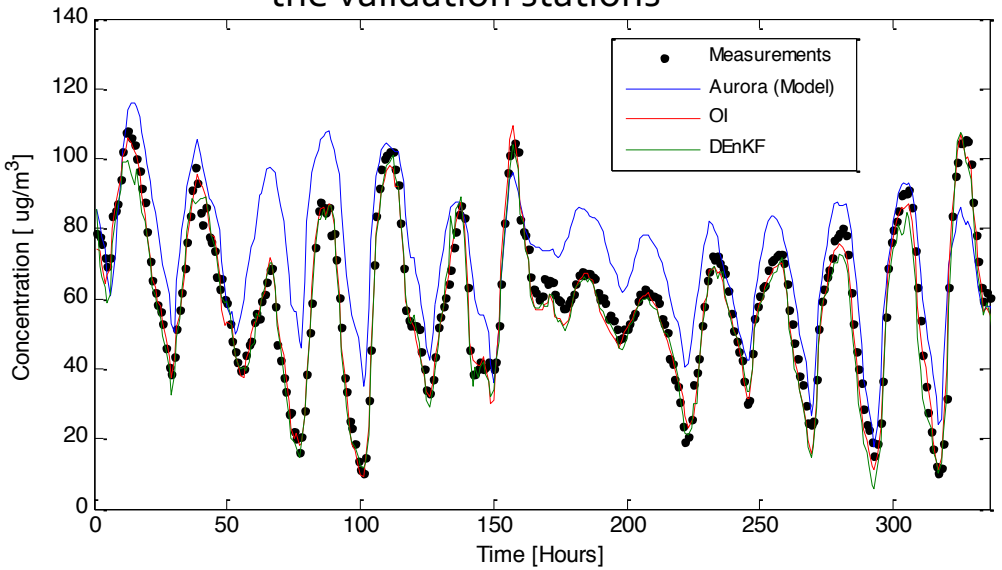
- **Utility Networks**
  - **Micro-Climate → Spatial-temporal prediction**
  - **Water → Spatial-temporal control**
  - **Power → Predictive maintenance & market segmentation**
  - **Mobility → Incident management**
  - **Sports → Performance tracking**
  - **Telecommunication → Fraud detection**

Flanders O3/fine particle DSS

O_3 air-quality stations

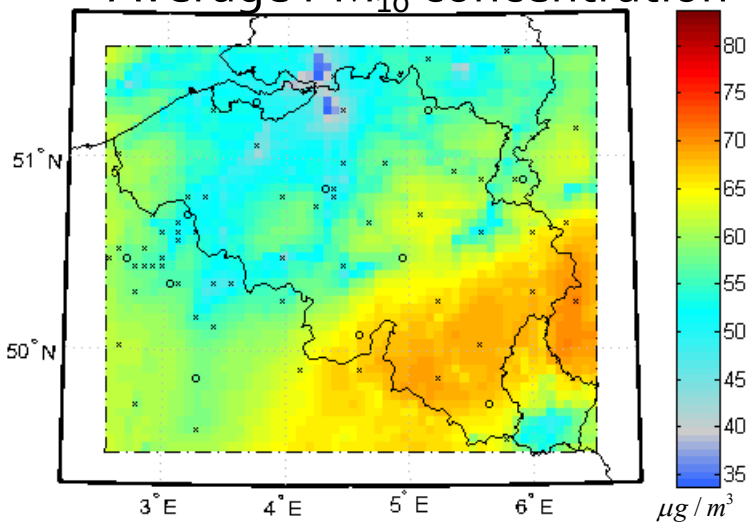


Average of the O_3 concentration over the validation stations

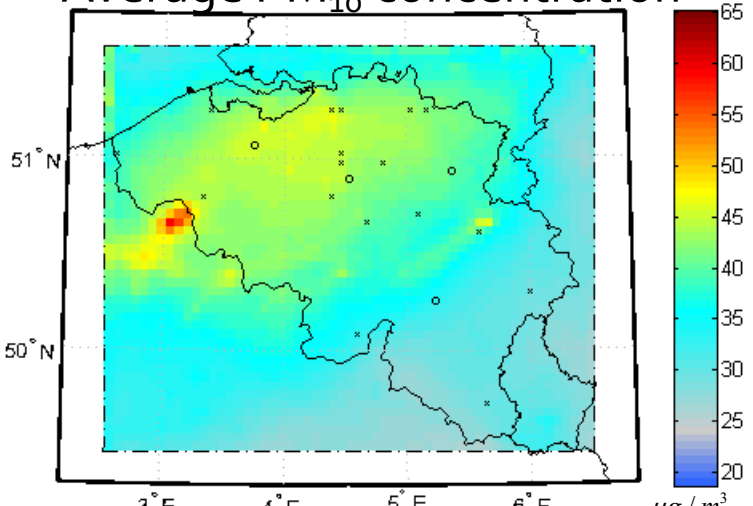


Starting date: May 28th, 2005 at midnight

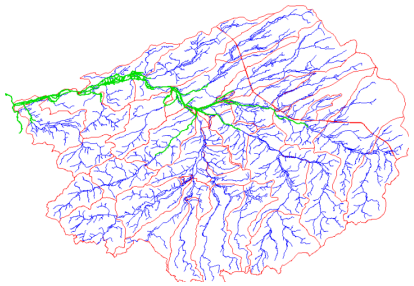
Average PM_{10} concentration

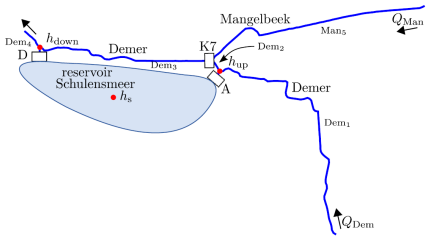


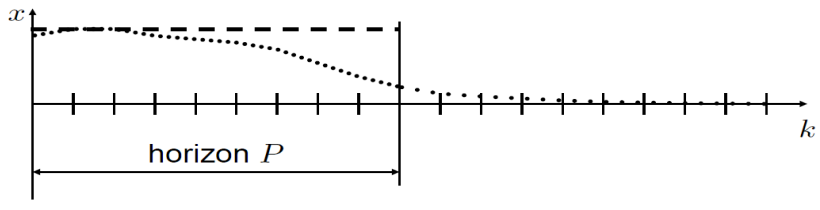
Average PM_{10} concentration

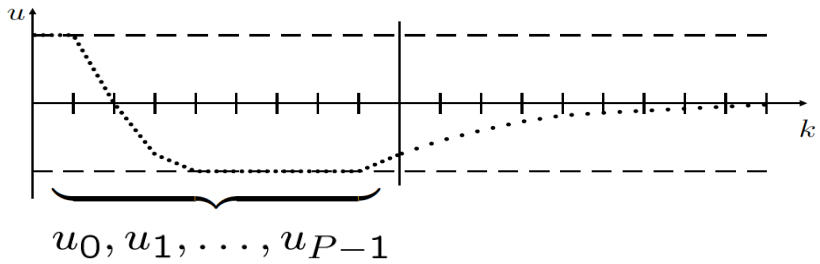


Demer Flood Regulation DSS









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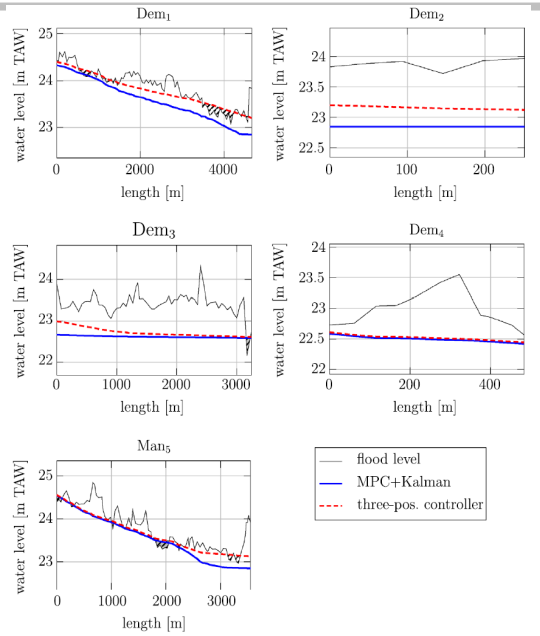
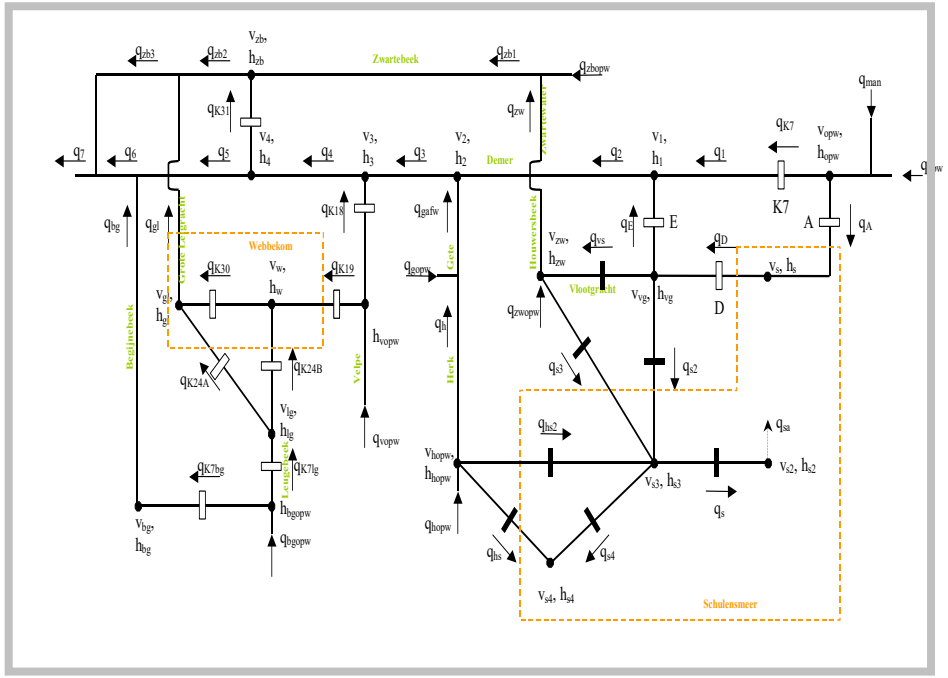
IMDC
International Marine & Dredging Consultants

IPCOS

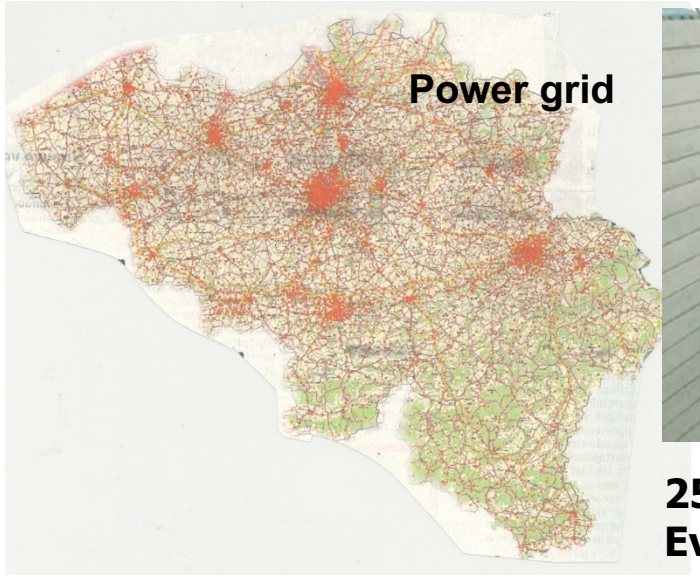
COFELY FABRICOM
GDF SUEZ

anteagroup

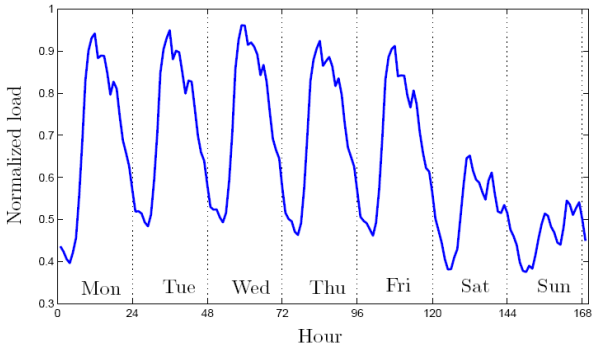




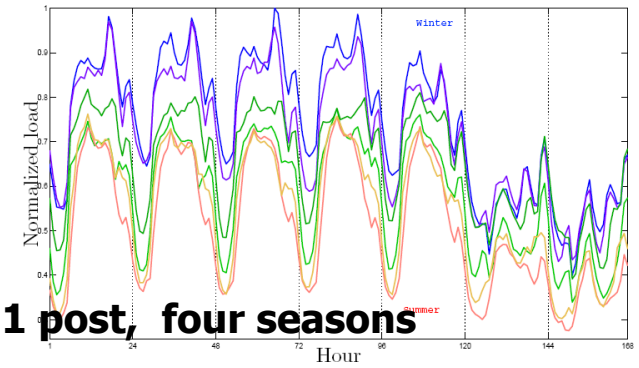
Belgian smart electricity grid DSS



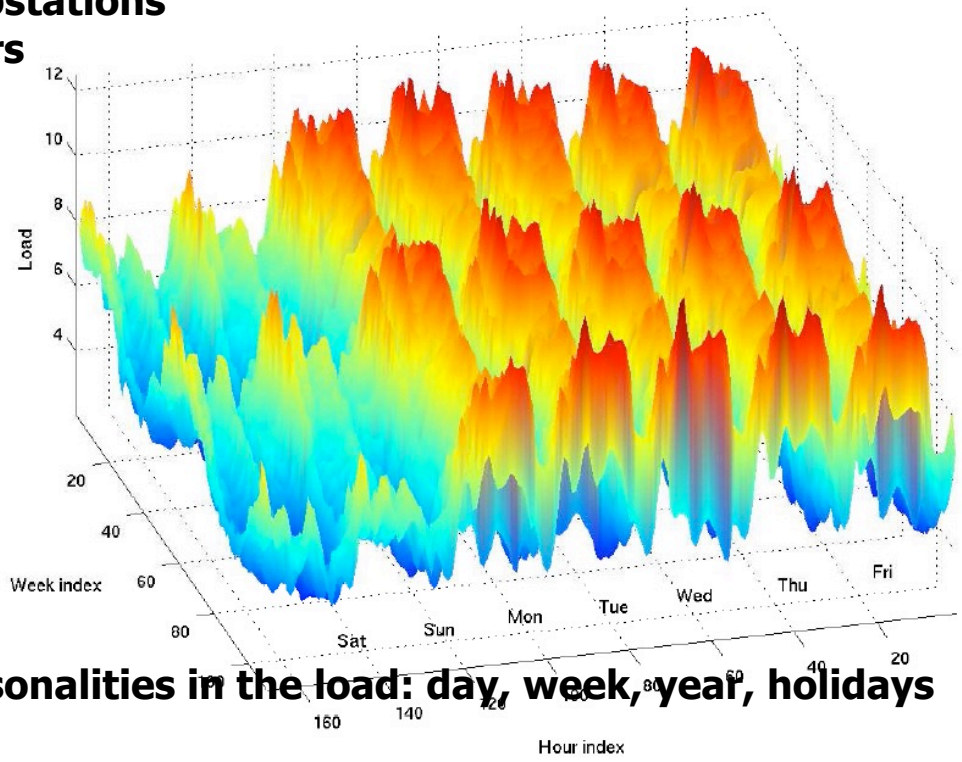
250 transformer substations
Every 15 min, 5 years



