

# ► Applied machine learning for predictive maintenance

welcome

# ► Jihed Ben Salah

- Final year AI engineering student
- AI research intern at VW Group
- Co-Founder of DeepFlow AI
- Co-Founder of EPISAFE
- Winner of AINS 2023 Hackathon
- Winner of OST competition 2023
- Winner of AIHACK 2022



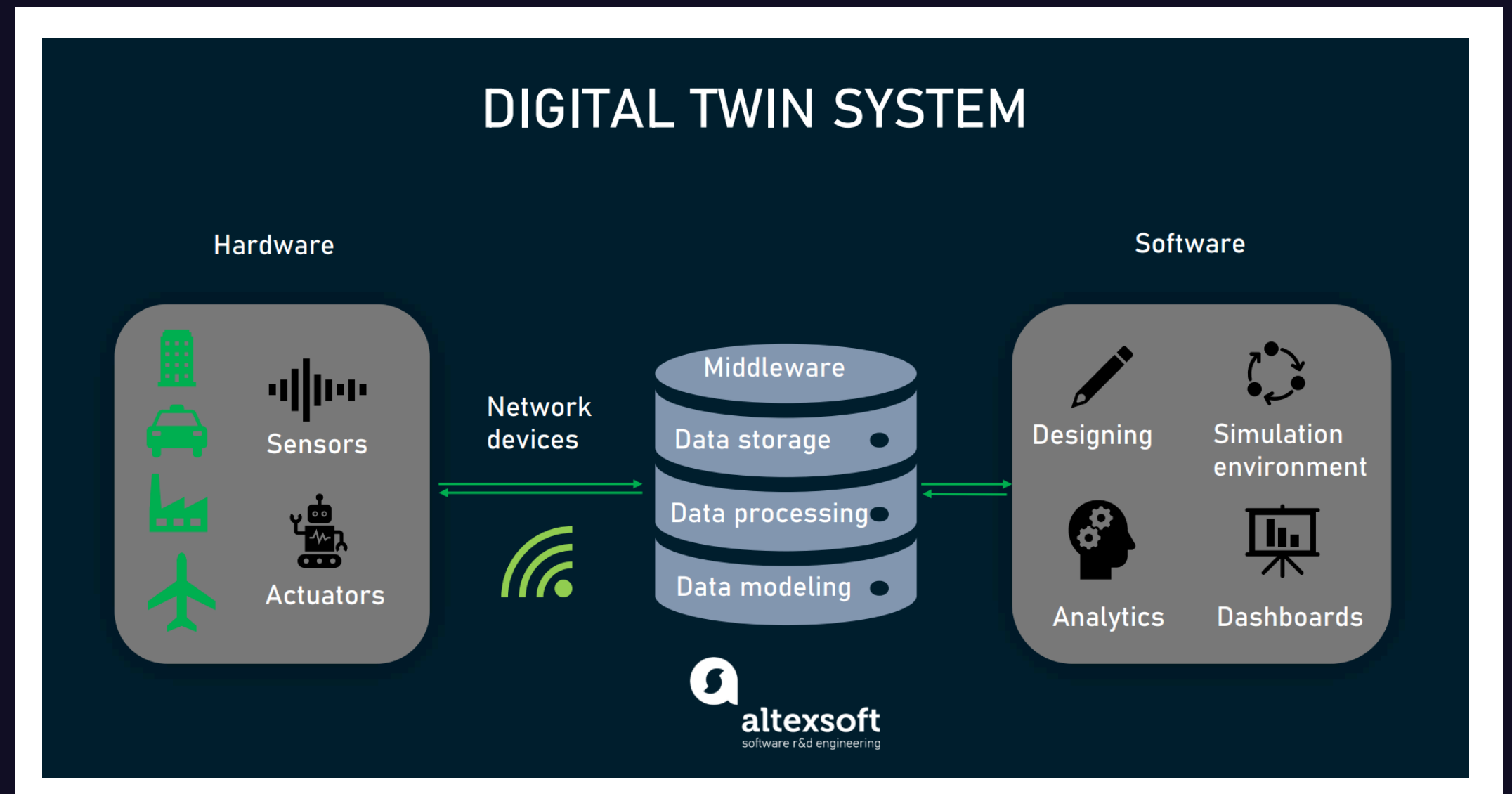
Jihed.bensalah.ai@gmail.com

# ► TABLE OF CONTENTS

- 01 Role of AI in Digital Twins
- 02 Predictive maintenance
- 03 Introduction to AI
- 04 Machine learning pipeline
- 05 PDM models explanation
- 06 Technical Notebooks
- 07 Deployment

# ► Role of AI in Digital Twins

- Real-time monitoring and diagnostics
- Predictive and prescriptive maintenance
- Optimization of operations and resource usage



# ► Predictive maintenance

Predictive maintenance (PdM) involves using data analysis tools and techniques to detect anomalies in equipment operation and predict failures before they happen.

