Silesian University of Technology

RESEARCH UNIVERSITY
EXCELLENCE INITIATIVE
Ministry of Science and Higher Education

SILESIAN UNIVERSITY OF TECHNOLOGY

FOR POLAND IN SILICON VALLEY FOR SCIENCE, INNOVATION, AND ENTREPRENEURSHIP

Prof. Dariusz Mrozek

www.polsl.pl/rau

FACULTY OF

Automatic Control, Electronics and Computer Science

Established in 1964 as the first Faculty of Automatic Control in Poland:

- Full Title Professors: 30+
- Associate Professors (D.Sc.): 50+
- Lectures (Ph.D): 200+
- Students: ~3 000

Towards modern data analytics

Machine Learning & Artificial Intelligence

Data engineering

Big Data

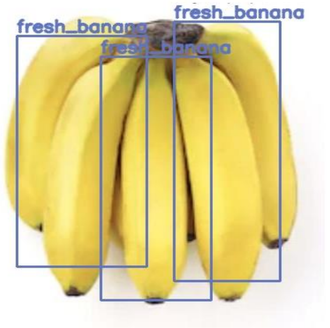
Internet of Things & Sensor Data Analysis

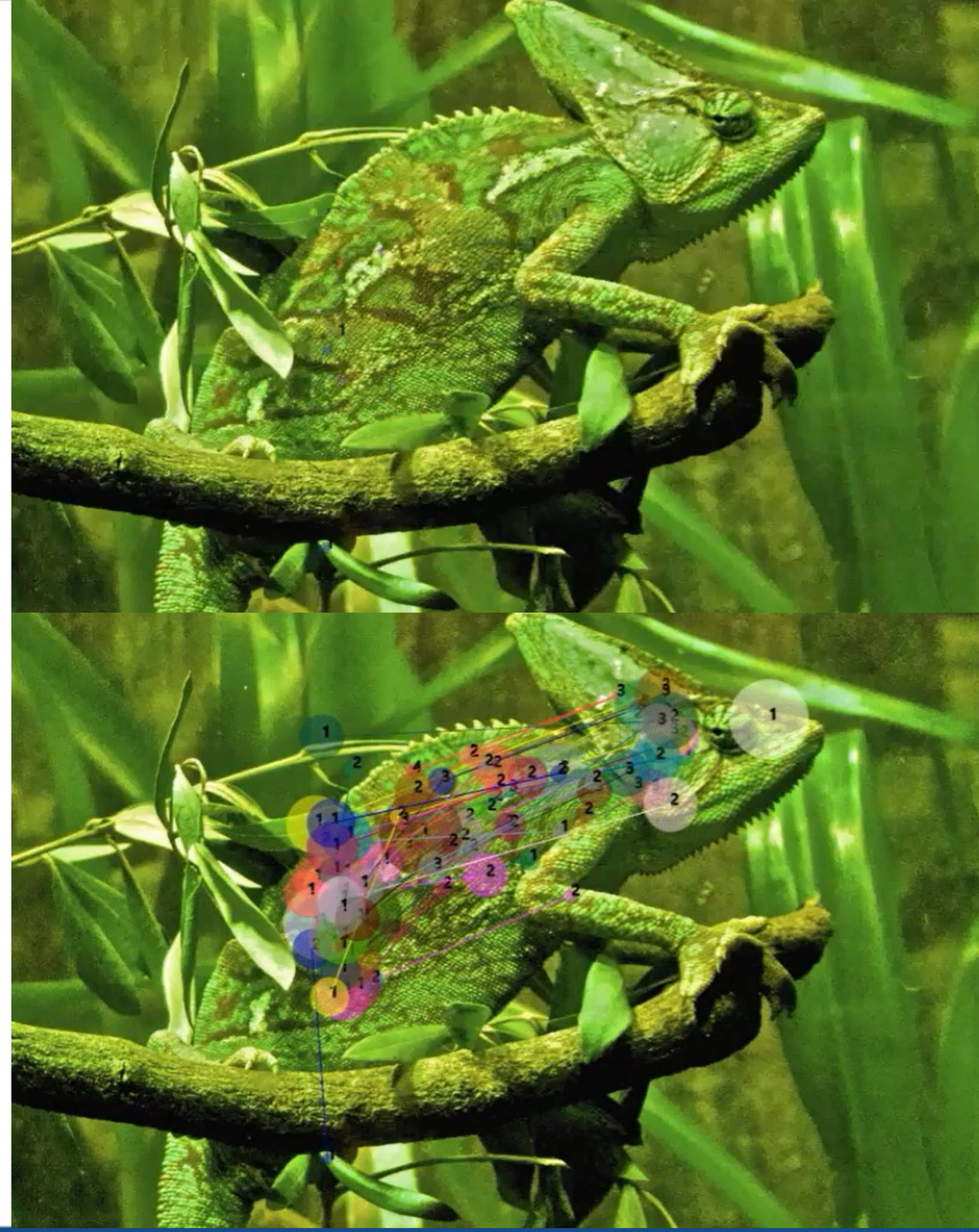
Cloud and Edge Data Science

DATA ANALYTICS AT SUT

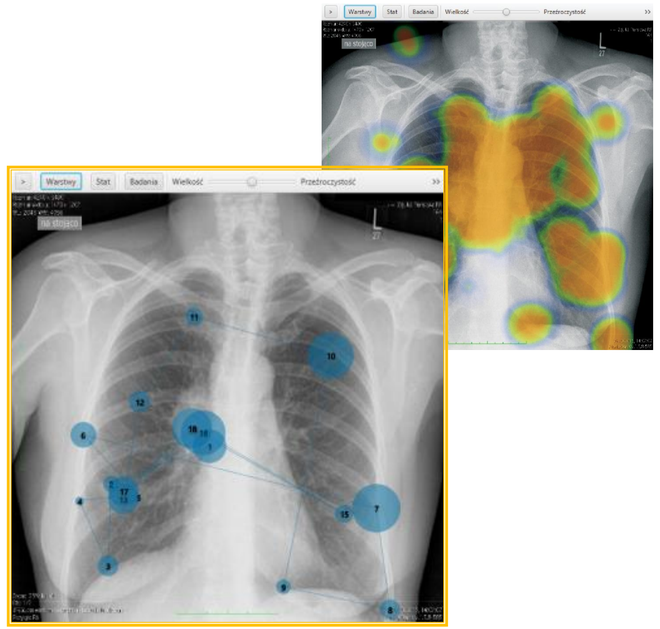
Machine Learning and Artificial Intelligence (AI)

- Deep Learning
- Automated machine learning
- Explainable AI
- Platforms: TensorFlow, Keras, and more

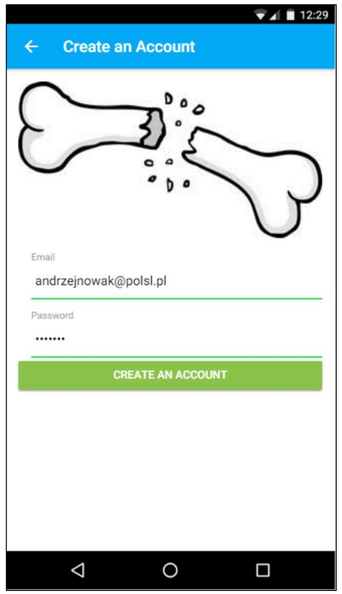




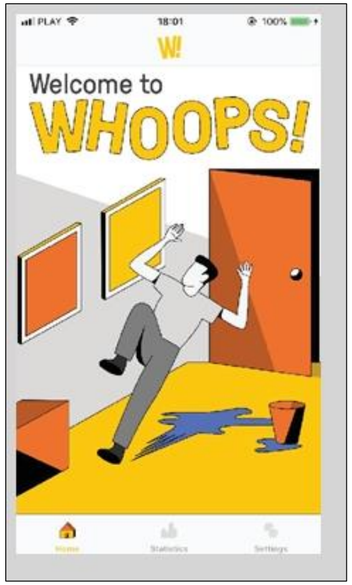
Medical applications and Smart Farming



ML-based COVID-19 lung damage detection



Osteoporosis Risk Calculator



Mobile AI for Fall Detection

Smart Apiaries: detection of diseases in bees

EXAMPLE: SMART FACTORIES

AI-driven AGVs on Production Lines

Cooperation with AIUT Ltd.