1 post, 1 week



1 post, four seasons



Seasonalities in the load: day, week, year, holidays

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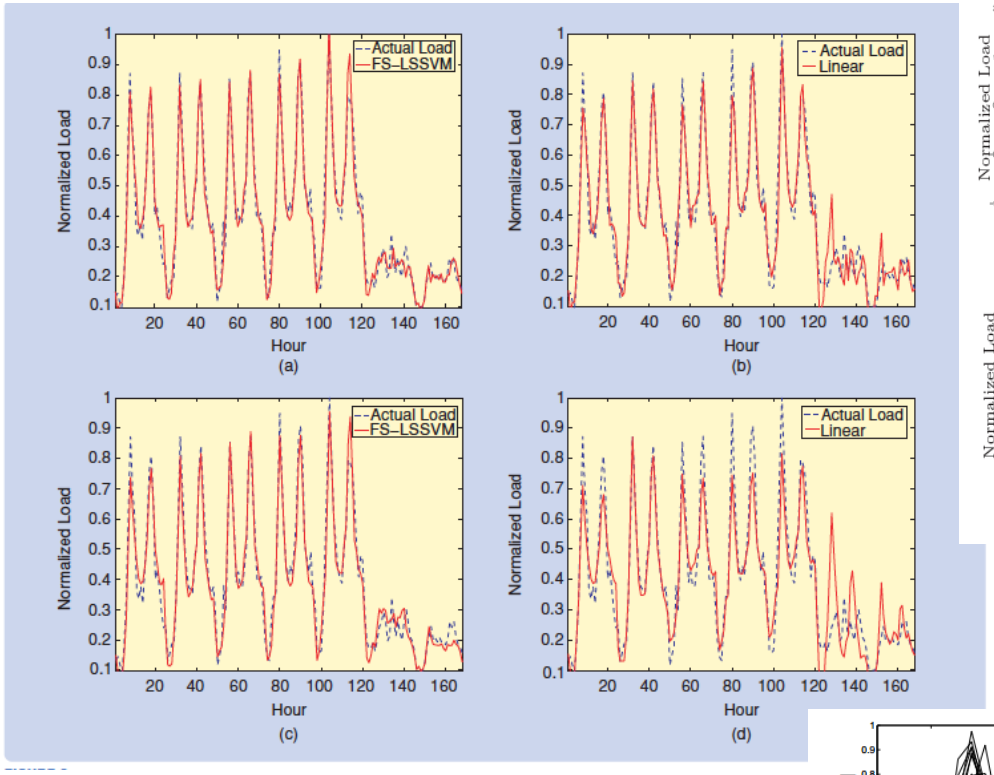
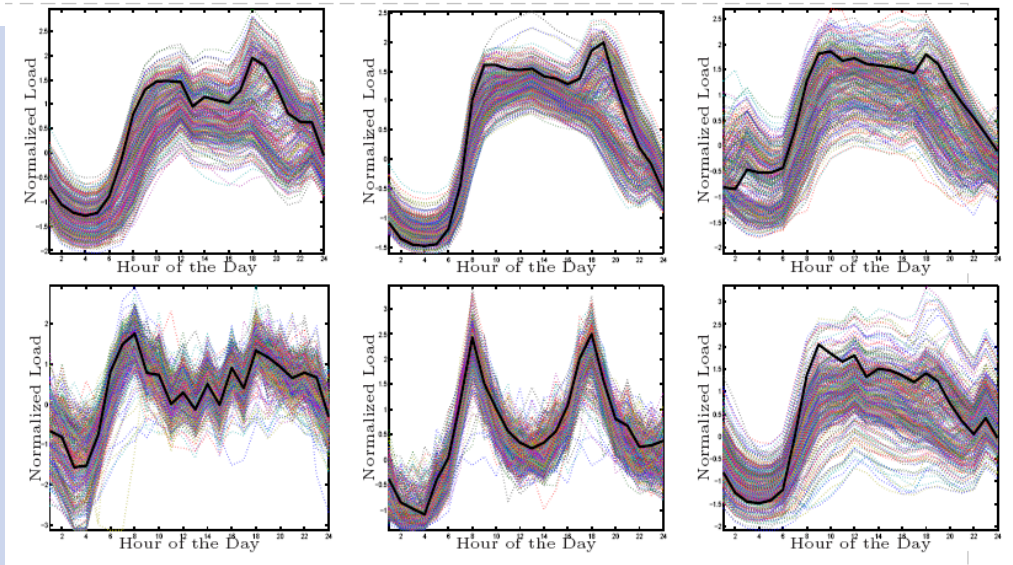
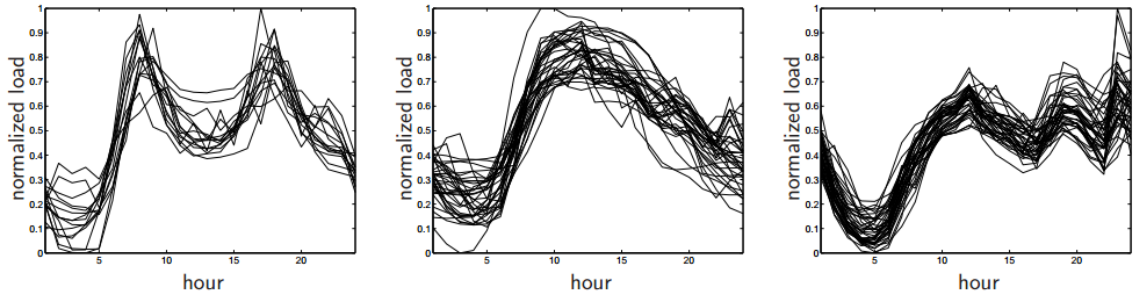
elia





6 posts, 1 year
Seasonalities, calender holidays !

1 month predictions
depending
on day, season
and weather prediction



Electricity load: 245 substations in Belgian grid (1/2 train, 1/2 validation)
$x_i \in \mathbb{R}^{43.824}$: spectral clustering on **high dimensional data** (5 years)

3 of 7 detected clusters:
- *1: Residential profile: morning and evening peaks*
- *2: Business profile: peaked around noon*
- *3: Industrial profile: increasing morning, oscillating afternoon and evening*

Customer profiling:
Residential, business, industrial

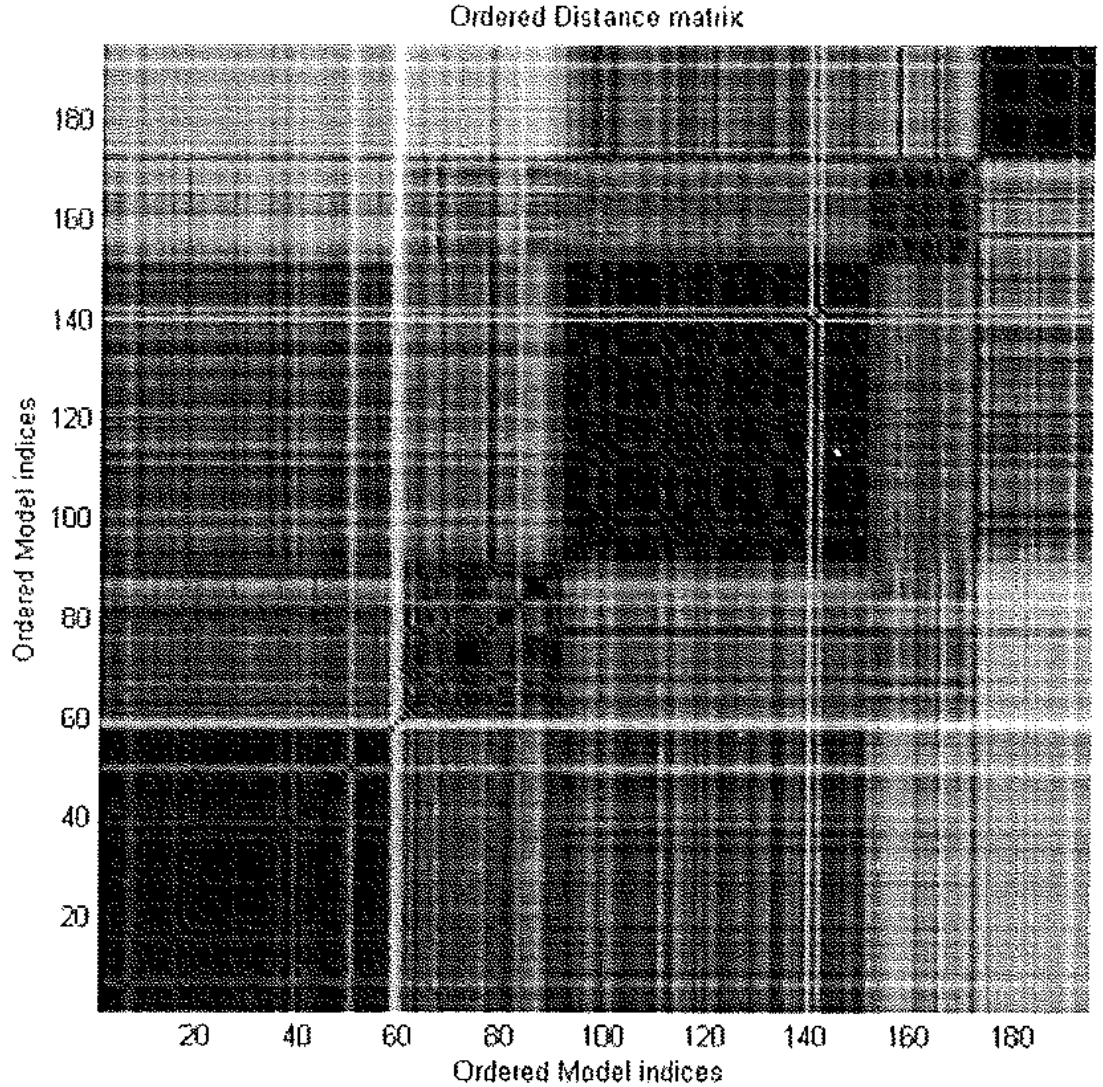


FIG. 6. *The matrix of all pairwise cepstral distances between the* 195 *substations where the stations have been rearranged according to the cluster partition with* $N_C = 6$. *The color varies from black (small distances) to white (large distances). There appear to be five clusters, three of which are more dense than the others. The sixth cluster contains only one substation (on the* 59^{th} *position) which clearly has a large distance to all other models. A few other outliers can also be identified, but they were assigned to one of the larger clusters.*

