



Towards AI powered manufacturing services, processes, and products in an edge-to-cloud-knowlEdge continuum for humans

**Kautex Pilot
Dissemination Meeting, Online,
2024-03-13**



Anomaly Detection

Outline

- Kautex pilot overview
- Decision Support Framework for Anomaly Detection
- Model building, labeling & recommendation
- Impacts

Kautex Pilot Overview

Decision Support Framework (DSF)



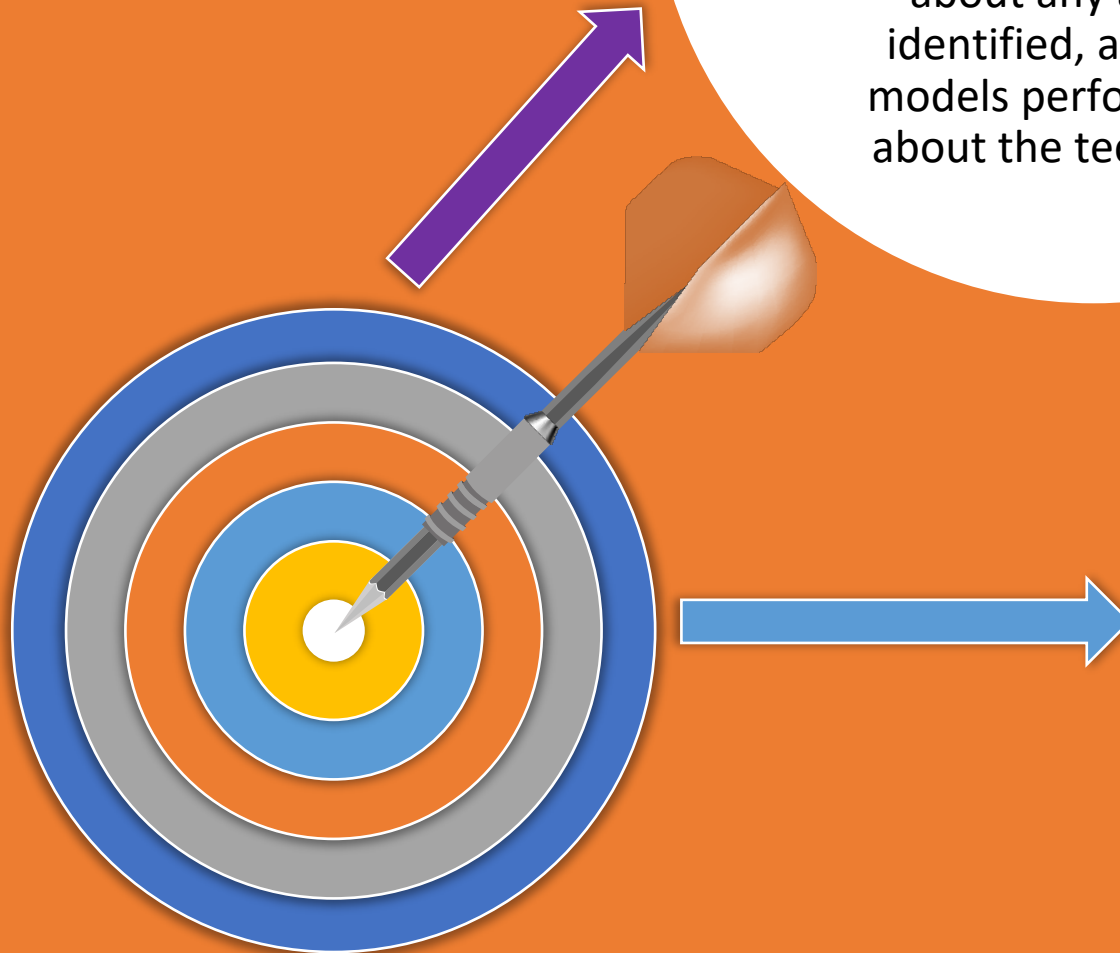
Demo Session

Scenario

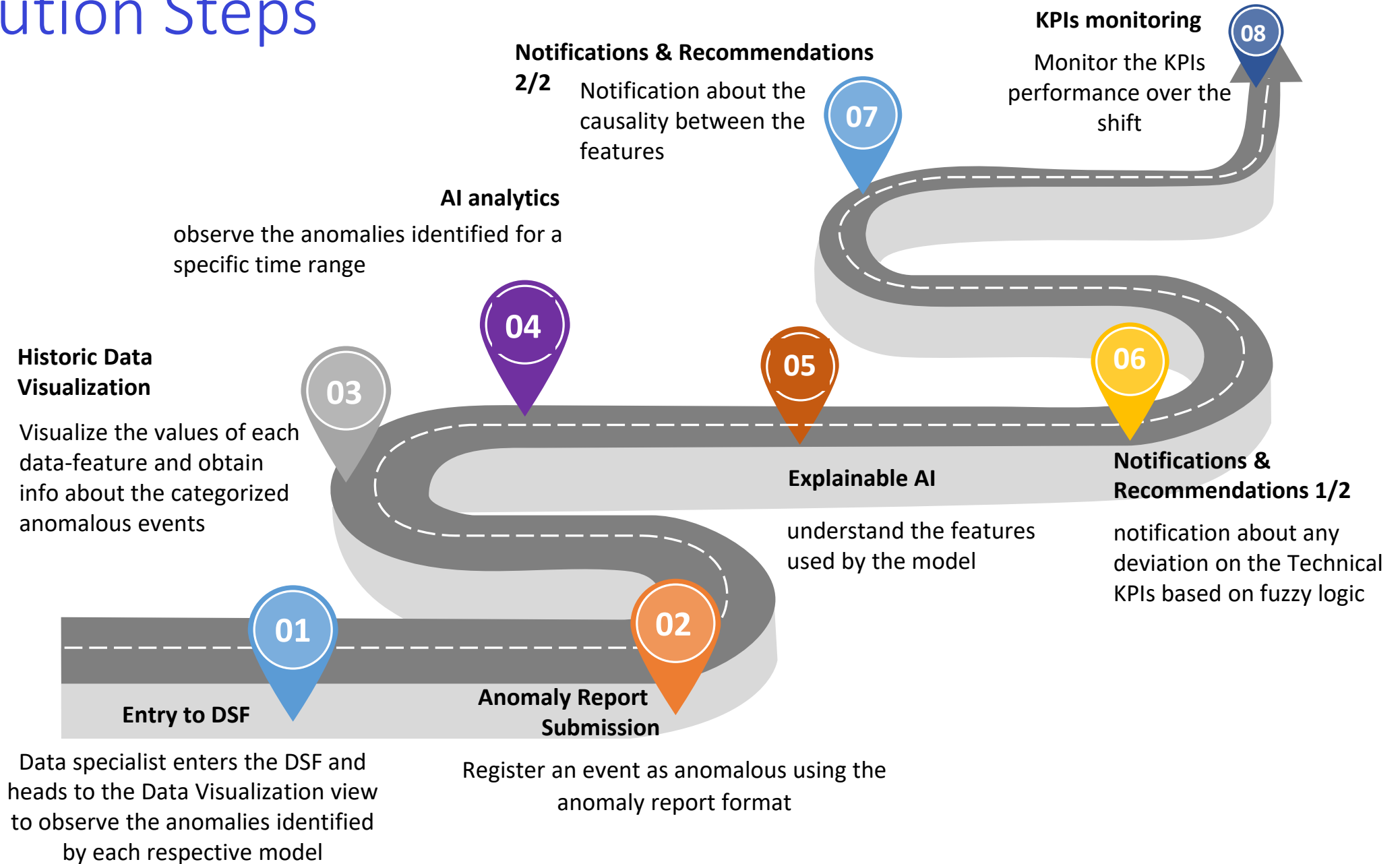
The data specialist wants to be informed about the anomalies detected during a shift. For this reason, he/she wants to be informed about any anomalies identified, about the AI models performance and about the technical KPIs.

Objectives

1. Demonstrate the assistance of a decision support framework for anomaly detection to enhance the process efficiency.
2. Showcase the ability to create anomaly reports
3. Utilize the CausaLogic Recommender to identify underlying patterns in the data and understand the root cause of anomalies



Execution Steps





Home

Data Sources & Monitoring

AI Analytics & Explanation

Key Performance Indicators (KPIs)

Recommendations

Decision Support System Homepage

Welcome

Data Sources & Monitoring



This section includes live and historical monitoring of all the available data sources. You can either explore these data sources or visualize them using various parameters.

AI Analytics & Forecasting



In this section you can explore all the available Artificial Intelligence (AI) models created by the KnowEdge team. All these models can be used in forecasting and their outcomes can be examined in historical data. Depending on the performance of the models you can select which ones to trust.