- AGV driving, obstacle avoidance and conflict resolving
- Fault detection
- Battery lifetime prediction

DATA ANALYTICS AT SUT

Data engineering and Big Data

- Big Data platforms, incl. Hadoop, Hive, Pig, Spark
- Stream Analytics with Apache Kafka, Spark Streaming, and Flink
- Data Lakehouse solutions
- Large computational clusters for data storage and HPC computations

EXAMPLE: BIG DATA & DATA ENGINEERING

Detecting leaks from liquid fuel tanks

Cooperation with the AIUT Ltd. Company

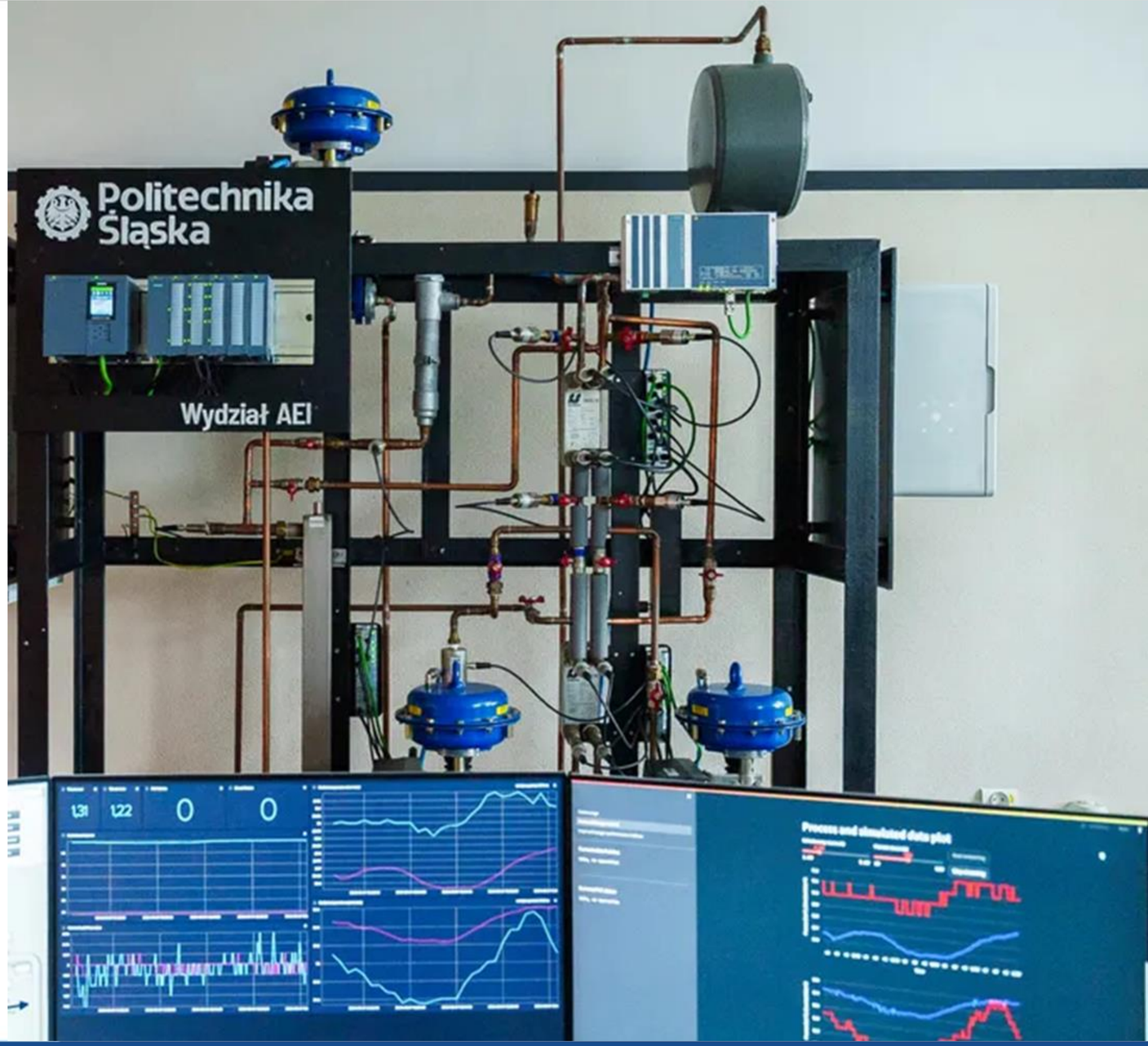
- Data warehouse and Big Data processing
- Statistical data analysis