Sport Analytics Decision Support Systems

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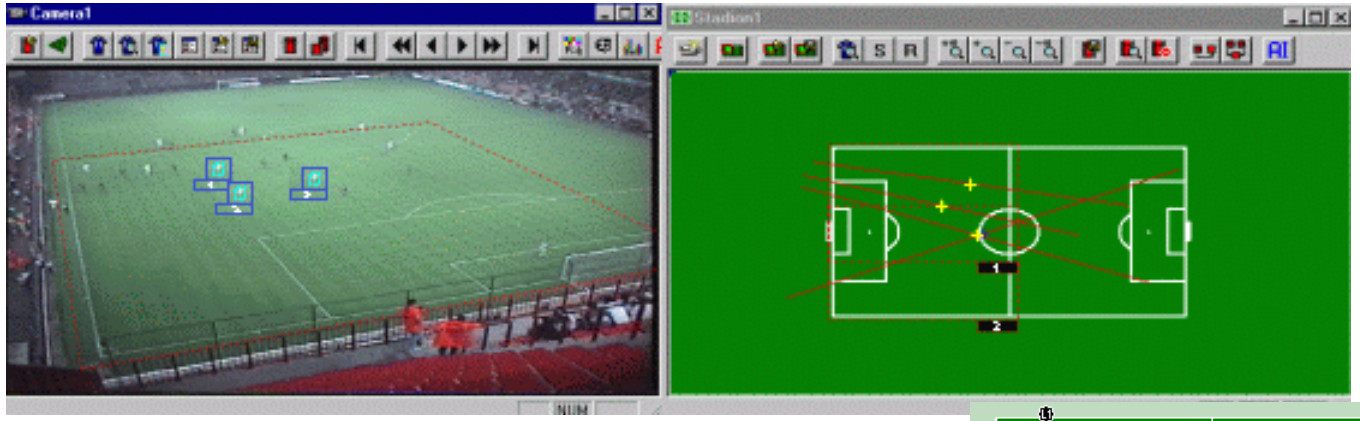
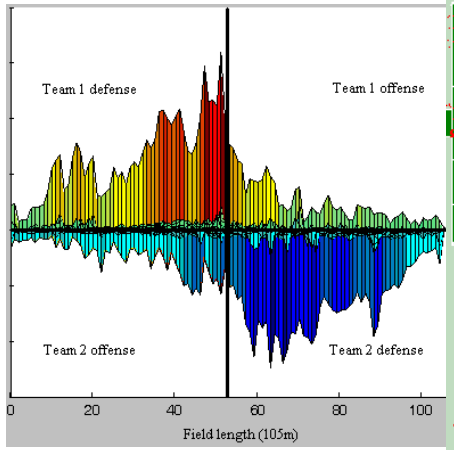
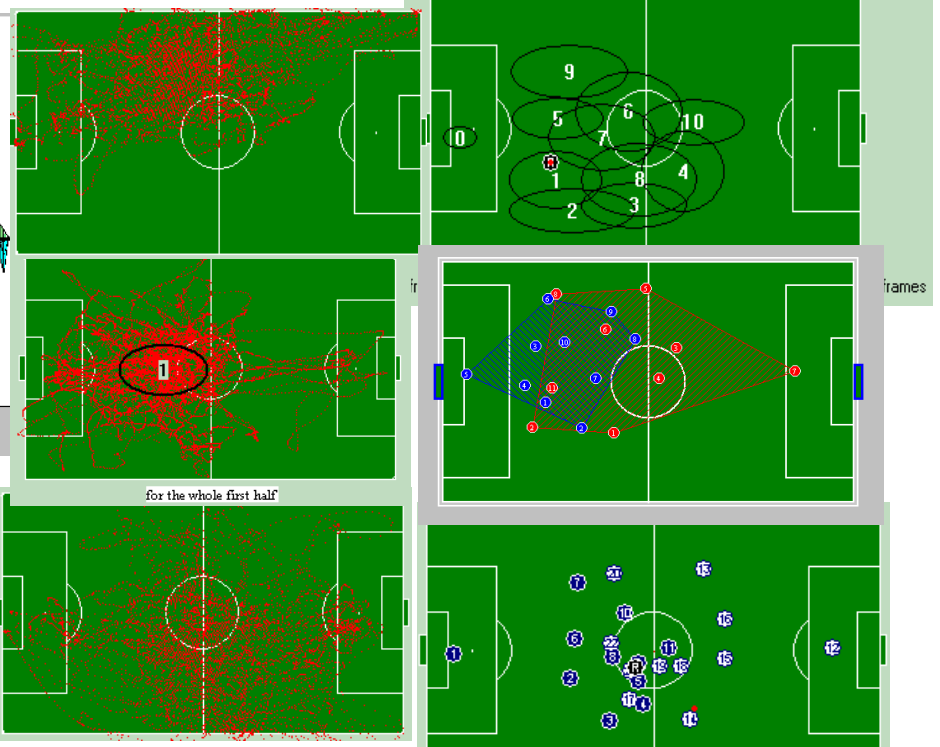
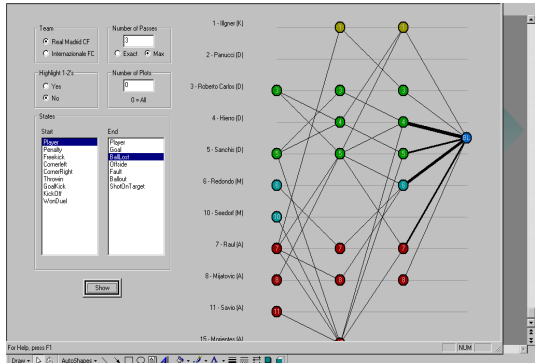
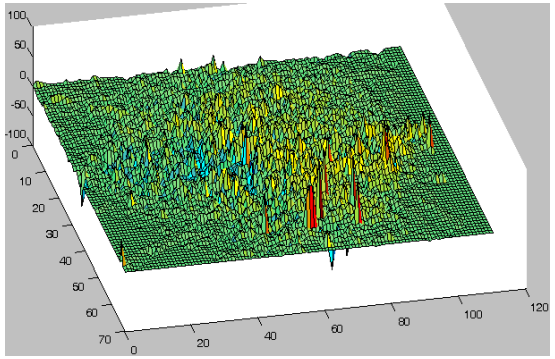


Time	Team	Action	Player	Position
0:00:00	1	Kick Off	9	(50,30)
0:00:01	1	Has Ball	10	(49,29)
0:00:04	1	Has Ball	8	(45,31)
...	...	...	...	...
0:12:25	1	Ball Out	6	(0,57)
0:12:46	2	Corner	3	(0,60)
0:12:47	2	Has Ball	4	(4,29)
0:12:49	2	Goal	4	(0,29)
0:13:38	1	Kick Off	10	(50,30)
...	...	...	...	...



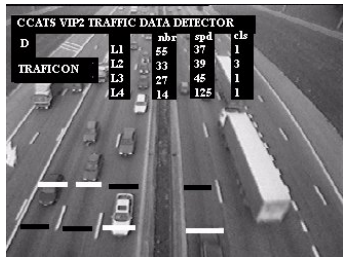




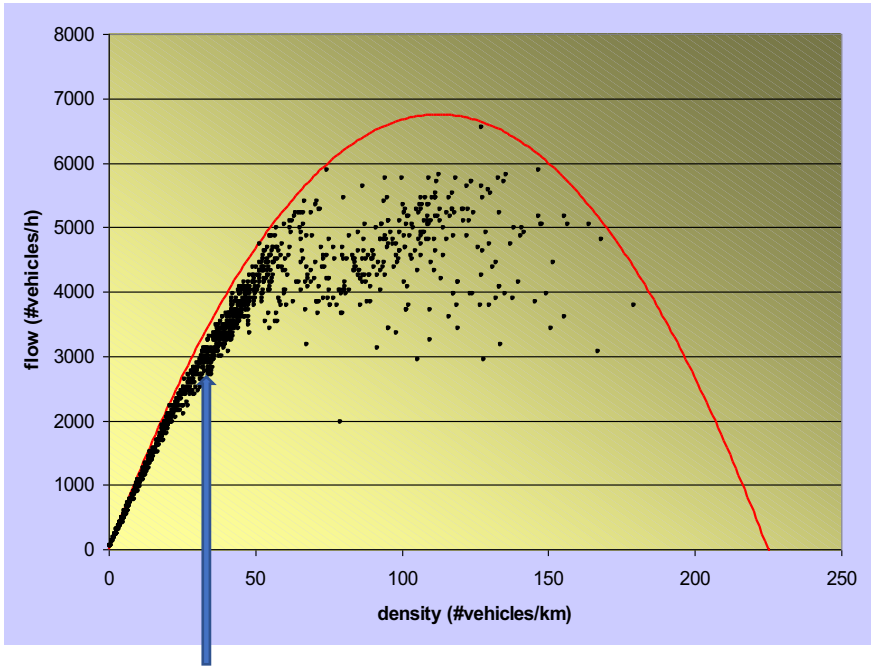


Traffic & Mobility DSS

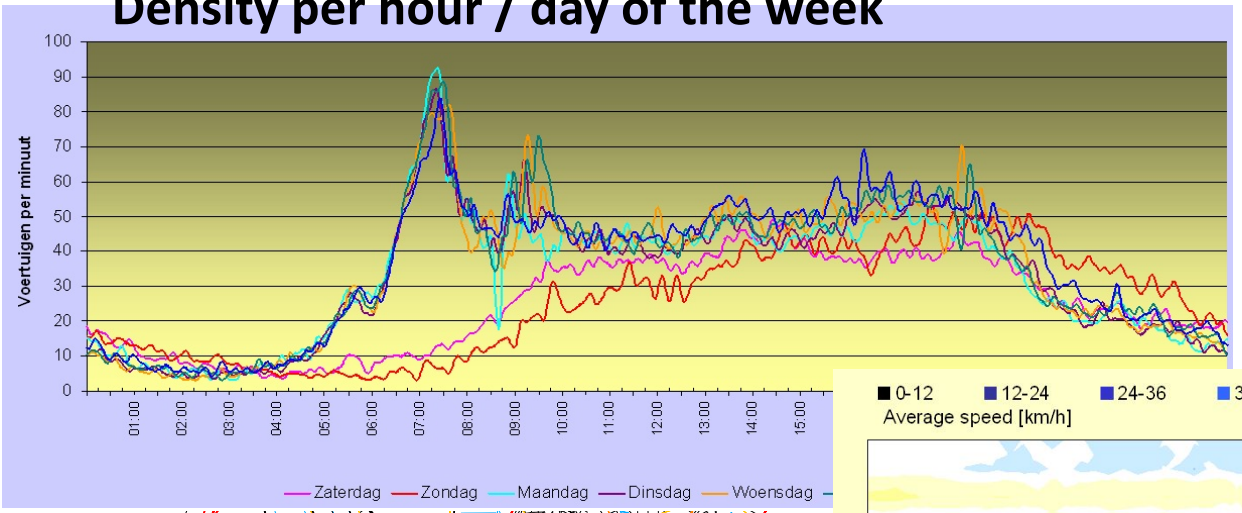
Detector technology: inductive loops, Gatso-meters, camera's