Notifications & Recommendations



Here you can view all the available notifications and their corresponding recommendations



Key Performance Indicators (KPIs)



In this section you can explore all the available Key Performance Indicators (KPIs). You can see the details of the already existing and even create a new one. Furthermore, you can select a KPI to visualize it.



Model Building, Labeling & Recommendation

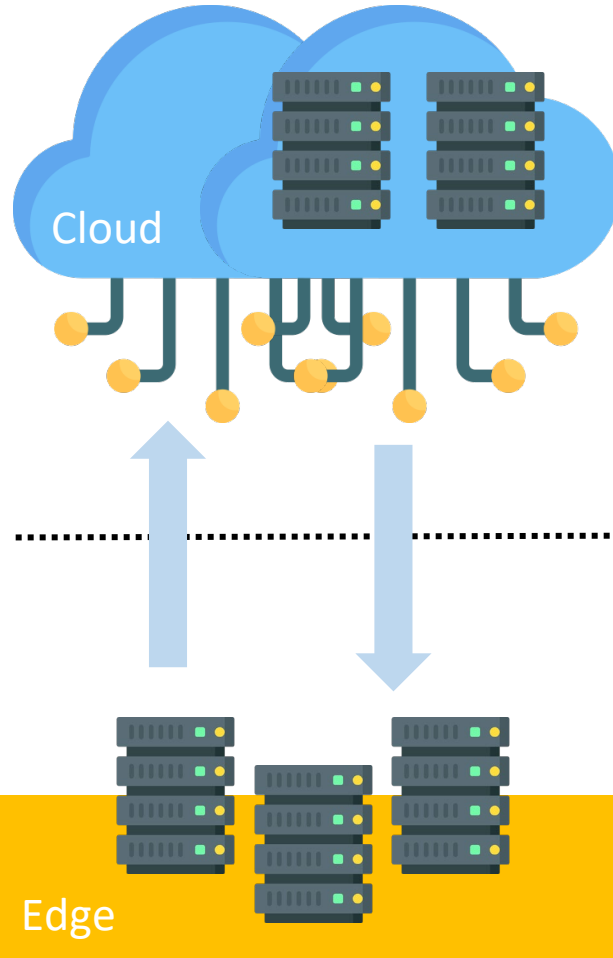


-> Scenario



Scenario

Training Cloud-Based/Inference Fog-Based



High computational capabilities



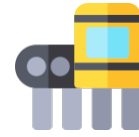
Complex trainings
Processing extensive datasets