DATA ANALYTICS AT SUT

Internet of Things & Sensor Data Analysis

- IoT Analytics
- Sensor Data Analysis
- Spatial Data Analysis and Imaging

Cooperation with Siemens company

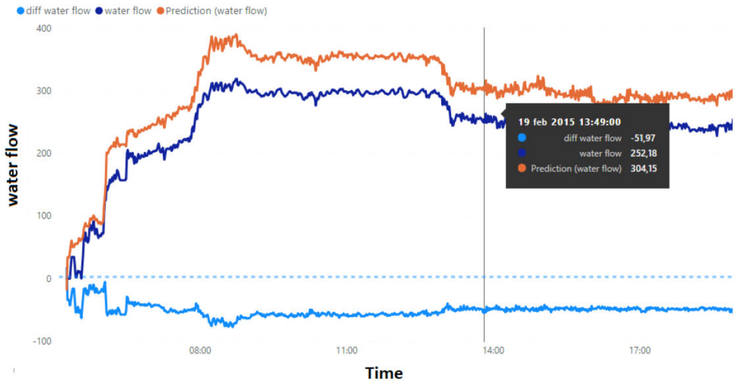


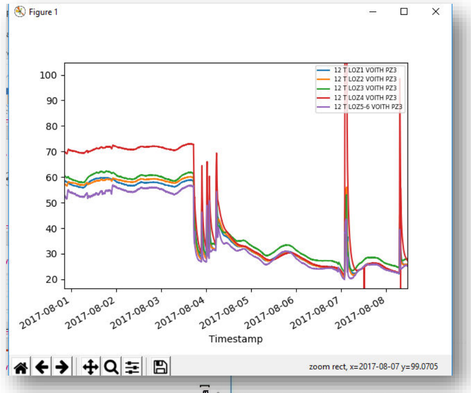
EXAMPLE: IOT & AI

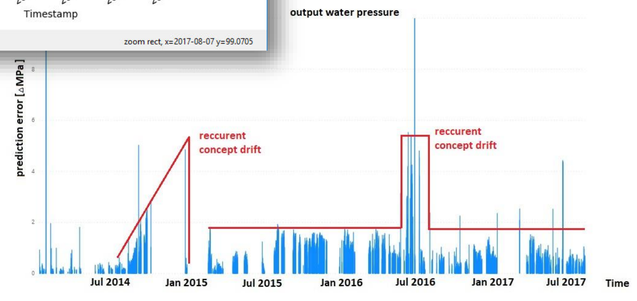
Fault detection in Power Plants

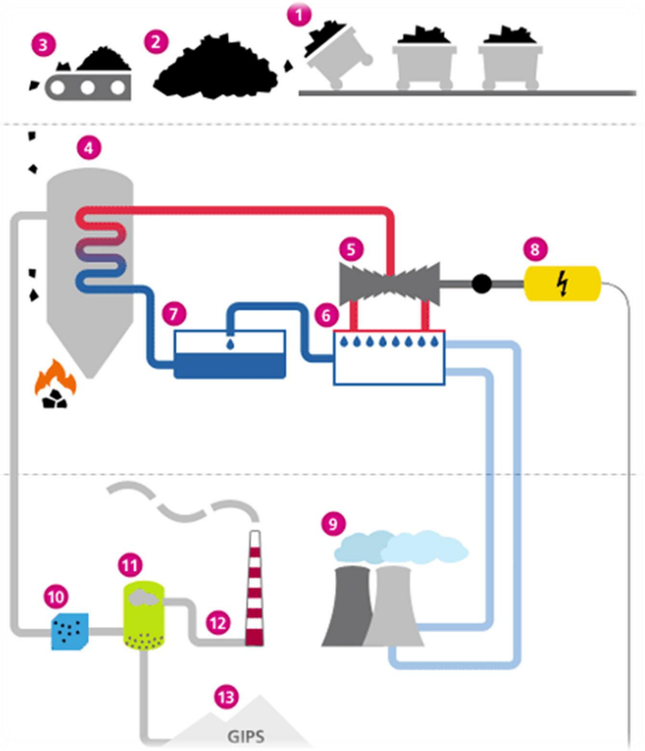
Cooperation with the TAURON Company