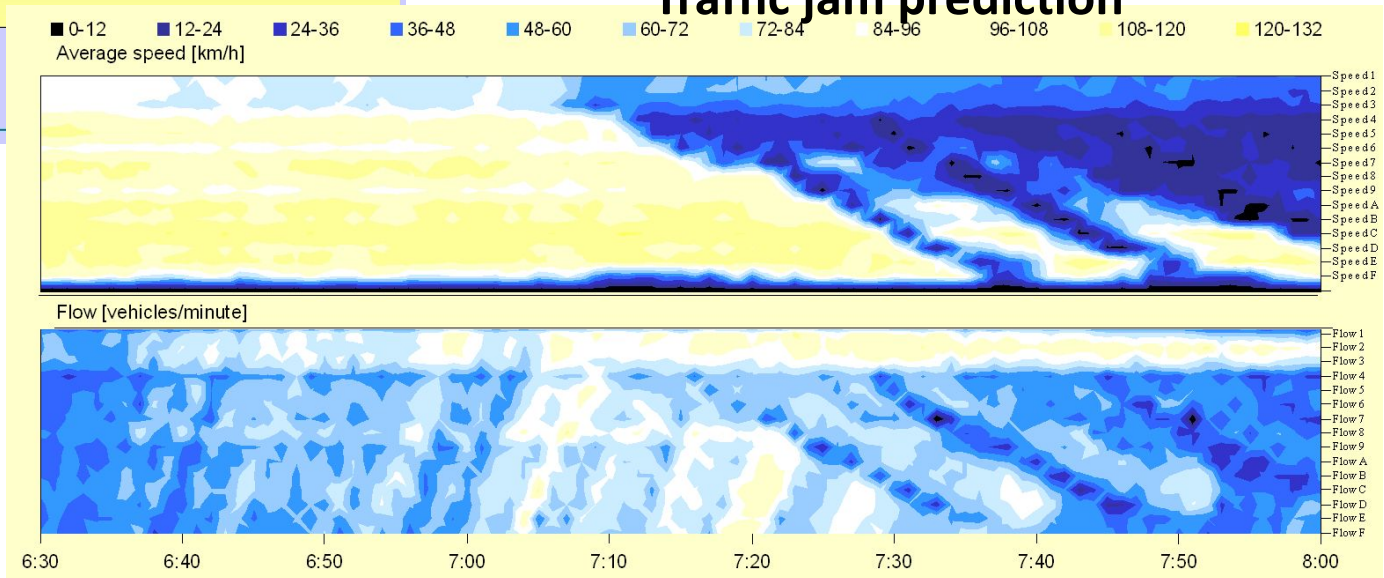
Density – Flow



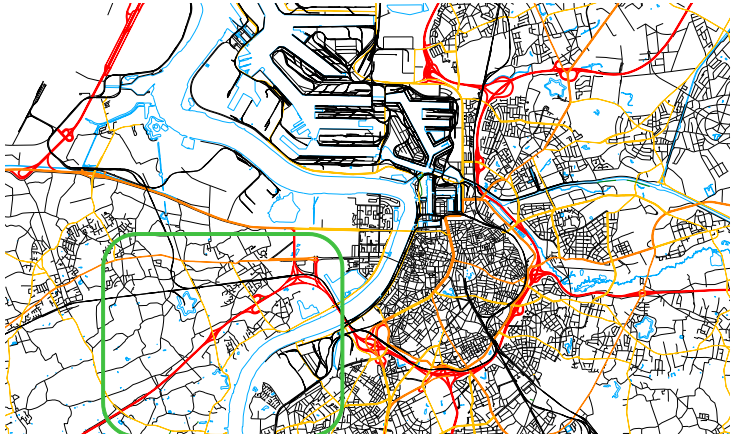
Density per hour / day of the week



Traffic jam prediction

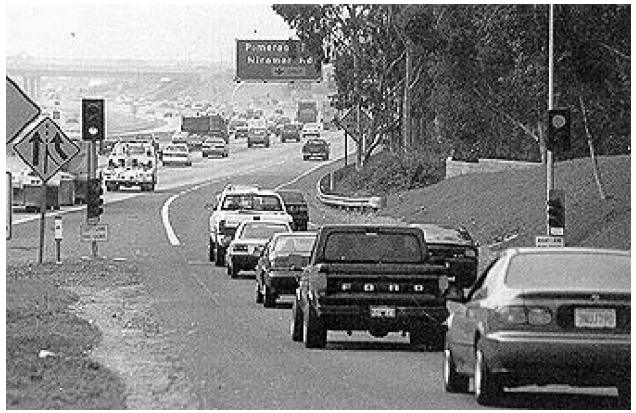


Antwerp Ring



Traffic & Mobility DSS: control

Speed harmonisation

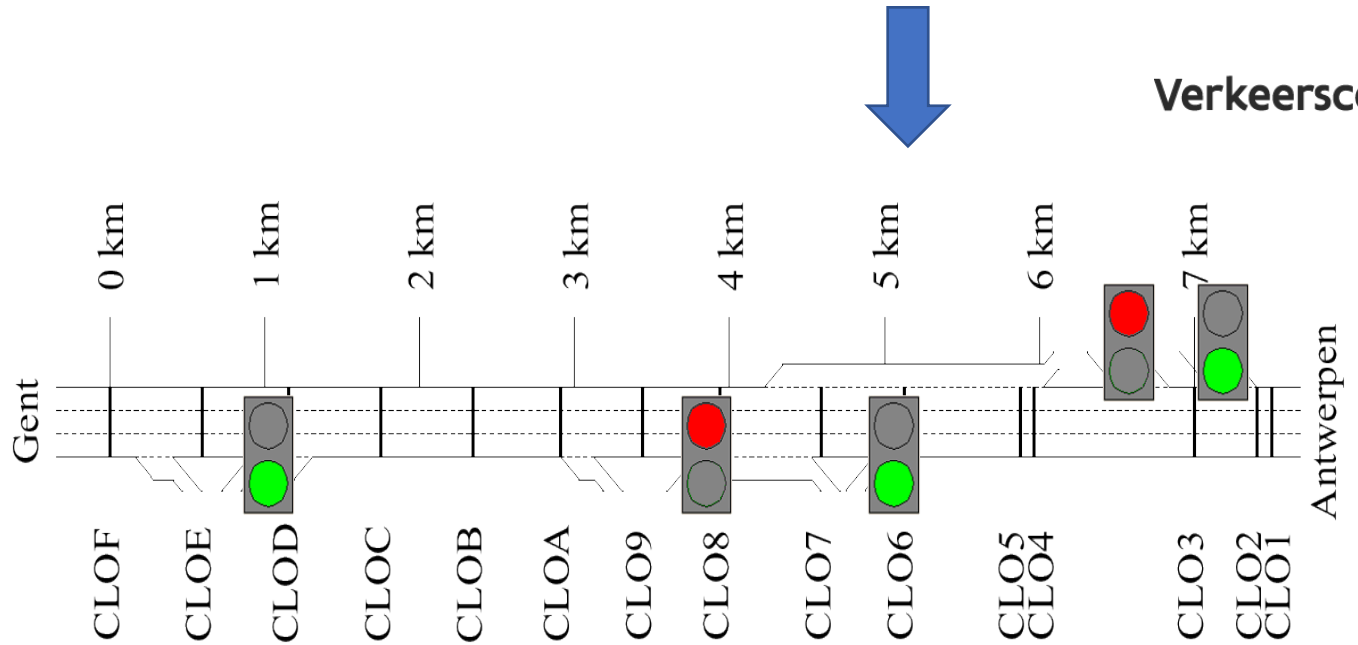


Ramp metering

DRIP

Vlaams Verkeerscentrum

Vlaamse overheid



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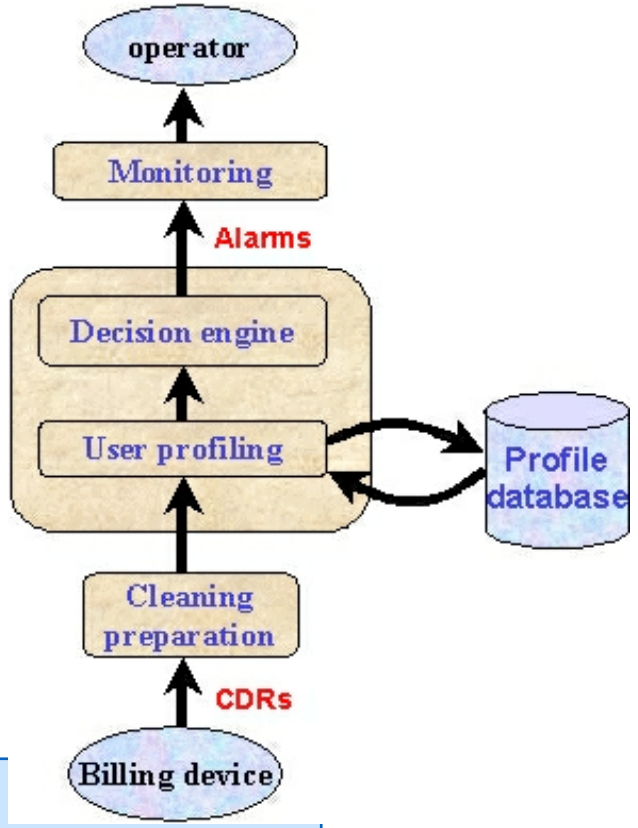
TRANSPORT & MOBILITY LEUVEN

Fraud Detection DSS (phones, credit cards, tax declaration,…)

	Short Duration	Long Duration	High Frequency	International	Same Destination	Off Peak	Call Forwarding	Behaviour Change
Direct call selling		X	X	X			X	
PABX fraud	X		X		X	X		X
Freephone fraud	X		X		X			X
Premium rate fraud		X	X		X			X
Subscription fraud			X					
Handset theft		X	X	X	X			X



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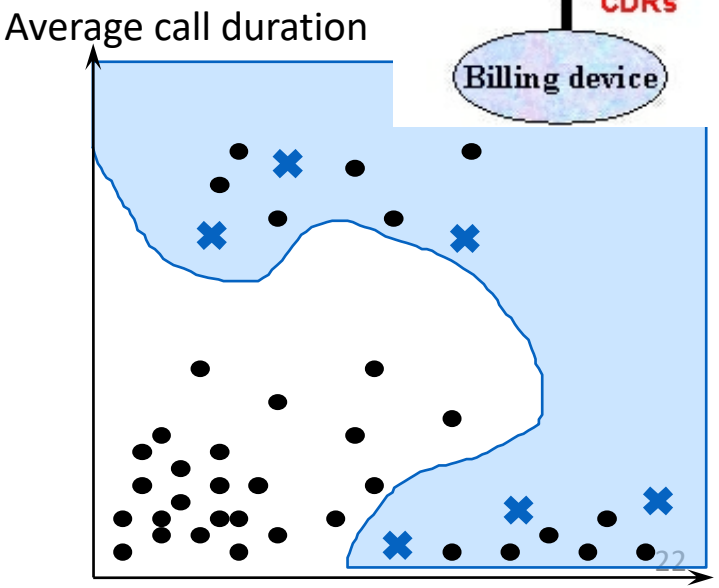

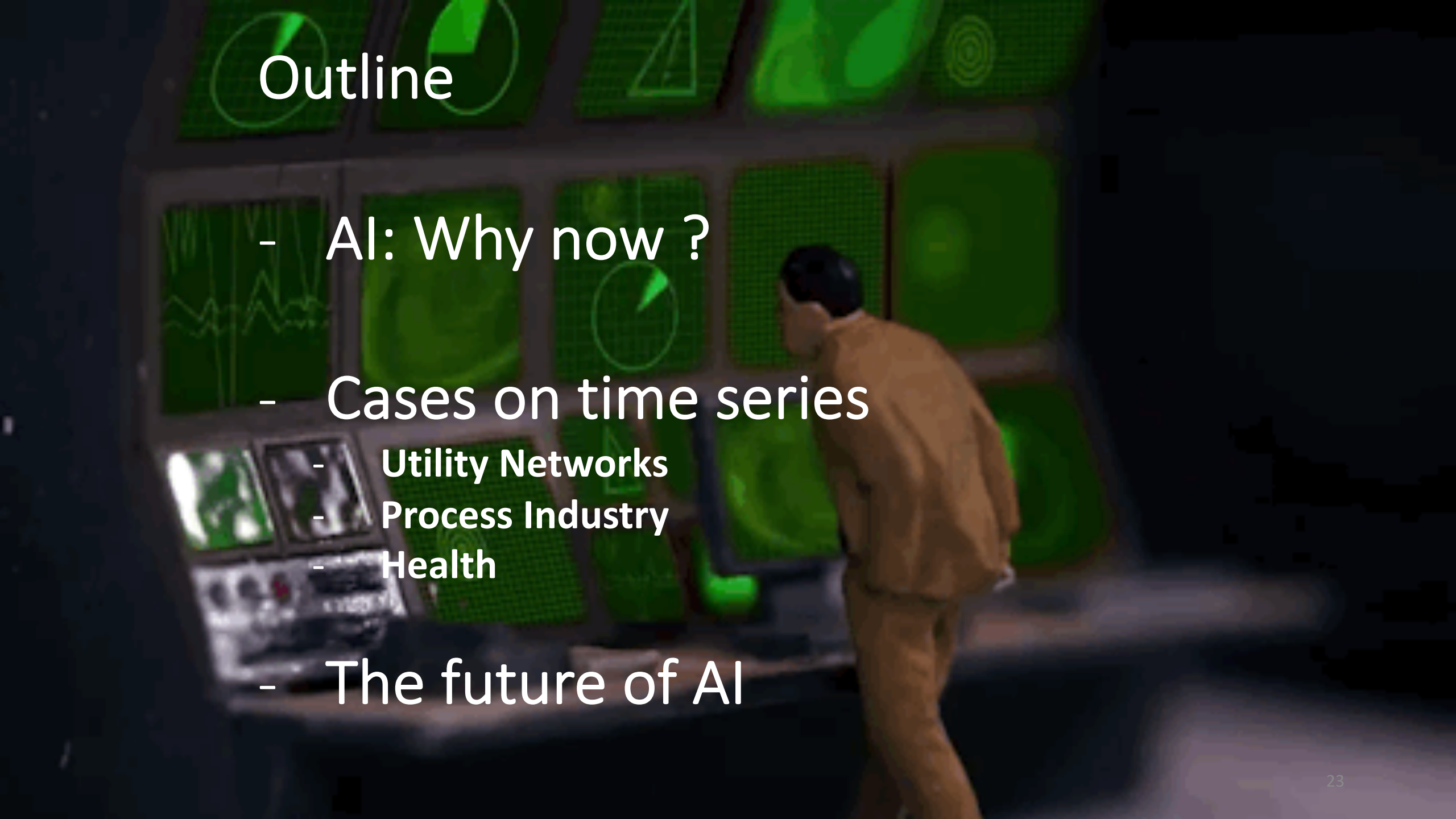

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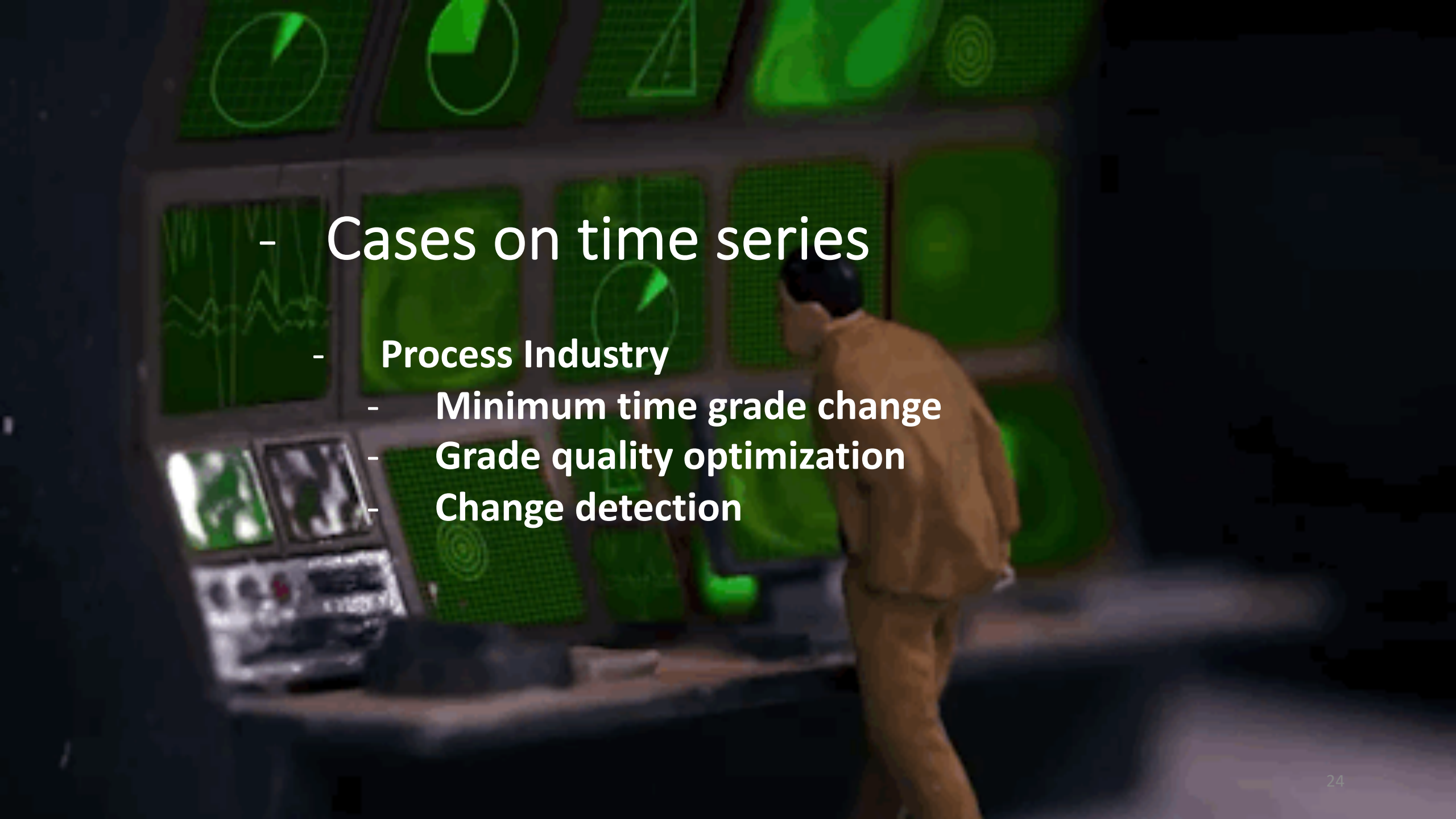
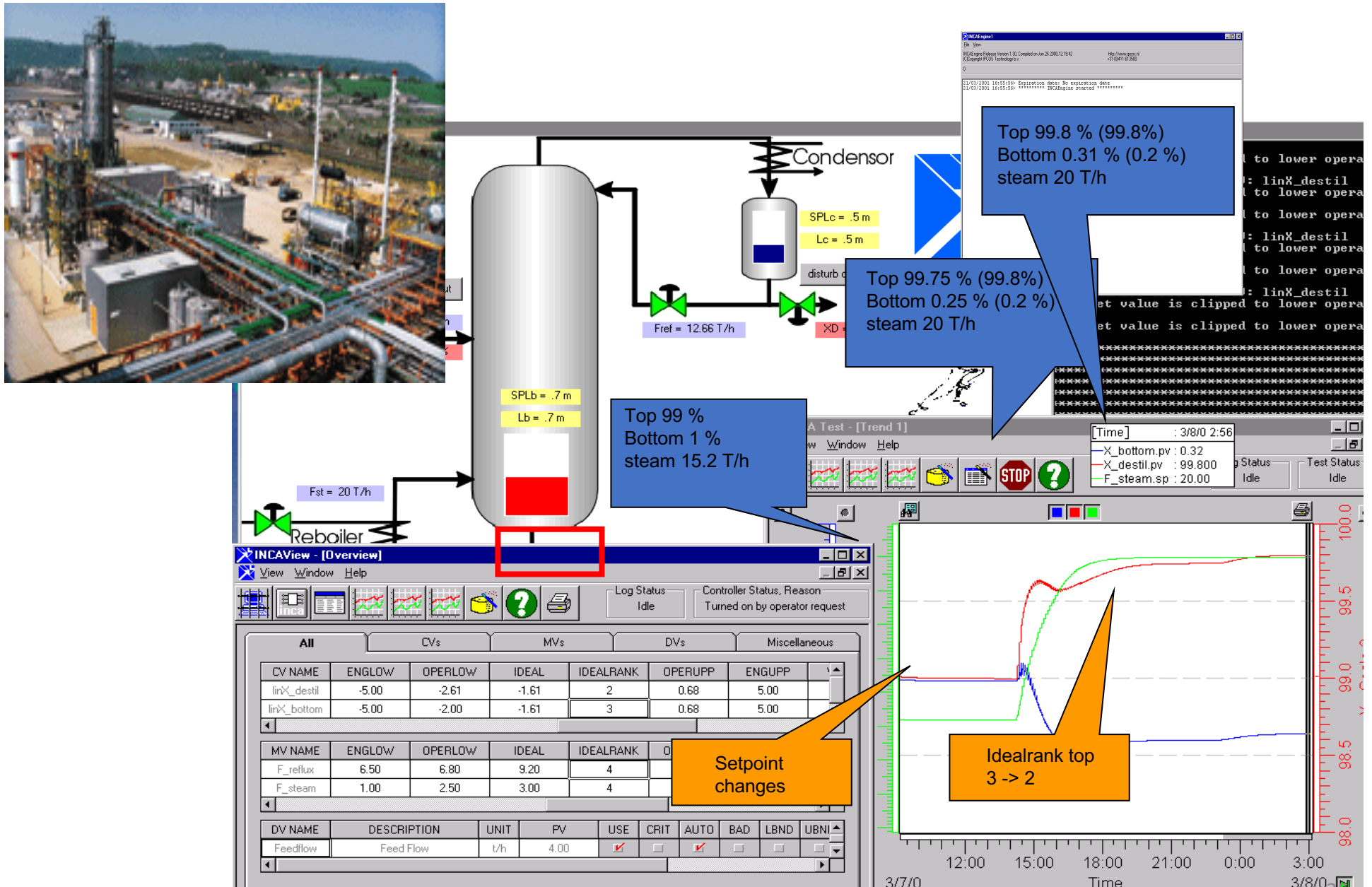
  - **Health**
- The future of AI