Closer to the client infrastructure



Efficient inference tasks
Local data more accessible

Scenario



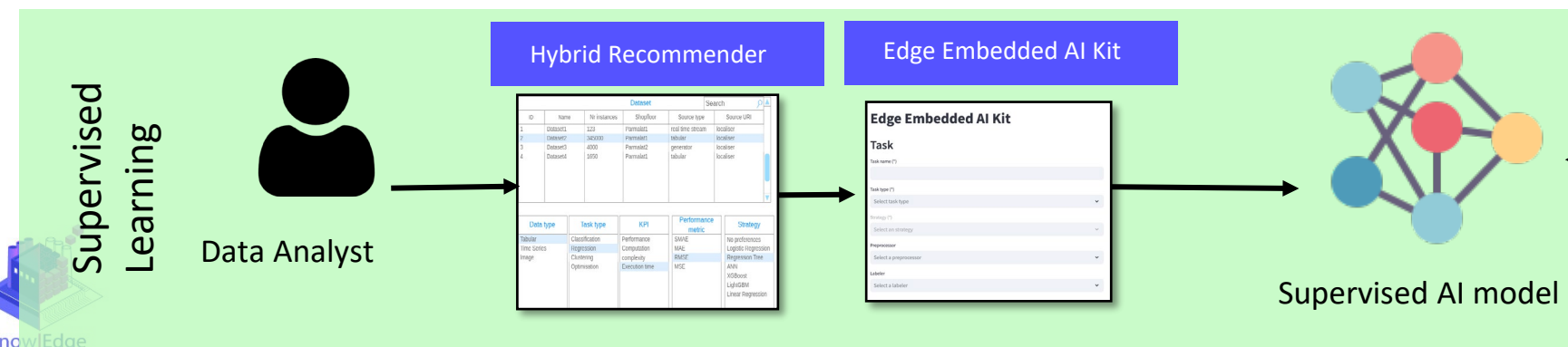
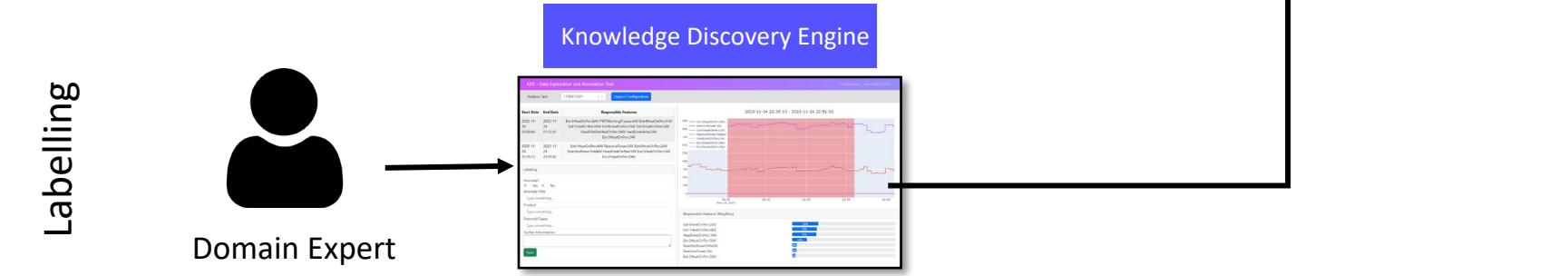
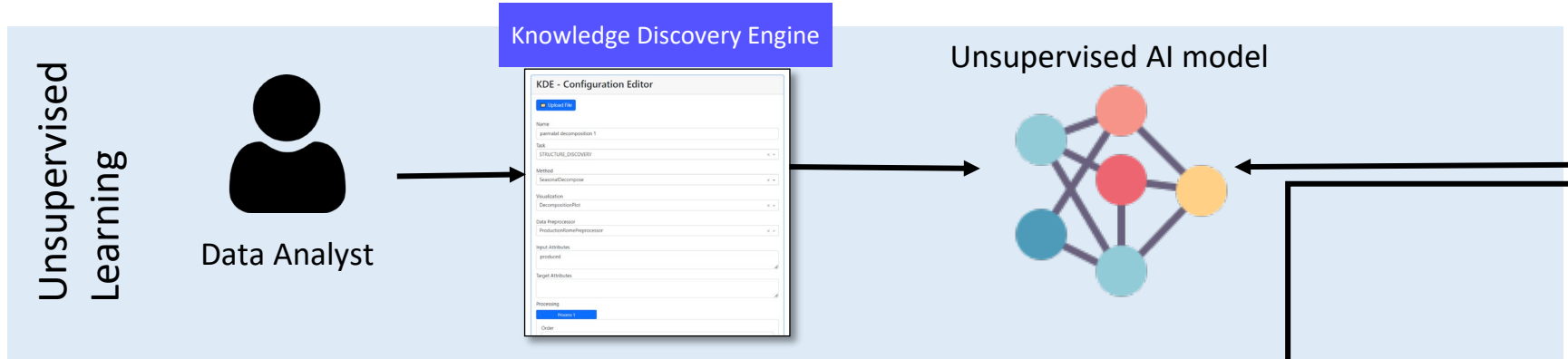
Manufacturing data



Historical Data Storage



Static Quality data



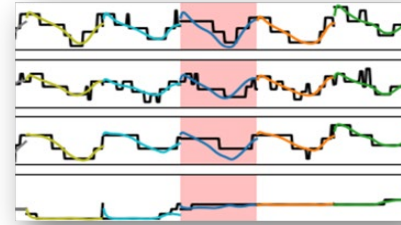
→ Approach



Tasks

Unsupervised Task - Detection of unusual behaviours in the data

- Multivariate anomaly identification in manufacturing data
- Manual evaluation and correction of identified anomalies

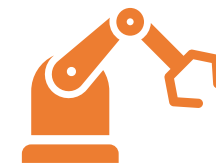


What is the usual behavior?