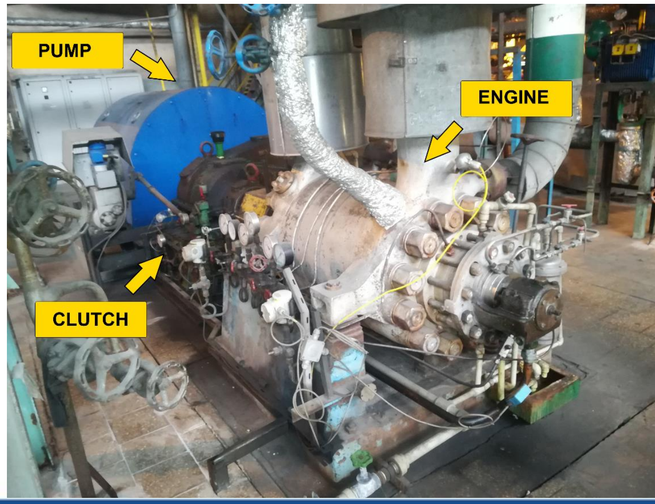
- Sensor-based monitoring and real-time data stream processing
- Predictive data analytics







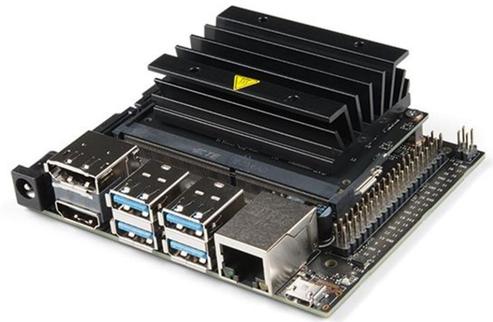




DATA ANALYTICS AT SUT

Cloud & Edge Data Analysis

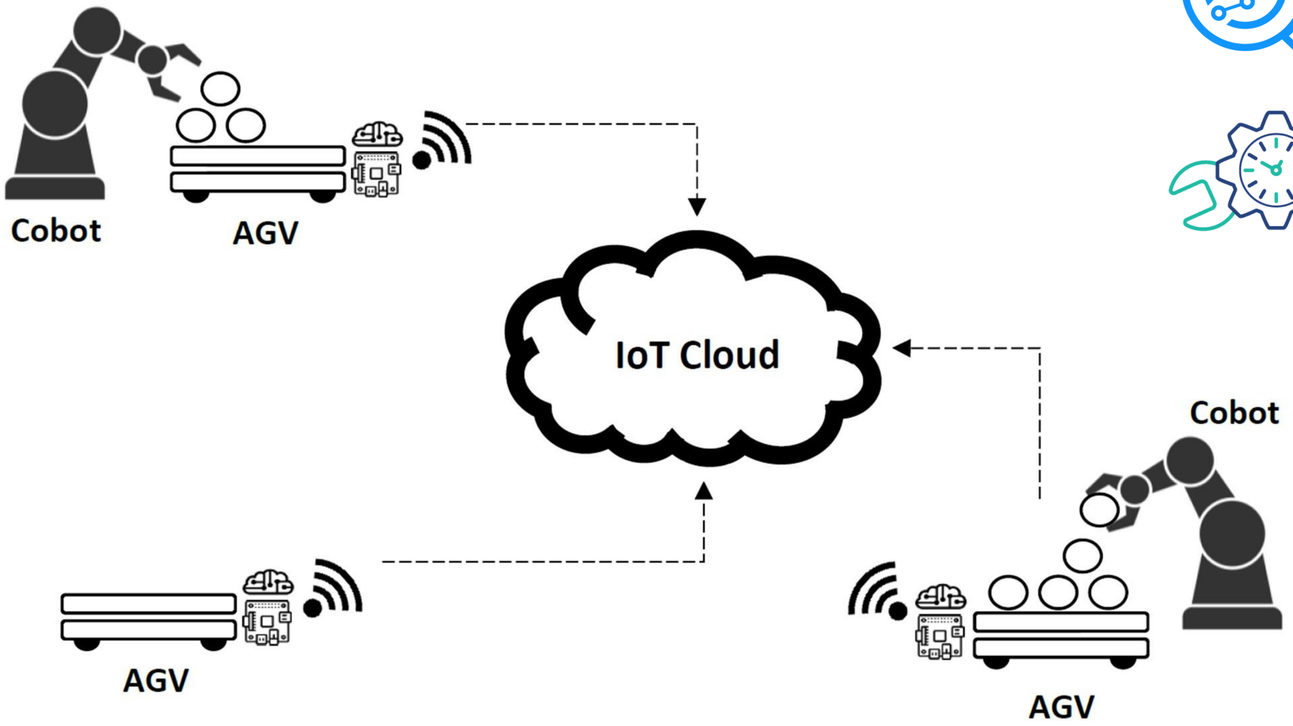
- Scaling storage and computer power for data analysis
- Bringing data analysis and storage close to the data sources