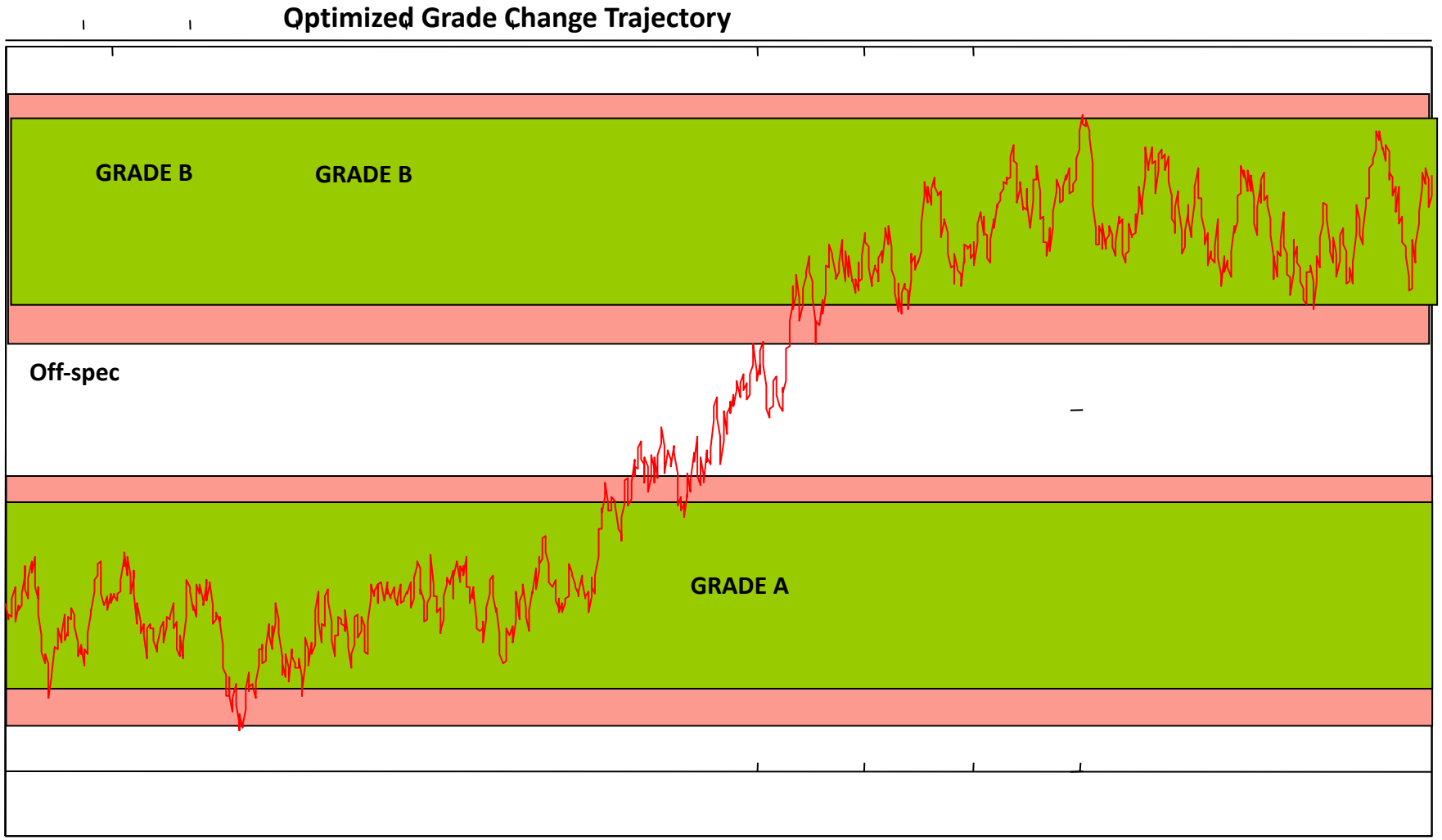
- Cases on time series

- **Process Industry**
  - **Minimum time grade change**
  - **Grade quality optimization**
  - **Change detection**

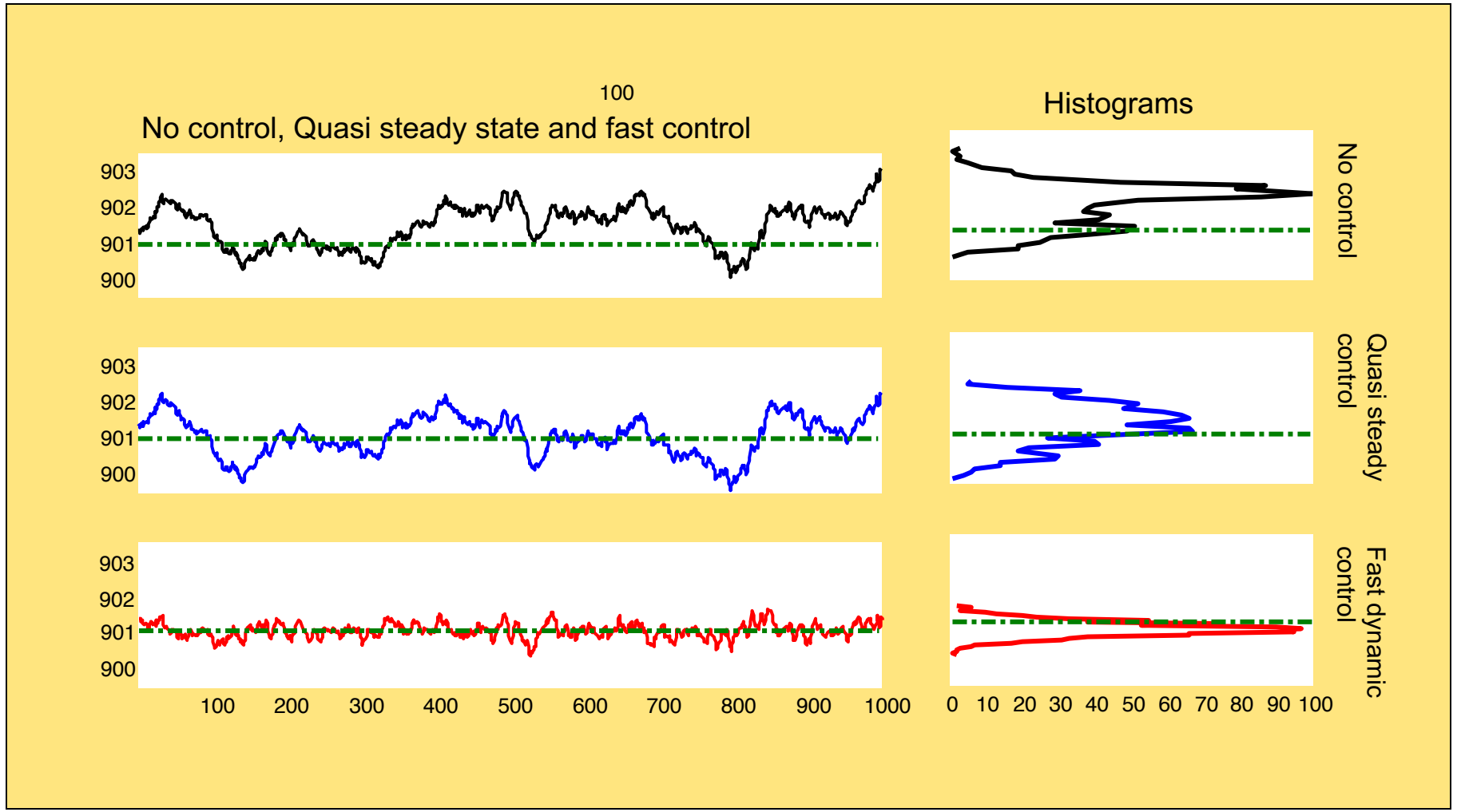
Chemical process DSS



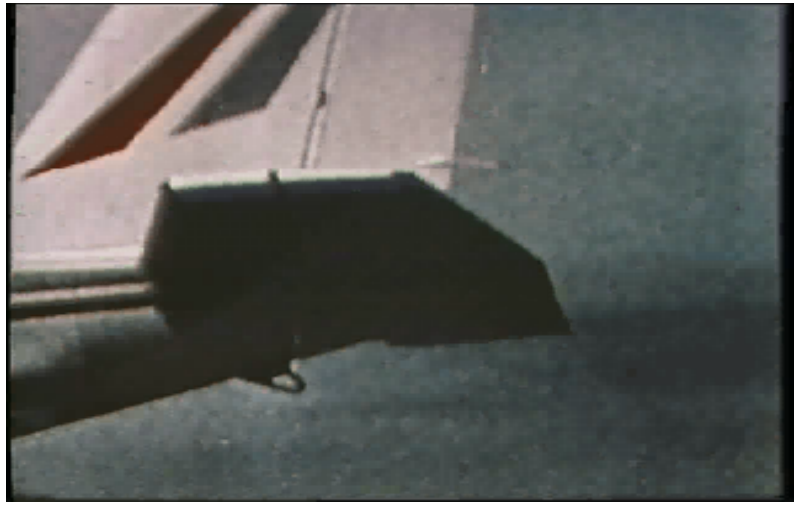
Grade transition with minimum off-spec

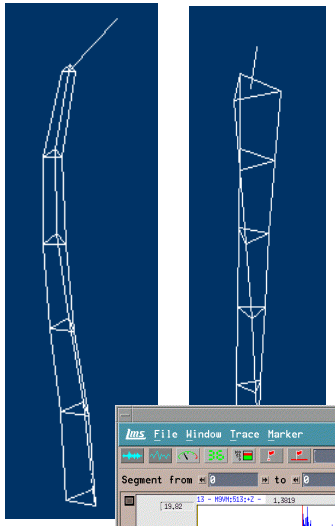


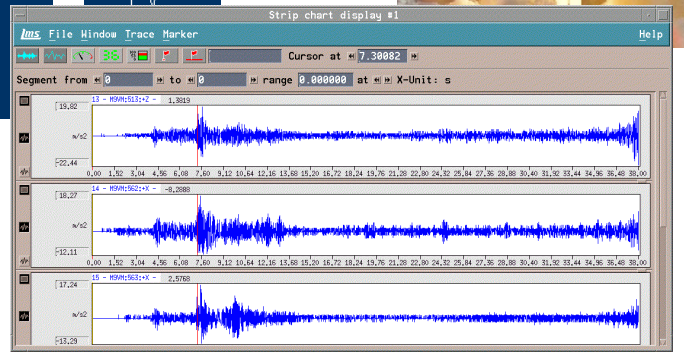
Product quality optimization



Mechanical structure monitoring DSS

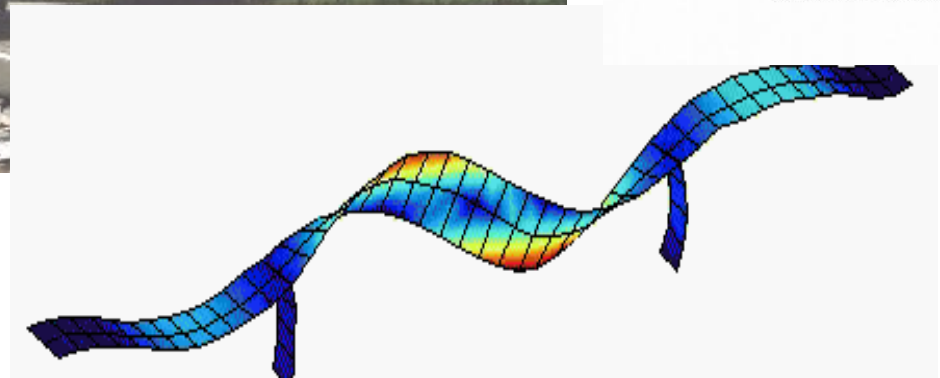


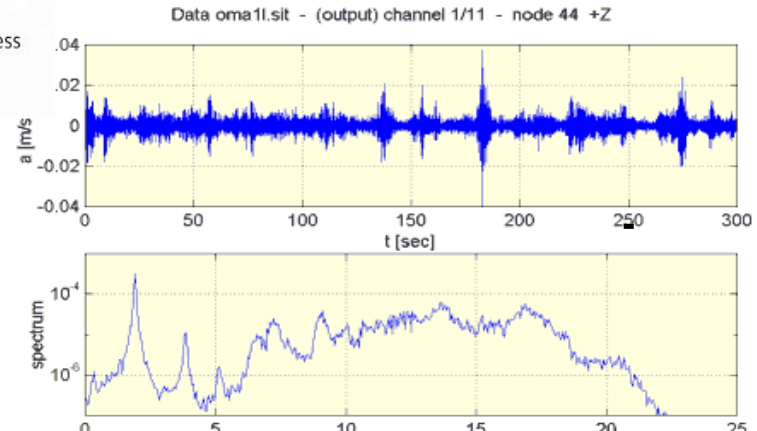




STADIUS
Center for Dynamical Systems, Signal Processing and Data Analytics

LMS®
A Siemens Business





Outline

- AI: Why now ?
- Cases on time series
  - **Utility Networks**
  - **Process Industry**
  - **Health**
- The future of AI