Supervised Task - Detection of anomalies via examples

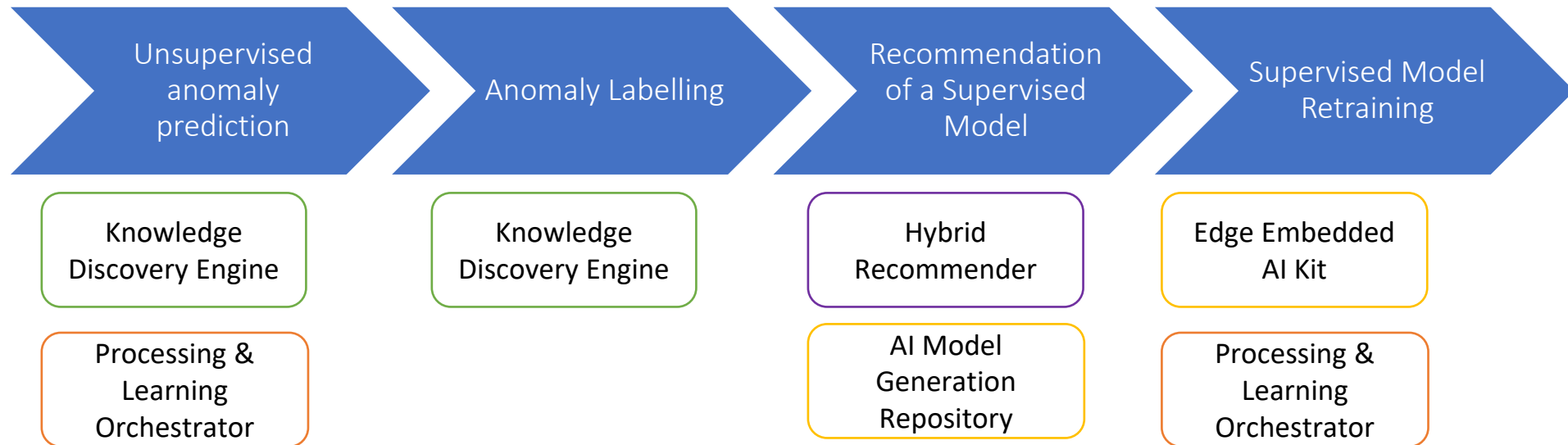
- Anomaly prediction by matching manufacturing and quality data
- Identification of relations between individual machine attributes and invalid quality values
- Recommendation of supervised algorithms for this task based on cost consumption



How do anomalies look like?



Workflow



Unsupervised Anomaly Prediction



Problems that can be solve

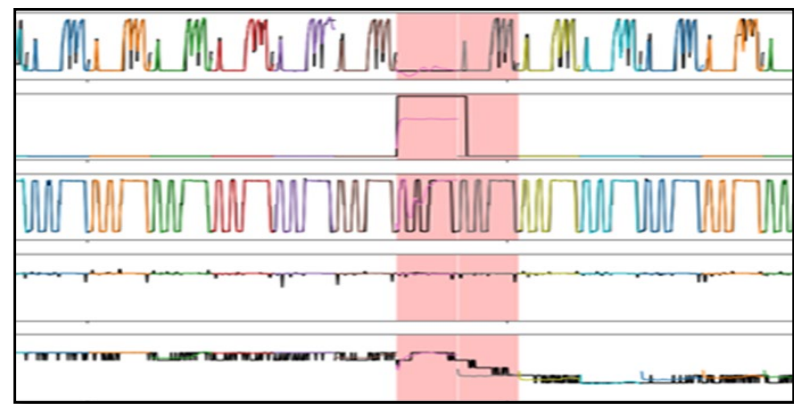
- Clustering -> "Which different types of anomalies we do have ?"
- Feature Extraction -> "Which are the features affecting the anomalies ?"
- Structure Discovery -> "Are there any hide patterns we are not considering ? "
- Outliers Detection -> "Do we have anomalies in a certain period of time ? "



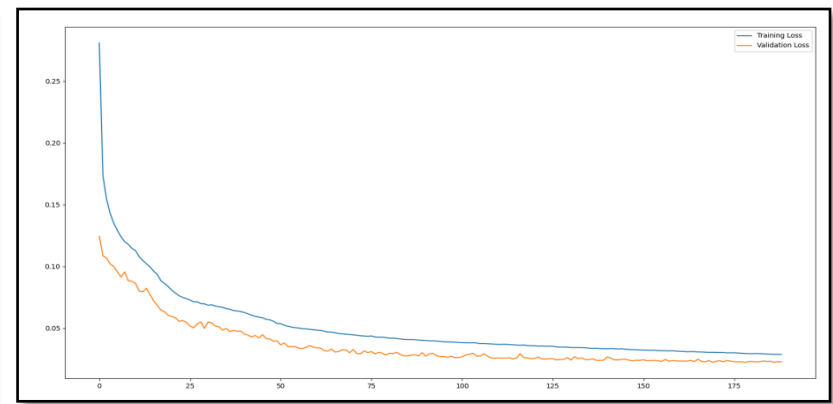
Models available

- LSTM Encoder Decoder
- DBSCAN
- Isolation Forest
- Transformer
- One-Class SVM
- Local Outlier Factor
- Matrix Profile