Cloud platforms for Data Analysis

IoT Edge and Cloud in AGV-enabled Smart Factories

- Cooperation with AIUT Ltd. company



Anomaly detection

Predictive maintenance

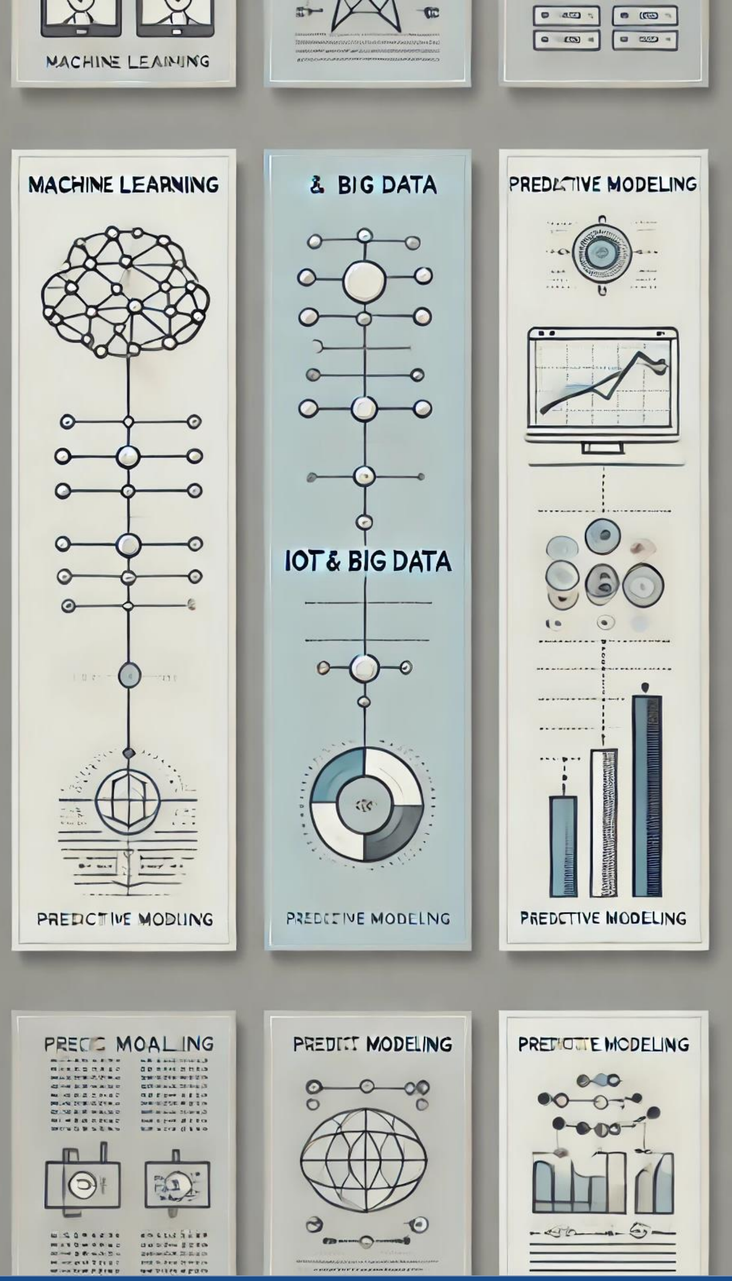
EXAMPLE: CLOUD & EDGE DATA ANALYSIS

Predictive maintenance for industrial AGVs

- Forecasting energy consumption and detecting deviations from normal levels as key factors for successful **predictive maintenance**

- **Machine Learning**:
  - **Neural networks** (LSTM, GRU) for forecasting
  - **Genetic algorithms** for optimizing feature weights fed into forecasting models

- **IoT** and **Big Data**:
  - Integration with IoT systems enables continuous monitoring of operational parameters
  - Big Data platforms support data stream analysis, enhancing system responsiveness