- Cases on time series

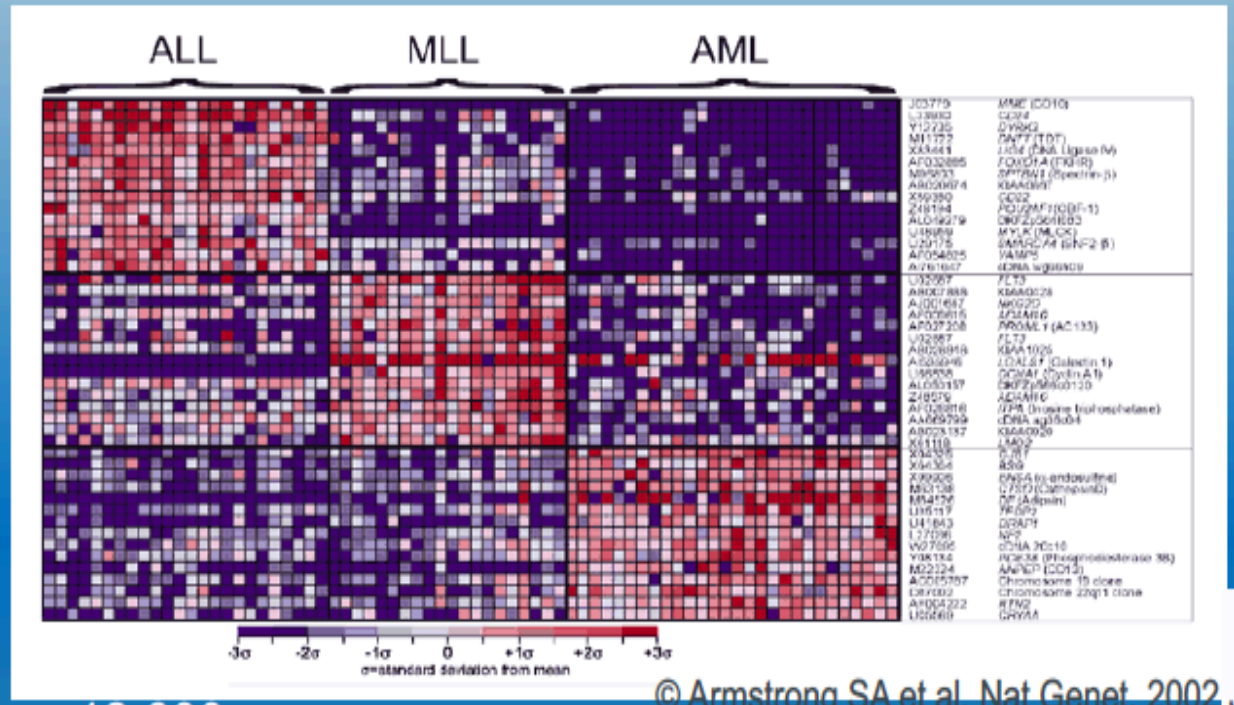
- **Health**
  - **Diagnostics → Clustering**
  - **Kidney Failure → Prediction**
  - **Epilepsy → Change detection**
  - **Intensive care → Monitoring and control**

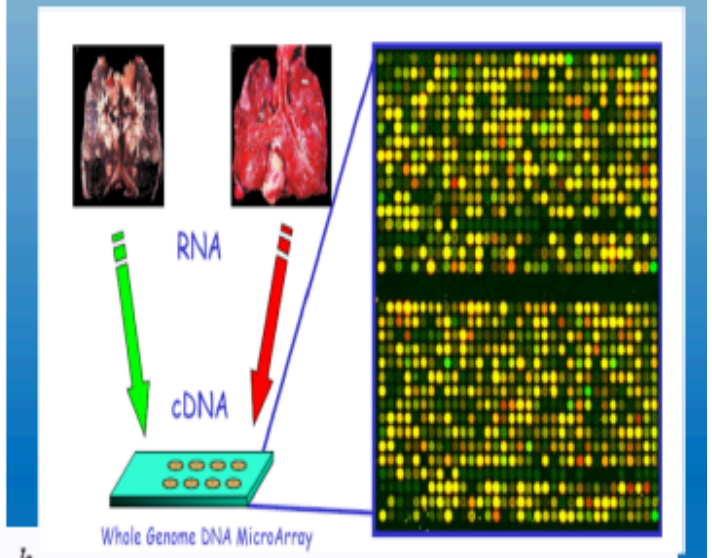
Dr. Algorithm is coming

"In the next 10 years, data science and software will do more for medicine than all the biological sciences together."

– Vinod Khosla, Khosla Ventures

Example: Genomic markers for Leukemia



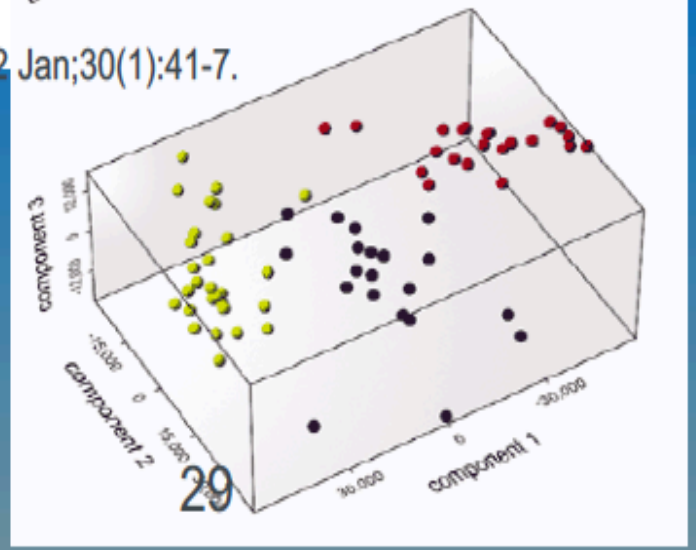


© Armstrong SA et al. Nat Genet. 2002 Jan;30(1):41-7.

12 600 genes

72 patients

- 28 Acute Lymphoblastic Leukemia (ALL)
- 24 Acute Myeloid Leukemia (AML)
- 20 Mixed Linkage Leukemia (MLL)



Forecasting kidney allograft function

Project cooperator: UZ Leuven

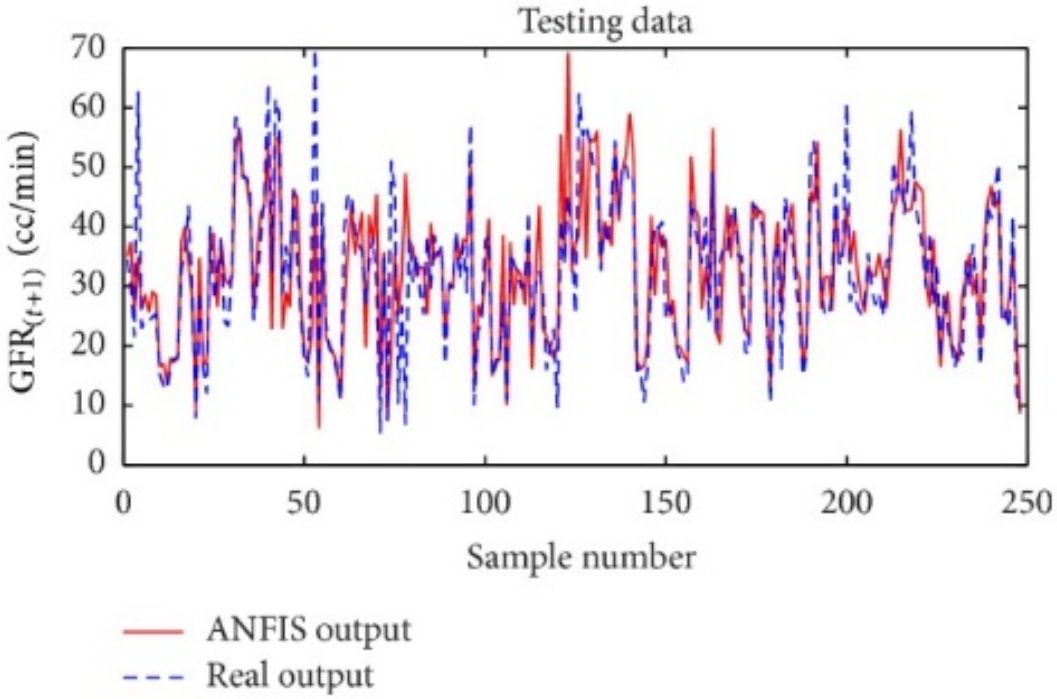
Time: 10/2018 – current (Ongoing)

Aim of Project: Forecast the kidney allograft function after kidney transplantation based on patients' sequential kidney function values

Impact: provide a renal allograft function forecasting model for clinicians to help guide indication for biopsies in transplant recipients in the early stage after kidney transplantation

Related research:

'Predicting Renal Failure Progression in Chronic Kidney Disease Using Integrated Intelligent Fuzzy Expert System' [1]



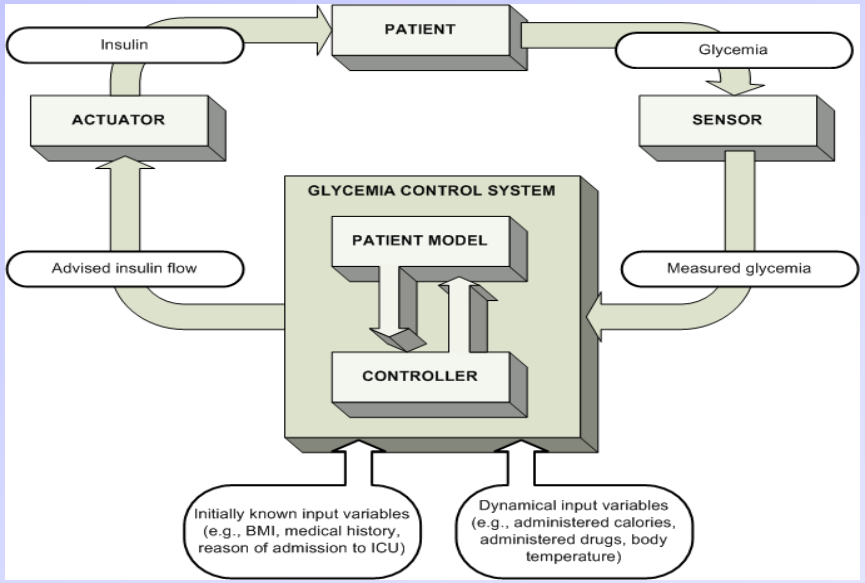
Comparison of the ANFIS prediction and real $GFR_{(t+1)}$ values for the test dataset at 6-month interval [1].

[1] Norouzi, Jamshid, et al. "Predicting renal failure progression in chronic kidney disease using integrated intelligent fuzzy expert system." *Computational and mathematical methods in medicine* 2016 (2016).