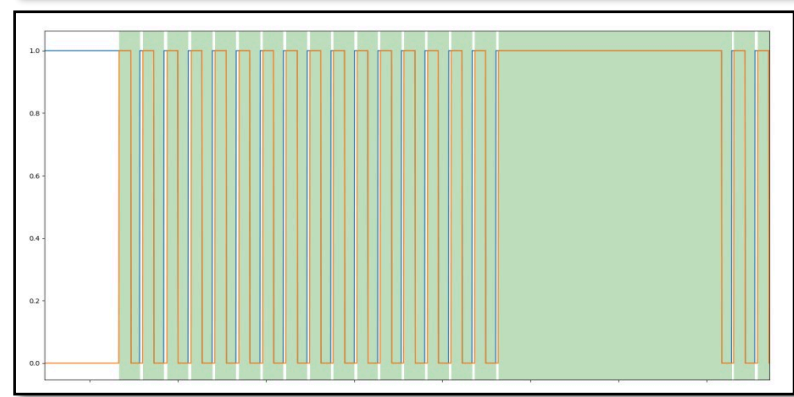
LSTM Encoder Decoder - Anomaly Example



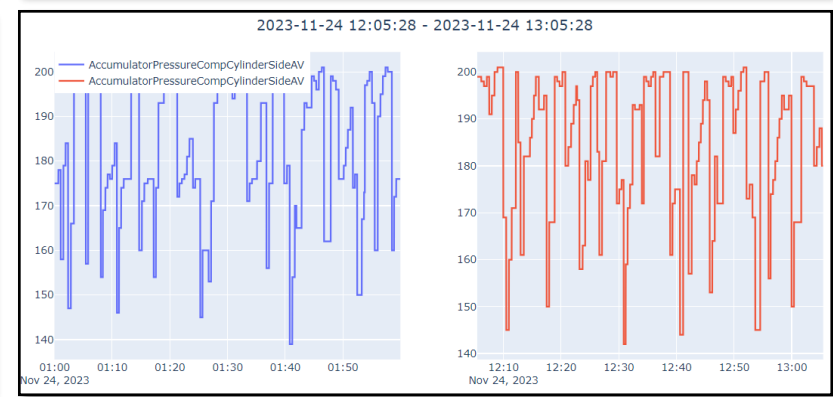
Model Training



Knowledge Discovery Example Results



Preprocessing: Machine Cycle Identification



Similarity Search



Anomaly Labelling

- Regular Labelling for long term retraining
- Domain knowledge injection
- Boost performance

KDE - Data Exploration and Annotation Tool Configuration Annotation Tool

Analysis Task: 1709921429 Inspect Configuration

Start Date	End Date	Responsible Features
2023-11-24 00:08:08	2023-11-24 01:03:42	Extr3HeatOnPerc8AV PWTWorkingPressureAV Extr4HeatOnPerc1AV Extr1HeatOnPerc9AV Extr6HeatOnPerc1AV Extr3HeatOnPerc5AV HeadFlatDieHeatOnPerc9AV FeedZoneTemp3AV Extr3HeatOnPerc3AV
2023-11-24 22:35:13	2023-11-24 22:51:02	Extr1HeatOnPerc4AV ReactivePower3AV Extr6HeatOnPerc2AV ReactivePowerTotalAV HeadHeatOnPerc1AV Extr5HeatOnPerc5AV Extr2HeatOnPerc5AV

Labeling

Anomaly? Yes No

Anomaly Title

Product

Potential Cause

Further Information

2023-11-24 22:35:13 - 2023-11-24 22:51:02

Nov 24, 2023

Responsible Features Weighting

Extr6HeatOnPerc2AV	25%
Extr1HeatOnPerc4AV	23%
HeadHeatOnPerc1AV	23%
Extr2HeatOnPerc5AV	14%
ReactivePowerTotalAV	4%
ReactivePower3AV	4%
Extr5HeatOnPerc5AV	3%