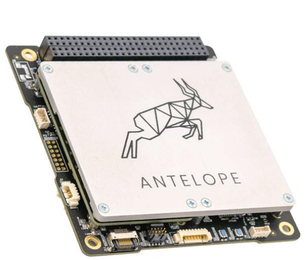
EXAMPLE: CLOUD & EDGE DATA ANALYSIS

Detecting anomalies in AGV

- Goal: Early detection of anomalies in AGV operations (e.g., excessive energy consumption, wheel damage)
- Methodology:
  - Using LSTM and GRU **neural networks** to forecast energy consumption
  - **Genetic algorithms** for selecting and weighting telemetry signals to increase model accuracy
- IoT Integration: AGV sensor data can be analyzed in real-time
- Benefits:
  - Early fault detection, reduced maintenance costs, and extended lifespan of AGV components
  - Enhanced operational efficiency of the AGV fleet in industrial environments

EXAMPLE: EDGE DATA ANALYSIS

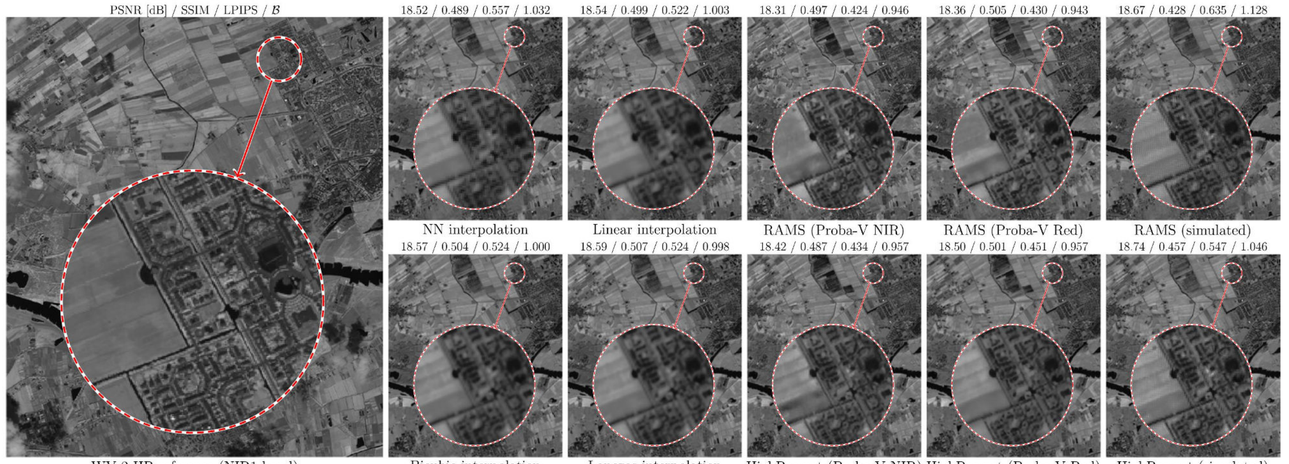
Intuition-1 Satellite



EXAMPLE: SATELLITE DATA ANALYSIS

Satellite image super-resolution

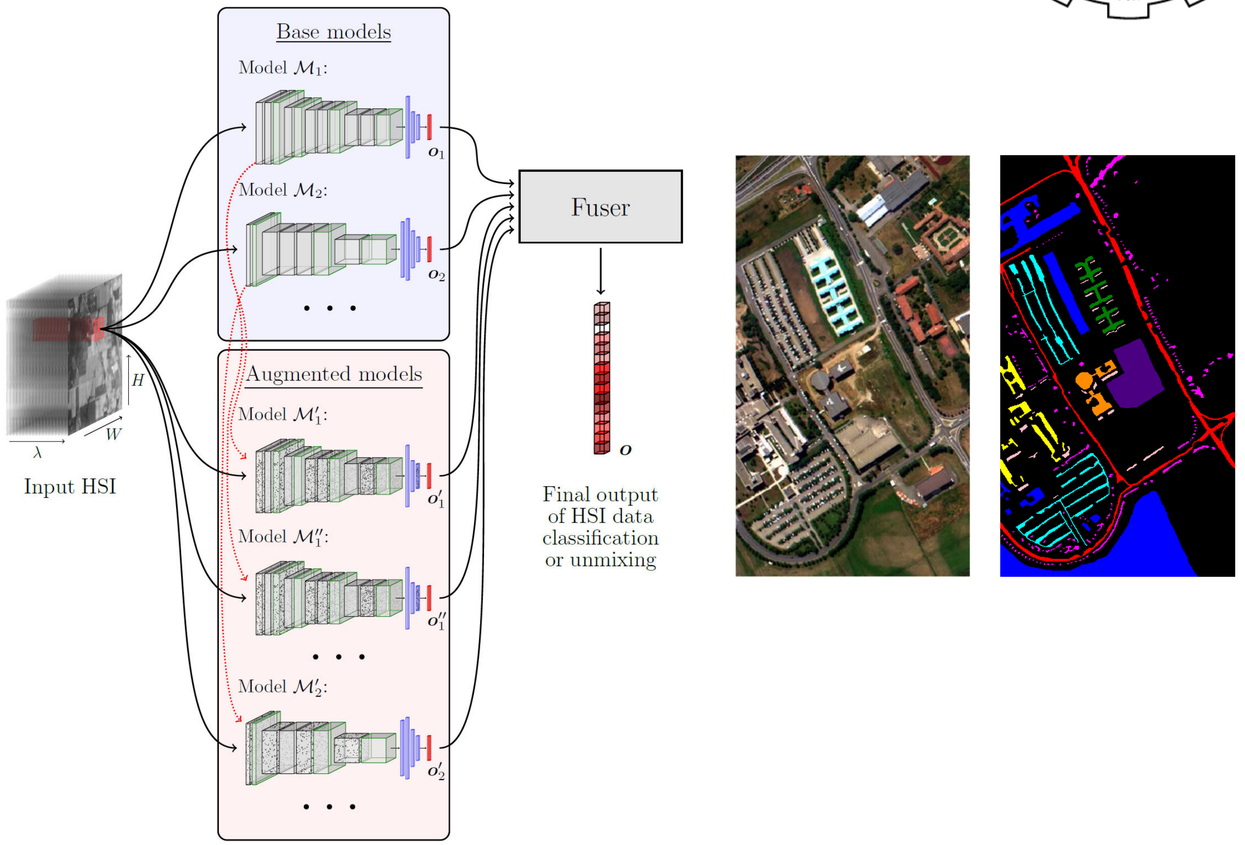
- Algorithms for enhancing image spatial resolution and reconstructing high-frequency details:
  - from a single image
  - from a multitemporal series of images captured at subsequent satellite revisits
  - methods underpinned with convolutional neural networks
- Validation oriented at specific Earth observation tasks
- Applied to a variety of image modalities, including:
  - hyperspectral images
  - multispectral images
  - panchromatic images
- New datasets for benchmarking super-resolution algorithms
  - simulation techniques
  - real-world datasets



Source: P. Kowaleczko, T. Tarasiewicz, M. Ziaja, D. Kostrzewa, J. Nalepa, P. Rokita, and M. Kawulok, "A realworld benchmark for Sentinel-2 multi-image superresolution," Scientific Data, vol. 10, no. 1, p. 644, 2023

Earth observation applications