The development of a control system to normalize glycemia in critically ill patients

Tom Van Herpe - Prof. Greet Van den Berghe - Prof. Bart De Moor

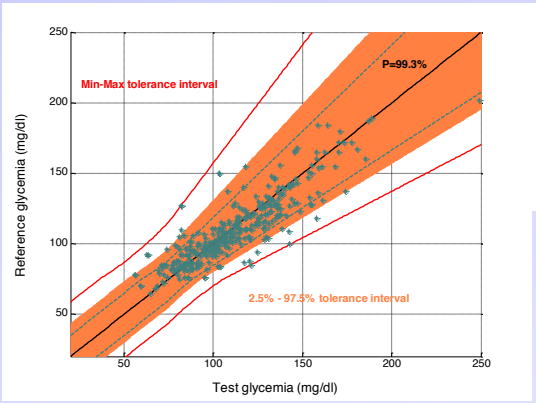
Department of Electrical Engineering (ESAT - SCD) - Intensive Care Unit (ICU - UZ Gasthuisberg)



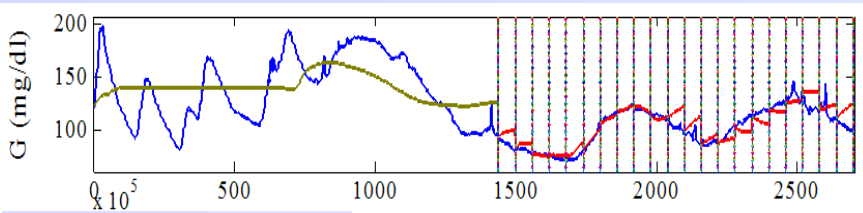
Critically ill patients:
lifes by normalizing glycemia

Saving

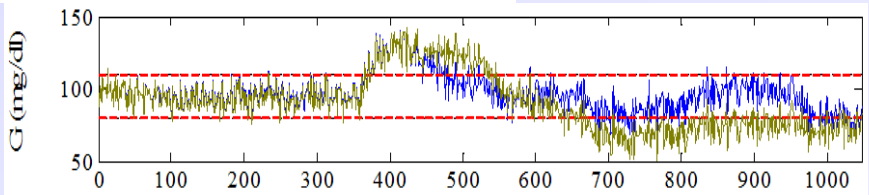
(Semi-)Automated control system leading to decreasing workload for medical staff



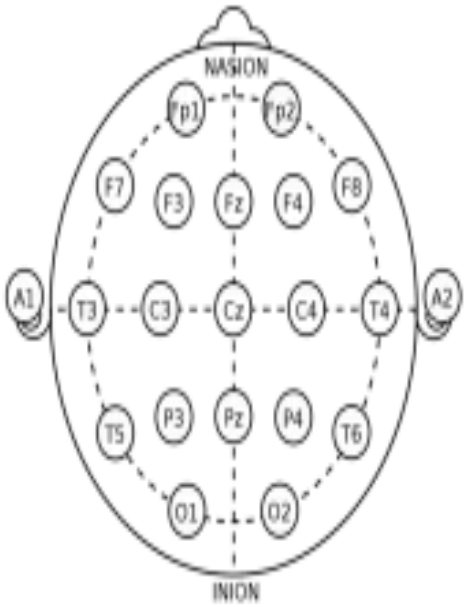
Glycemia sensor validation:
http://www.esat.kuleuven.be/GLYCENSIT