Recommendation



Problem that can be solve

Hybrid Recommender

Dataset						Search
ID	Name	Nr instances	Shopfloor	Source type	Source URI	
1	Dataset1	123	Parmalat1	real time stream	localiser	
2	Dataset2	345000	Parmalat1	tabular	localiser	
3	Dataset3	4000	Parmalat2	generator	localiser	
4	Dataset4	1650	Parmalat1	tabular	localiser	

Data type	Task type	KPI	Performance metric	Strategy
Tabular	Classification	Performance	SMAE	No preferences
Time Series	Regression	Computation	MAE	Logistic Regression
Image	Clustering	complexity	RMSE	Regression Tree
	Optimisation	Execution time	MSE	ANN
				XGBoost
				LightGBM
				Linear Regression

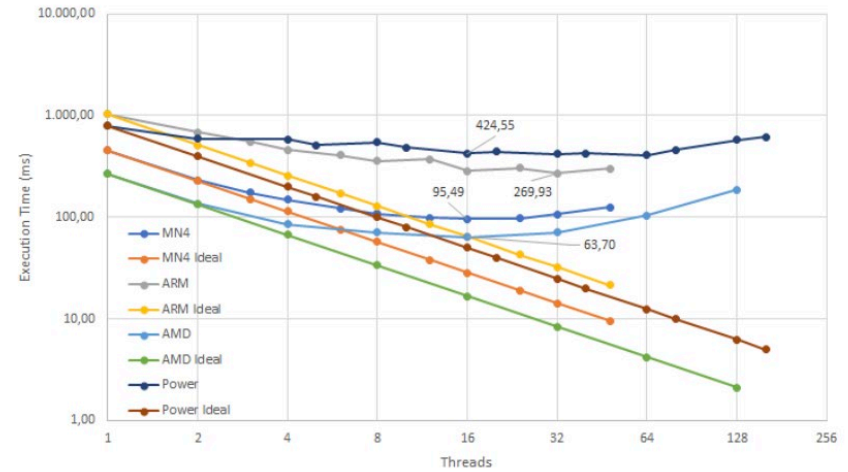
Recommended strategies					
Strategy					KPI
ID	Method	Method Setup	Performance	Cost	Execution time
1	Support Vector Machine	{'C': 1.0, 'kernel': 'rbf', 'degree': 3}	int	int	int
2	Artificial Neural Network	ANN-1-3 (0.01, 0.2, 2000)	int	int	int

Recommender input

Recommender output

"Based on the data, problem type and model metadata, which is the best model to be train / retrained ?"

Time execution



Trace example



Supervised Model Training



Problems that can be solve

- Classification => "Classify elements between a list of categories "
- Anomaly detection -> "Based on CAQ data, is this an anomaly ?"
- Prediction / forecasting -> "Predict values in time series data"

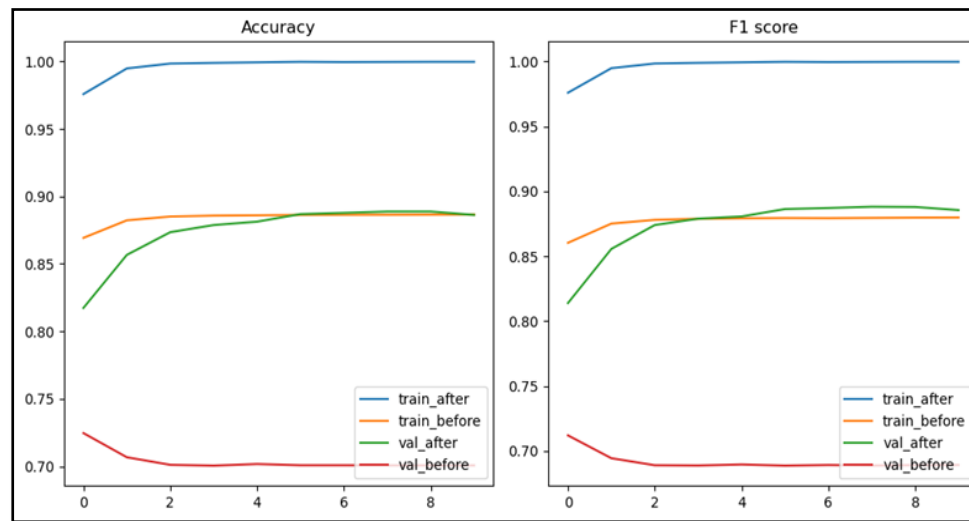
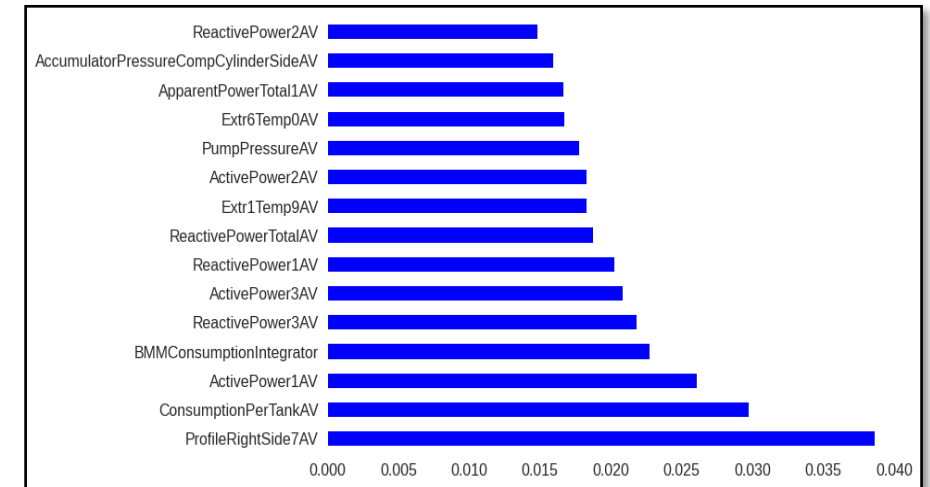