- Reduced downtime
- Lower maintenance costs
- Increased equipment lifespan
- Enhanced safety



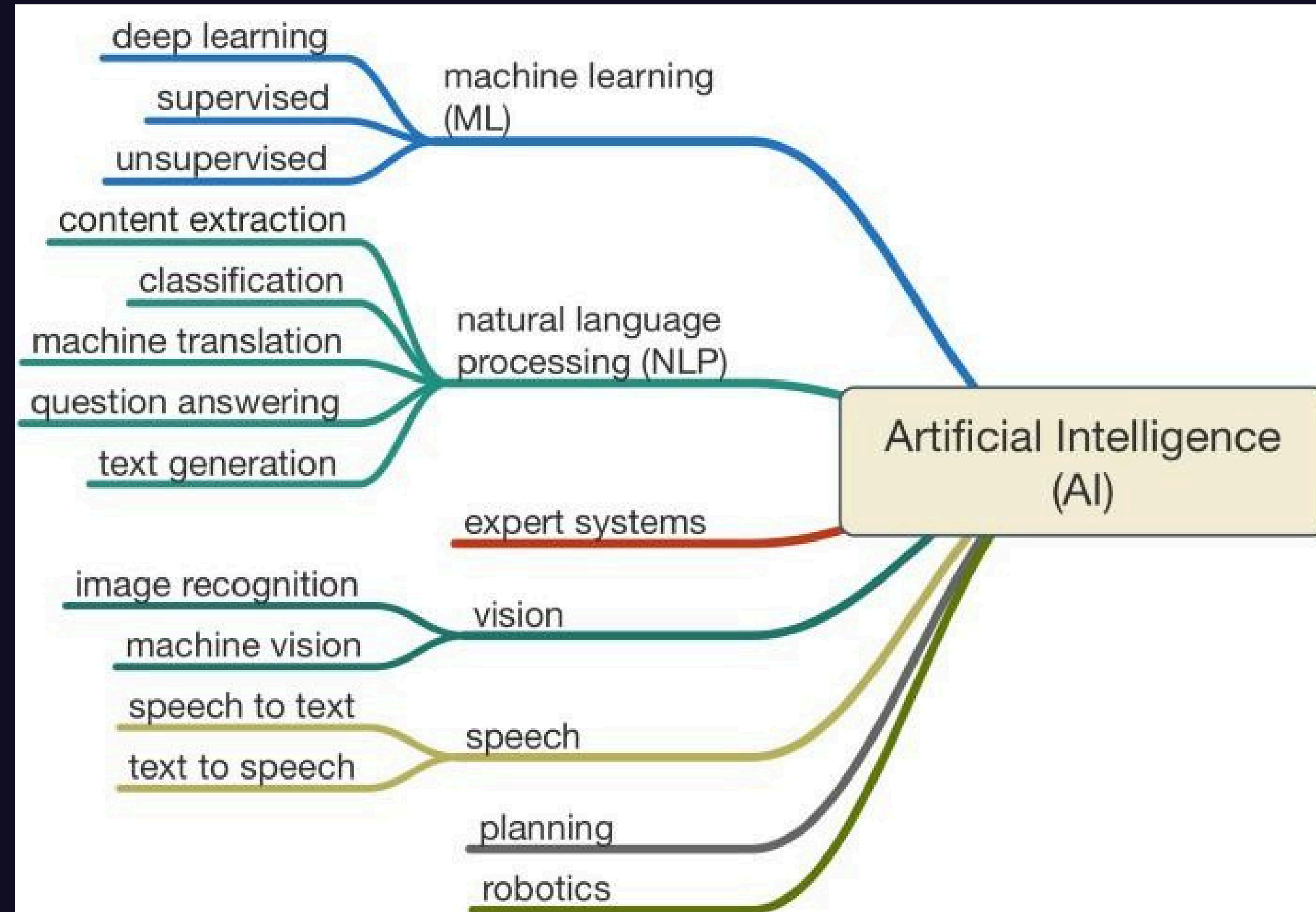


01

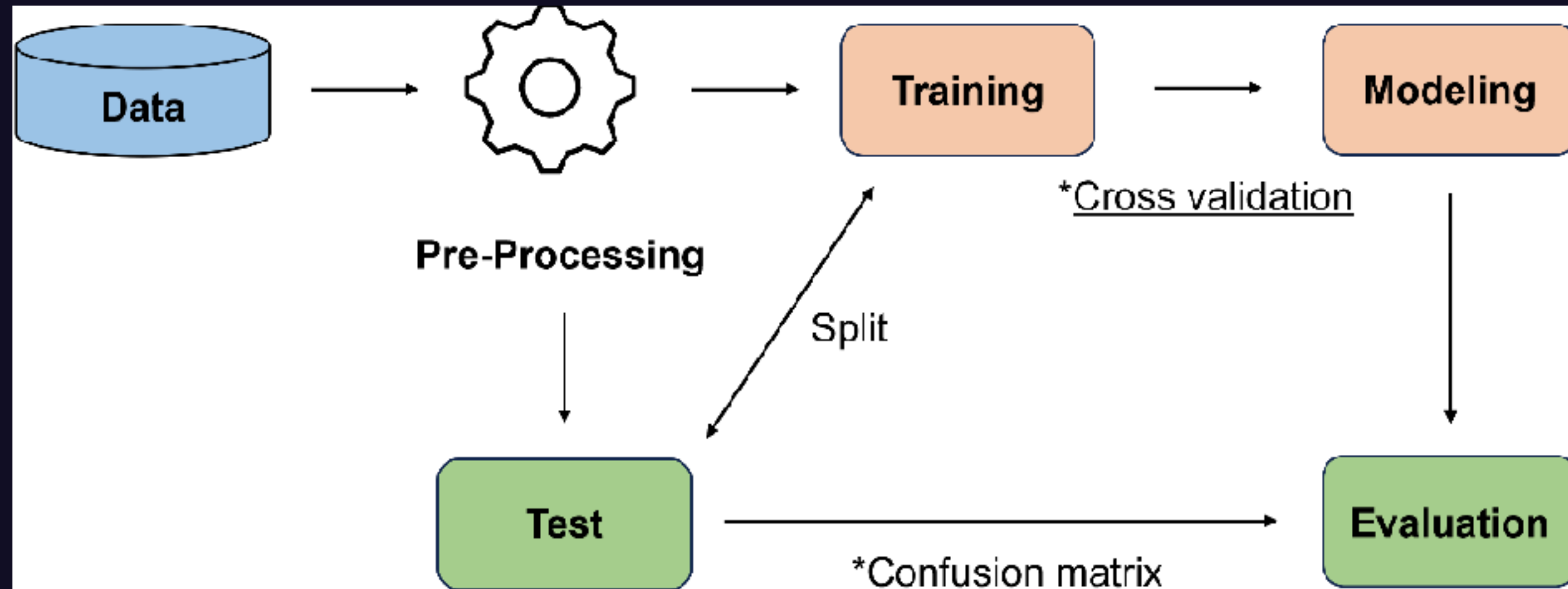
# ▶ AI INTRODUCTION



# ► AI diagram



## ► Machine learning pipeline



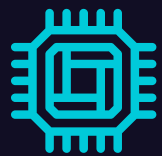




01

# ► PDM models explanation

# ► How can we use it ?



## Prediction

- Time Series Forecasting (LSTM, ARIMA, Prophet)
- Recurrent Neural Networks (RNNs)
- Linear Regression
- XGBoost