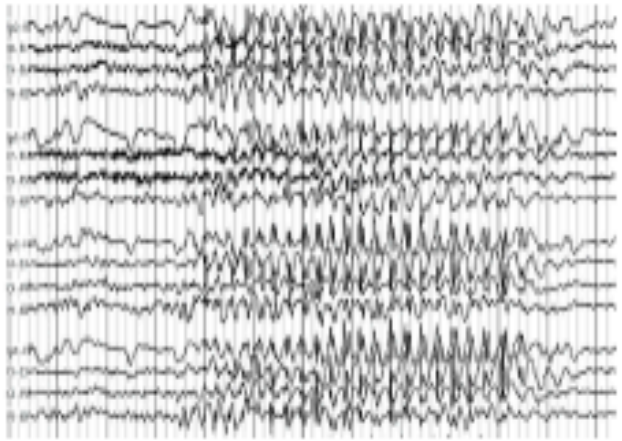


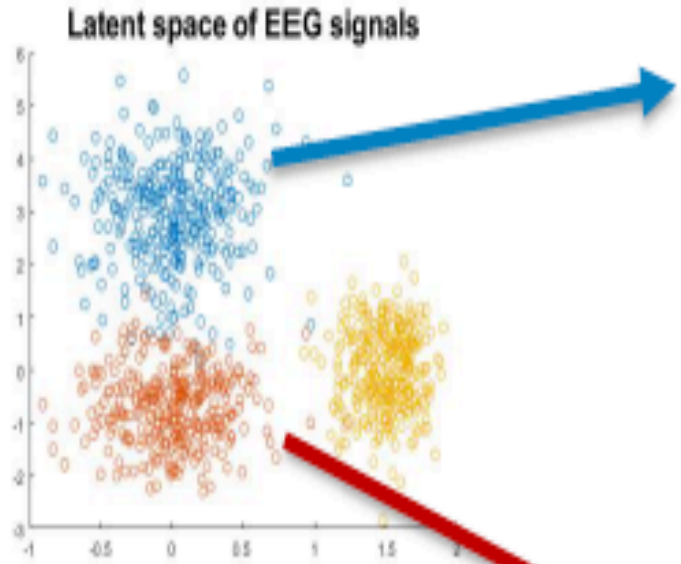
Glycemia prediction

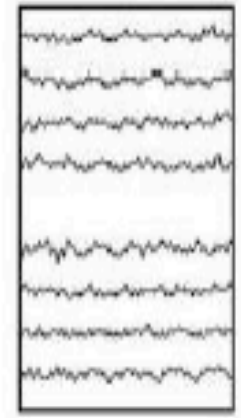


Control of glycemia in normoglycemic target range

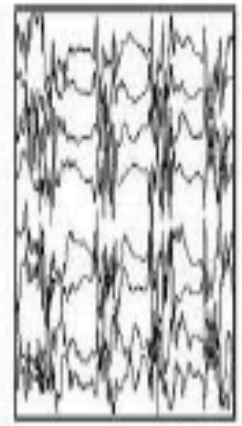




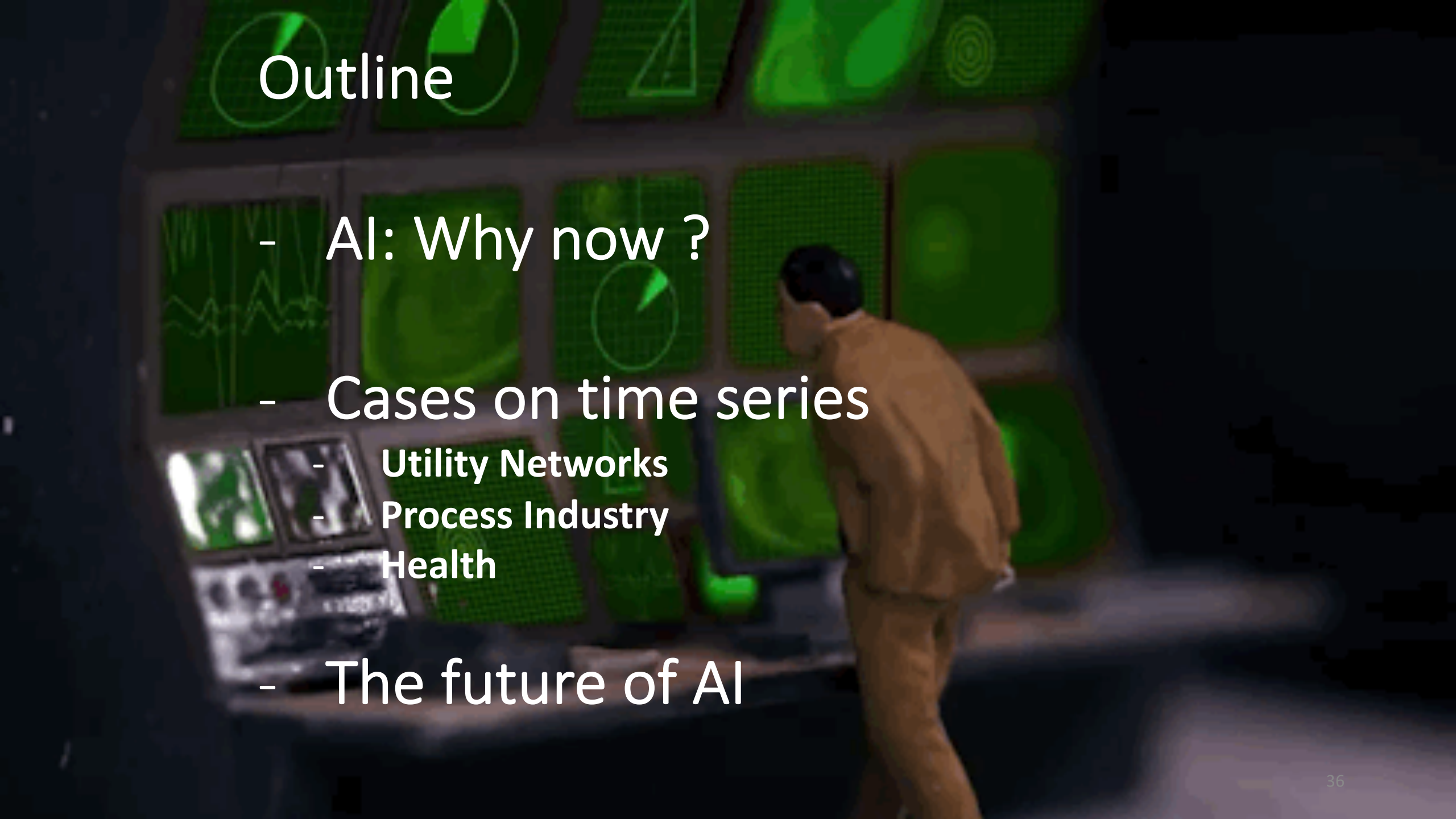




Normal EEG



Generalized seizure EEG



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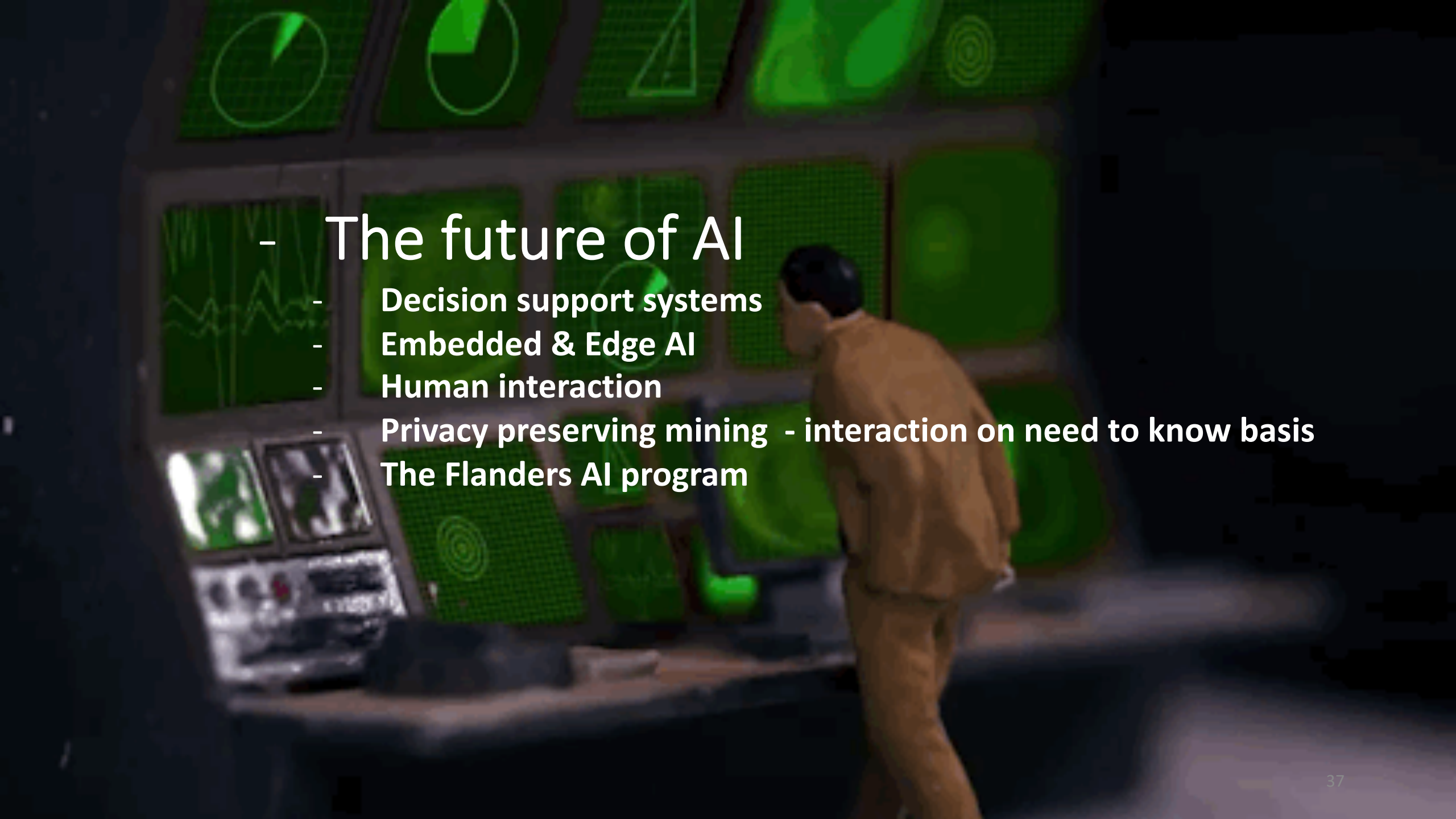
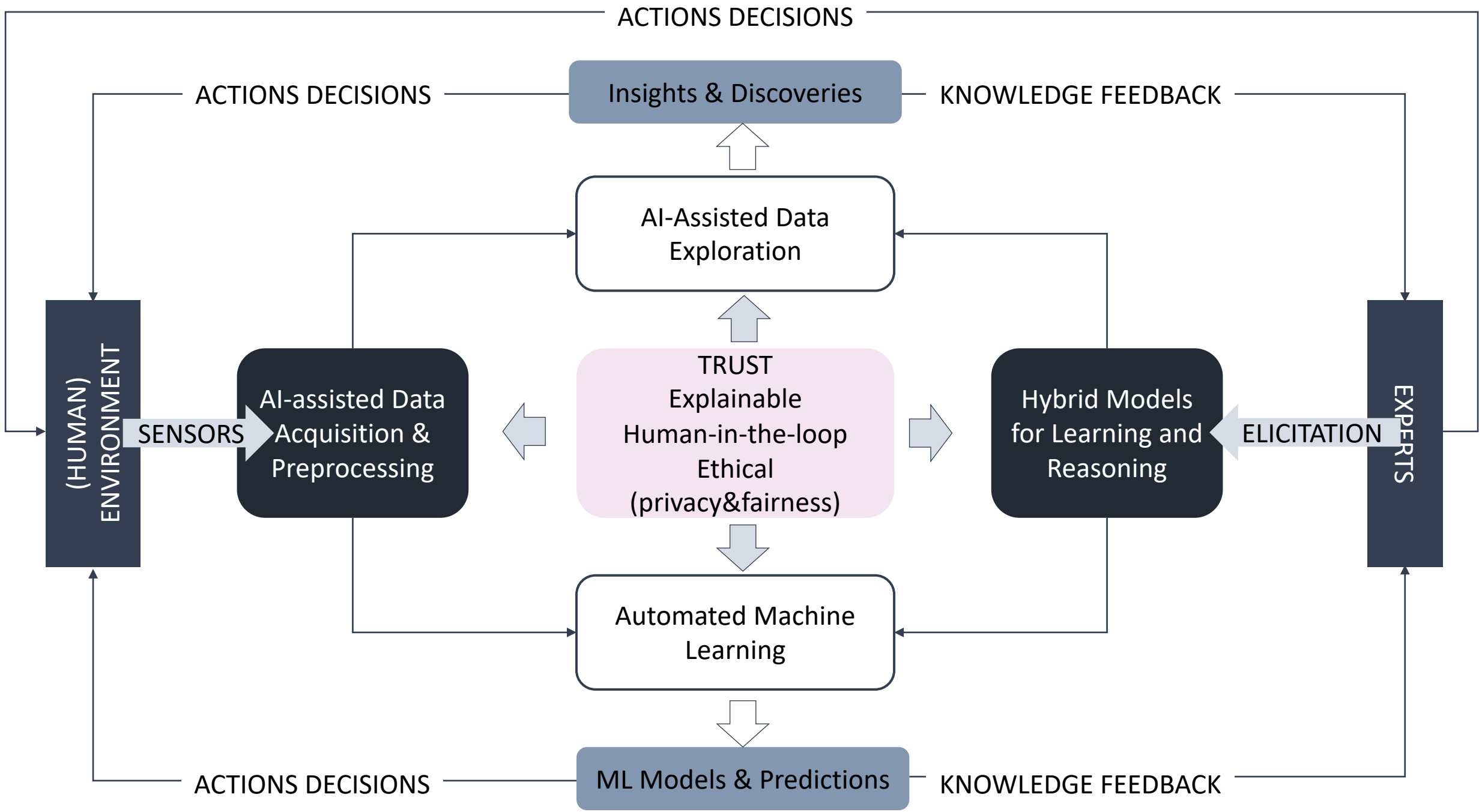
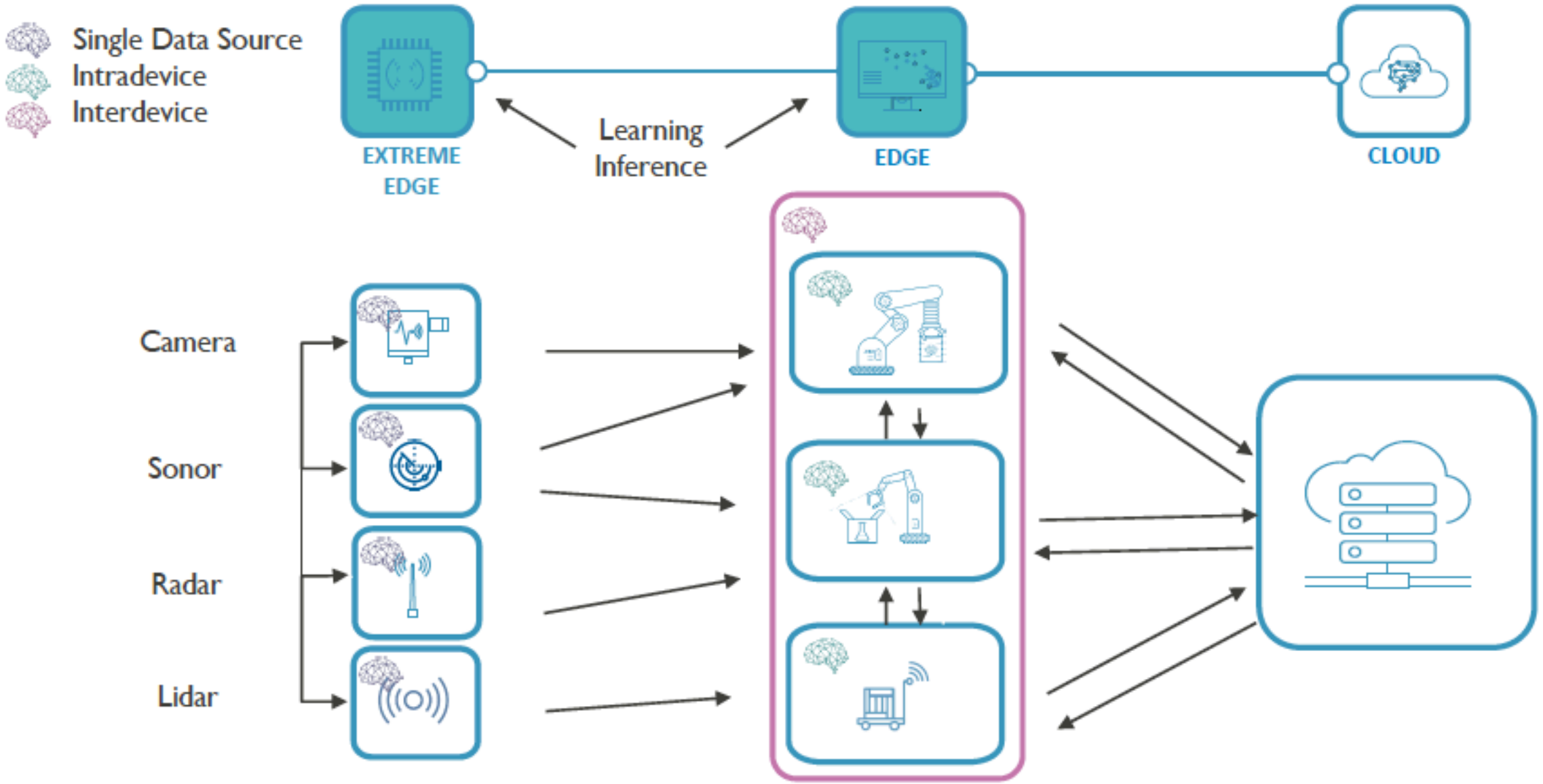


The future of AI

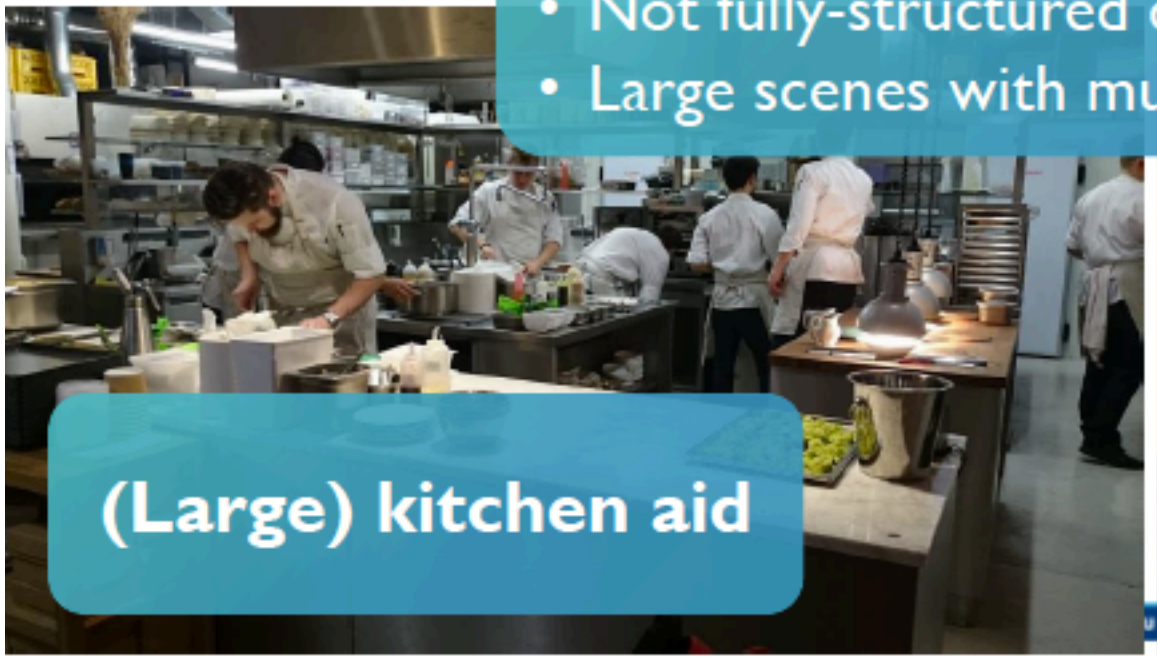
- **Decision support systems**
- **Embedded & Edge AI**
- **Human interaction**
- **Privacy preserving mining - interaction on need to know basis**
- **The Flanders AI program**


ACTIONS DECISIONS
ACTIONS DECISIONS
Insights & Discoveries
KNOWLEDGE FEEDBACK
AI-Assisted Data Exploration
(HUMAN) ENVIRONMENT
SENSORS
AI-assisted Data Acquisition & Preprocessing
TRUST
Explainable
Human-in-the-loop
Ethical
(privacy&fairness)
Hybrid Models for Learning and Reasoning
ELICITATION
EXPERTS
Automated Machine Learning
ACTIONS DECISIONS
ML Models & Predictions
KNOWLEDGE FEEDBACK

FUTURE DISTRIBUTED AI ENVIRONMENTS



- Interaction between AI system – humans
- Not fully-structured domains
- Large scenes with multiple actors



Data interaction on a need to know basis - privacy preserving machine learning

Flanders AI Impulse Program

Program Structure with 3 pillars, funded by the Flemish Government

	Yearly budget
1 FLANDERS AI RESEARCH PROGRAM	12 Mio €
2 FLANDERS AI IMPLEMENTATION PROGRAM	15 Mio €
3 FLANDERS AI SUPPORTING ACTIVITIES: ETHICS, EDUCATION AND TRAINING	5 Mio €

Funding for R&D Projects
Digital transformation trajectories in companies,...

Knowledge Centre Data & Society

Flanders AI Academy

The 2019 IAB advices mapped on the structure of this presentation

(1) BRANDING, VISIBILITY, PR

Valorisation & Outreach

(2) INTERNATIONAL POSITIONING

International Positioning

(3) PROGRAM MANAGEMENT AND STRUCTURE

Organisation, Governance, Program Mgmt
Collaboration with other programs

(4) INTERACTION BETWEEN INDUSTRY AND ACADEMIA

Valorisation & Outreach

(5) PROGRAM EXECUTION

Organisation, Governance, Program Mgmt

CHALLENGE-SPECIFIC ADVICES

Sessions 2, 3 & 4

The ‘triple helix-model’

UNIVERSITIES

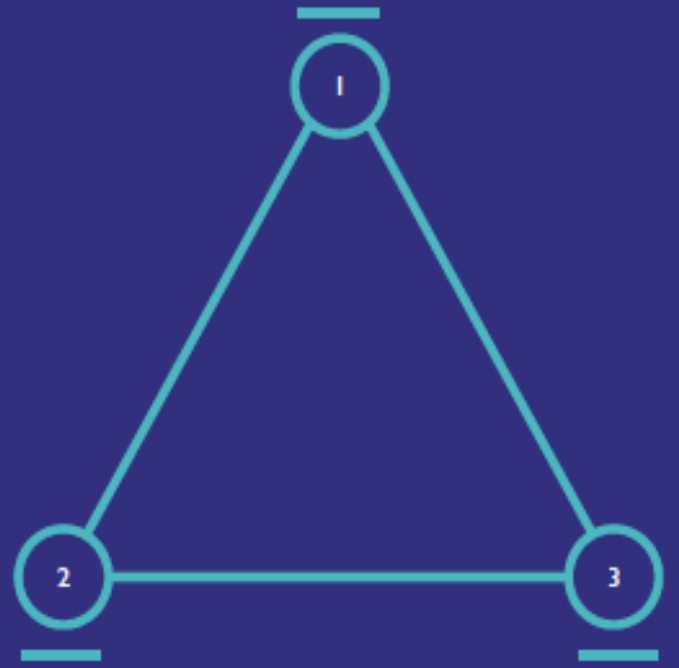
VUB VRIJE UNIVERSITEIT BRUSSEL

KU LEUVEN

Universiteit Antwerpen

UNIVERSITEIT GENT

UHASSELT



5 (STRATEGIC) RESEARCH CENTERS

imec embracing a better life

FLANDERS MAKE

VIB

vito

sirris driving industry by technology

.AGORIA

voka Vlaams netwerk van ondernemingen

sirris driving industry by technology

AGENTSCHAP INNOVEREN & ONDERNEMEN

DEPARTEMENT ECONOMIE WETENSCHAP & INNOVATIE

Our consortium in Numbers

5	Universities
5	(Strategic) Research Centers
40	Research Teams
89	Professors
500	PhD students

100+	R&D projects with funding of Flemish government
200+	Companies in Collaborative funded R&D projects
18	"PhD interns" in companies in 2020
400+	Publications in peer-reviewed journals
40+	European Funded Projects

Challenge-Based Research with Demand-Driven Impact

CHALLENGE BASED RESEARCH

WITH DEMAND-DRIVEN IMPACT

AI-DRIVEN DATA SCIENCE

AI IN THE EDGE

MULTI-AGENT COLLABORATIVE AI

HUMAN-LIKE AI

PROOFS-OF-CONCEPTS (Demonstrators)

FOCUS DOMAINS and USE CASES

CONFIDENTIAL

Management Flanders AI Research Program

Sabine Demey

Director Flanders AI Research Program

imec

AI-driven Data Science

KU LEUVEN

Prof. Bart De Moor

ESAT, KULeuven

UNIVERSITEIT GENT

Prof. Piet Demeester

IDLab, Ghent University-imec

Multi-agent Collaborative AI

Ann Nowé

Professor AI Lab, VUB

VUB VRIJE UNIVERSITEIT BRUSSEL

AI in the Edge

Mieke De Ketelaere

Program Director AI, imec

imec

CONFIDENTIAL

Human-Like AI

Prof. Steven Latré

IDLab, University of Antwerp - imec

Universiteit Antwerpen

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