Models available

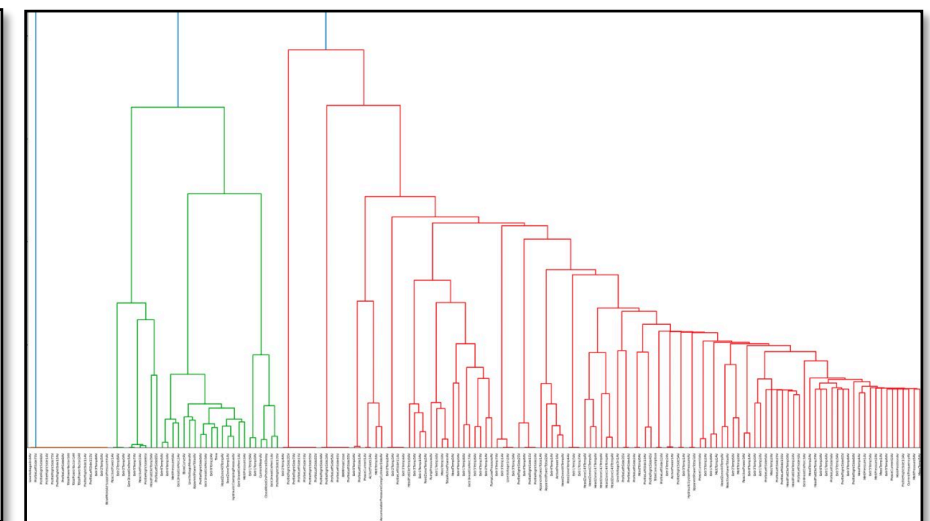
- KautexXgboost
- KautexRandomForest
- KautexTransformer
- KautexProgressiveLearner
- KautexLightGBM
- KautexDenseNN
- ...



Top-15 most important features from Xgboost



Progressive Learner performance



Hierarchical Clustering on Kolmogorov Matrix

-> Demo



Demo – KDE Labeling

KDE - Configuration

Configuration - Annotation Tool

KDE - Configuration Editor

Name

Task
Select...

Method
Select...

Visualization
Select...

Data Preprocessor
Select...

Input Attributes

Target Attributes

Load Name

Save Name

Processing

Order
0

Action
Select...

Demo – EEK using labeler

Edge Embedded AI Kit

Task

Task name (*)

Task type (*)

Select task type ▼

Strategy (*)

Select an strategy ▼

Preprocessor

Select a preprocessor ▼

Labeler

Select a labeler ▼

Impacts



Impacts

KPI	Description /Goal
Process Improvements	Amount of preventive process adjustments based on DSS proposals
Process Anomaly detection	Detect >80% of simulated process & equipment fluctuation or abnormal states that are found during a test scenario
Cycle time fluctation	Minimize the cycle time fluctuation by detection the cause for the fluctuations
Equipment Anomaly detection	Amount of preventive Equipment adjustments based on DSS proposals
Generic rules set based on equipment type	Define a set of generic rules that apply to a certain type of equipment.



Discussion

Questions?