## Classification

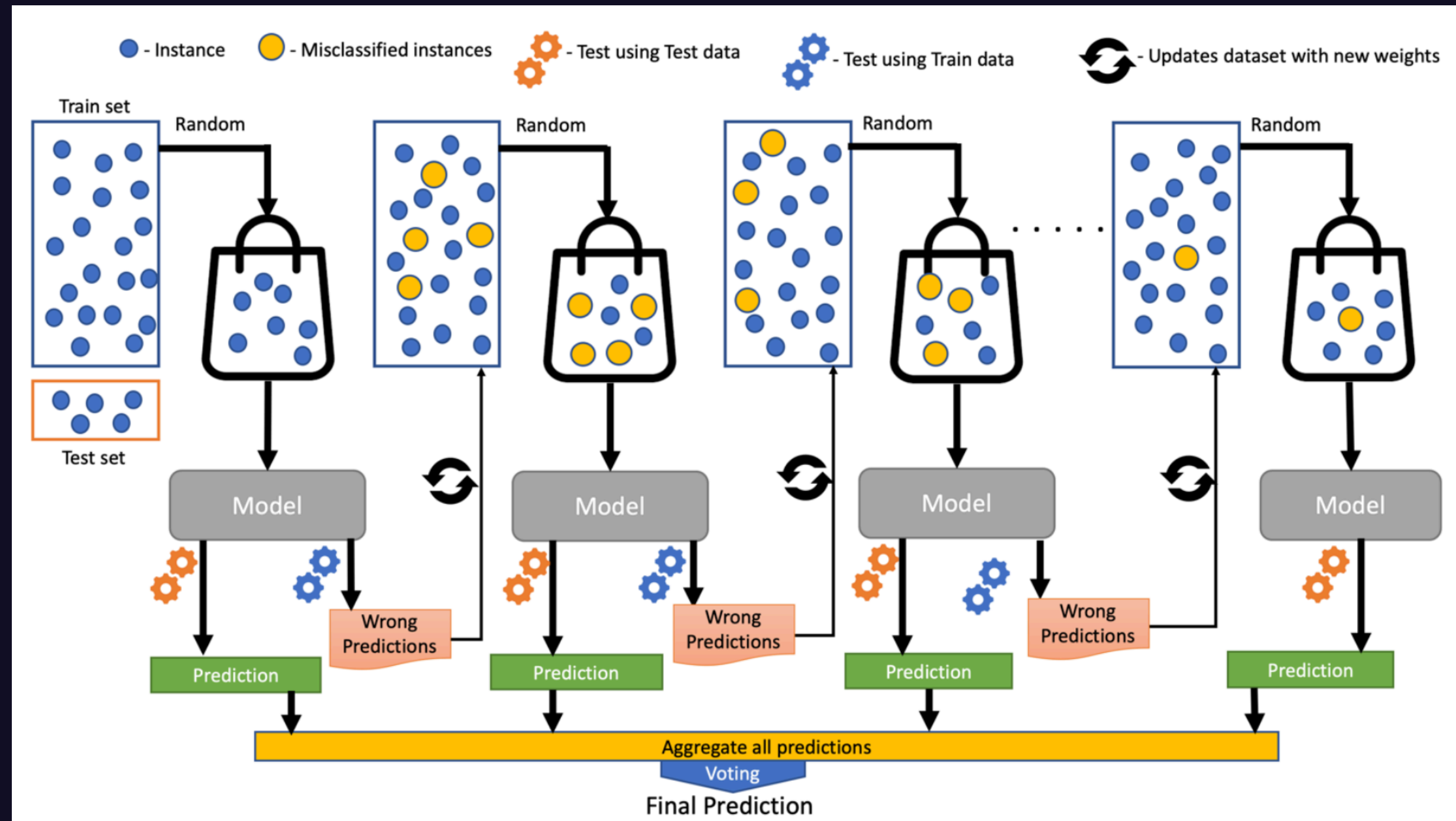
- Logistic Regression
- Decision Trees
- Random Forest
- Gradient Boosting Machines (GBM)
- XGBoost
- Support Vector Machines (SVM)
- Neural Networks (Deep Learning)