- Earth observation tasks:
  - soil parameter estimation
  - precision farming
  - air and water quality assessment
  - road and building segmentation
  - extraction of cultivated land maps
  - land-use classification and segmentation
  - and more...
- Image modalities:
  - hyperspectral images (e.g., PRISMA mission)
  - multispectral images (e.g., Sentinel-2 images)
- Methods:
  - deep learning and ensembling techniques
  - convolutional neural networks
  - graph neural networks
  - recurrent neural networks



Source: J. Nalepa, M. Myller, L. Tulczyjew, and M. Kawulok, "Deep Ensembles for Hyperspectral Image Data Classification and Unmixing," Remote Sensing, 13(20), 4133, 2021

Scientific projects

We are successful in obtaining external financing from different resources:

- Europe Union resources FP6, FP7, H2020, HE
- the EEA and Norway grants
- Microsoft Research, USA and Amazon, USA grants
- Ministry of Science and Higher Education
- National Science Centre, Poland
- The National Centre for Research and Development
- Polish Academy of Sciences

Narodowe Centrum Badań i Rozwoju

SIXTH FRAMEWORK PROGRAMME

SEVENTH FRAMEWORK PROGRAMME

ICELAND LIECHTENSTEIN NORWAY eea grants

norway grants

THE FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION HORIZON 2020

HORIZON EUROPE

Ministerstwo Nauki i Szkolnictwa Wyższego

NARODOWE CENTRUM NAUKI

STUDENTS RESEARCH CLUBS

Data Analytics in Student's Projects

- High Flyers – smart drones

  3rd place in the IEEE Autonomous UAV Chase Challenge, Purdue University, USA, 2023

- Control Engineers – autonomous guided vehicles

- Data science – algorithms for data analysis, risk prediction, object detection