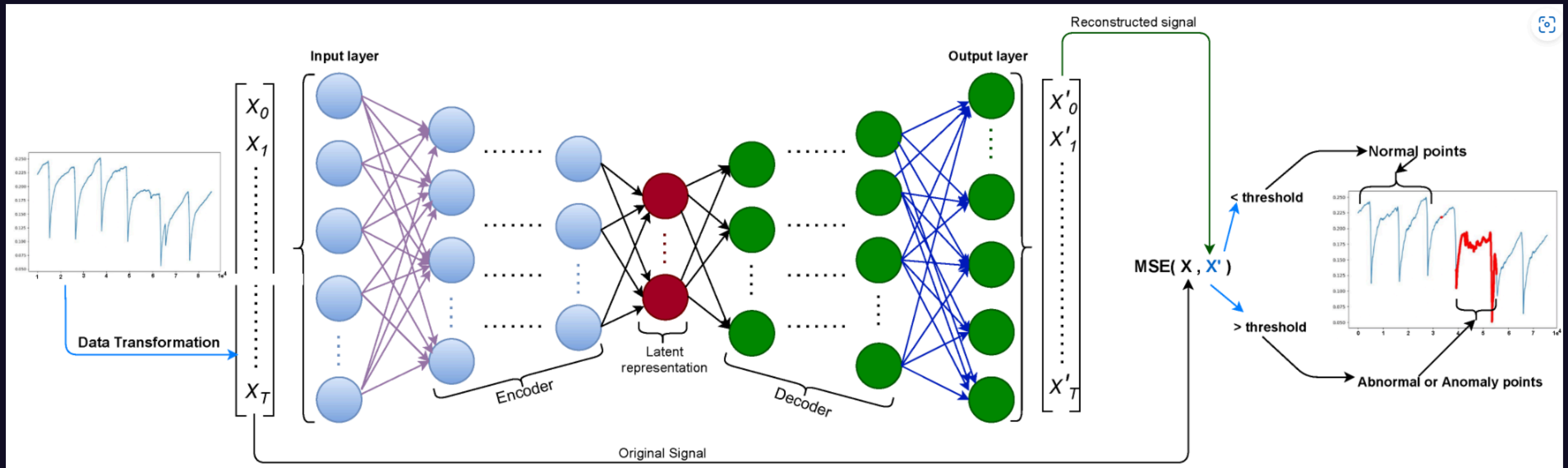
## Anomaly detection

- Isolation Forest
- Recurrent One-Class SVM
- Autoencoders (Deep Learning)
- Principal Component Analysis (PCA)

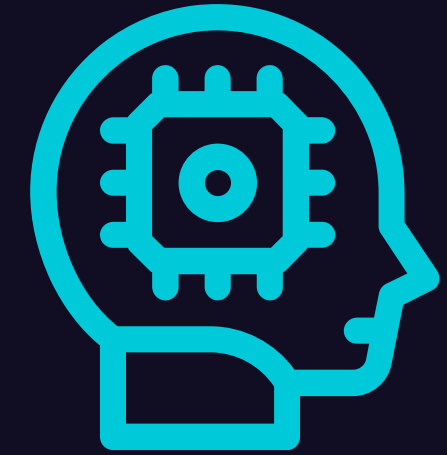
# ► Boosting



# ► Autoencoders



# ► Failure Pattern Analysis



## AI Analysis Type:

Classification

## Description:

- Utilizes historical maintenance and failure data.
- Analyzes historical failure patterns to predict future failures.

## Benefits:

- Identifies common failure patterns and root causes.
- Improves accuracy in predicting specific failure events.

## Usecase:

Maintenance of Heating, Ventilation, and Air Conditioning (HVAC) systems based on usage metrics such as run-time hours and load conditions.

# ► Usage-Based Maintenance



## AI Analysis Type:

Prediction

## Description:

- Schedules maintenance based on equipment usage metrics such as cycles, hours of operation, or load.
- Maintenance intervals are adjusted based on actual usage data.

## Benefits:

- Aligns maintenance schedules with actual equipment usage.
- Reduces unnecessary maintenance for lightly used equipment.

## Usecase:

Maintenance of Heating, Ventilation, and Air Conditioning (HVAC) systems based on usage metrics such as run-time hours and load conditions.

# ► Condition-Based Maintenance (CBM)



## AI Analysis Type:

Anomaly Detection

## Description:

- Continuous or periodic monitoring of equipment conditions (e.g., vibration, temperature, pressure) to detect signs of deterioration.

## Benefits:

- Detects potential failures before they occur.
- Optimizes maintenance schedules based on actual equipment condition

## Usecase :

In a commercial building's HVAC system, CBM with AI anomaly detection monitors compressor vibrations and refrigerant pressures to identify early signs of failure. This enables timely maintenance, reducing downtime and enhancing system efficiency.

The background is a dark blue gradient with various abstract geometric elements. In the top left, there are some thin white lines and a small cyan circle. A large, light blue number '06' is positioned in the upper left area. A prominent white line starts from the top center, goes up and to the right, then down and to the right, then up and to the right, and finally down and to the right. On the right side, there are several horizontal white lines of different lengths. In the bottom right, there is a small white circle and a larger cyan circle. The overall aesthetic is modern and minimalist.

06

► Let's practice together

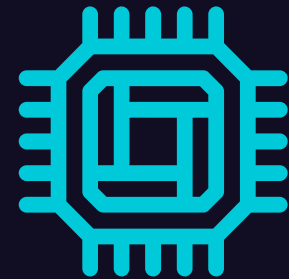




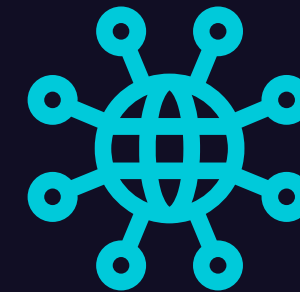
01

# ► Deployment

# ► Deployment



EDGE



Cloud



[Jihed.bensalah.ai@gmail.com](mailto:Jihed.bensalah.ai@gmail.com)

► Thank you