Pushing The Boundaries: Engineering-based Data-driven Analytics For Intelligent Manufacturing

Challenges, New methods & Case studies

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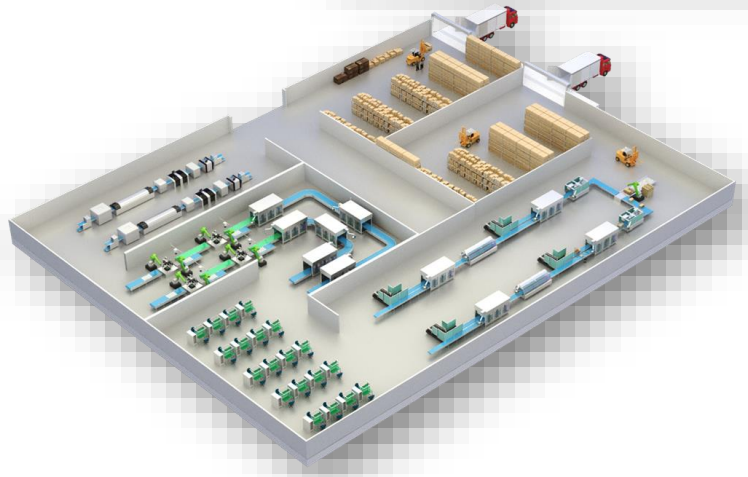
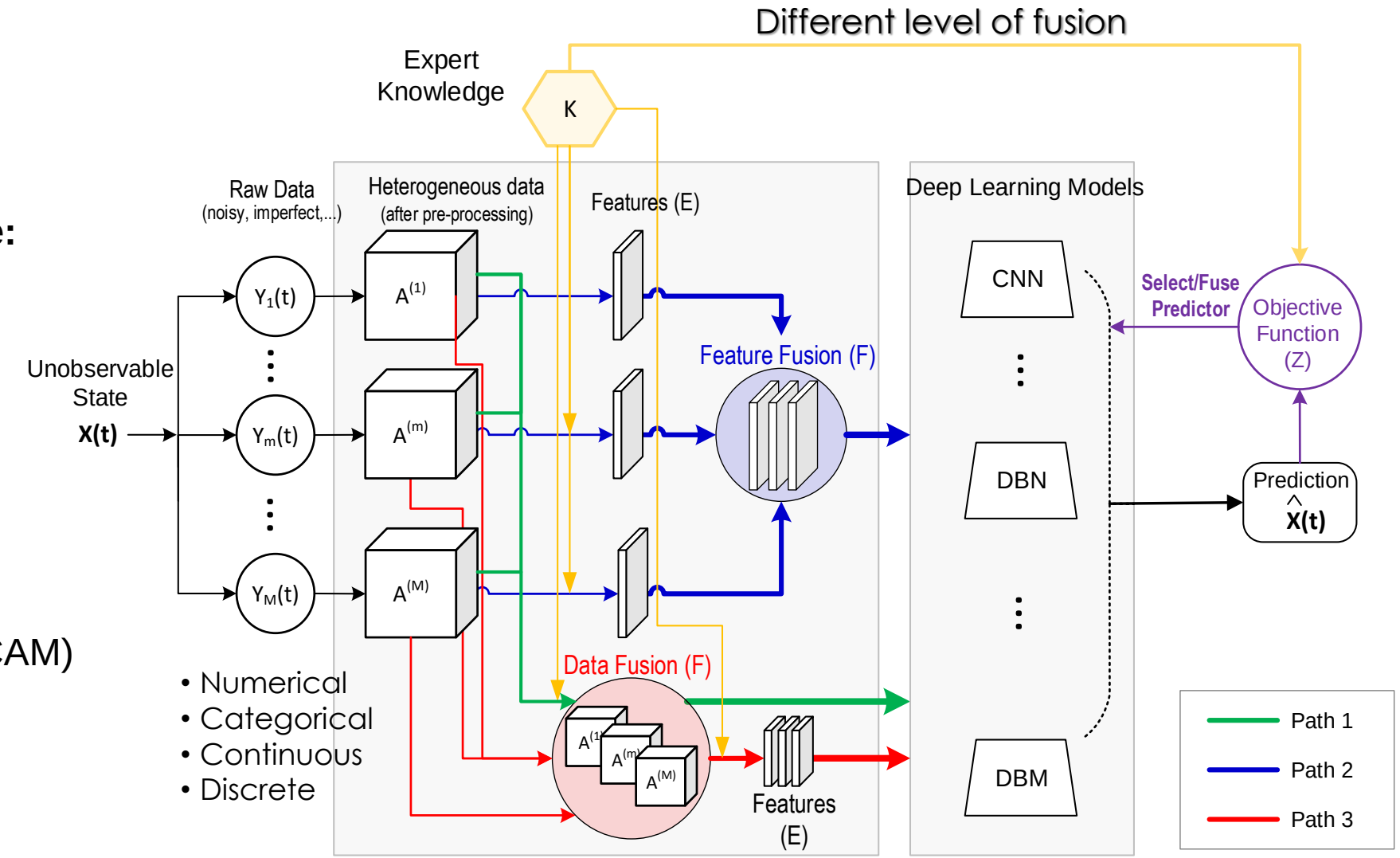
OUTLINE

- Sensor-Based PHM
- Challenges for Machine learning for PHM
  - Imbalanced data
  - Multi-source multi-modal data
- Integrating Engineering Knowledge and Data Analytics

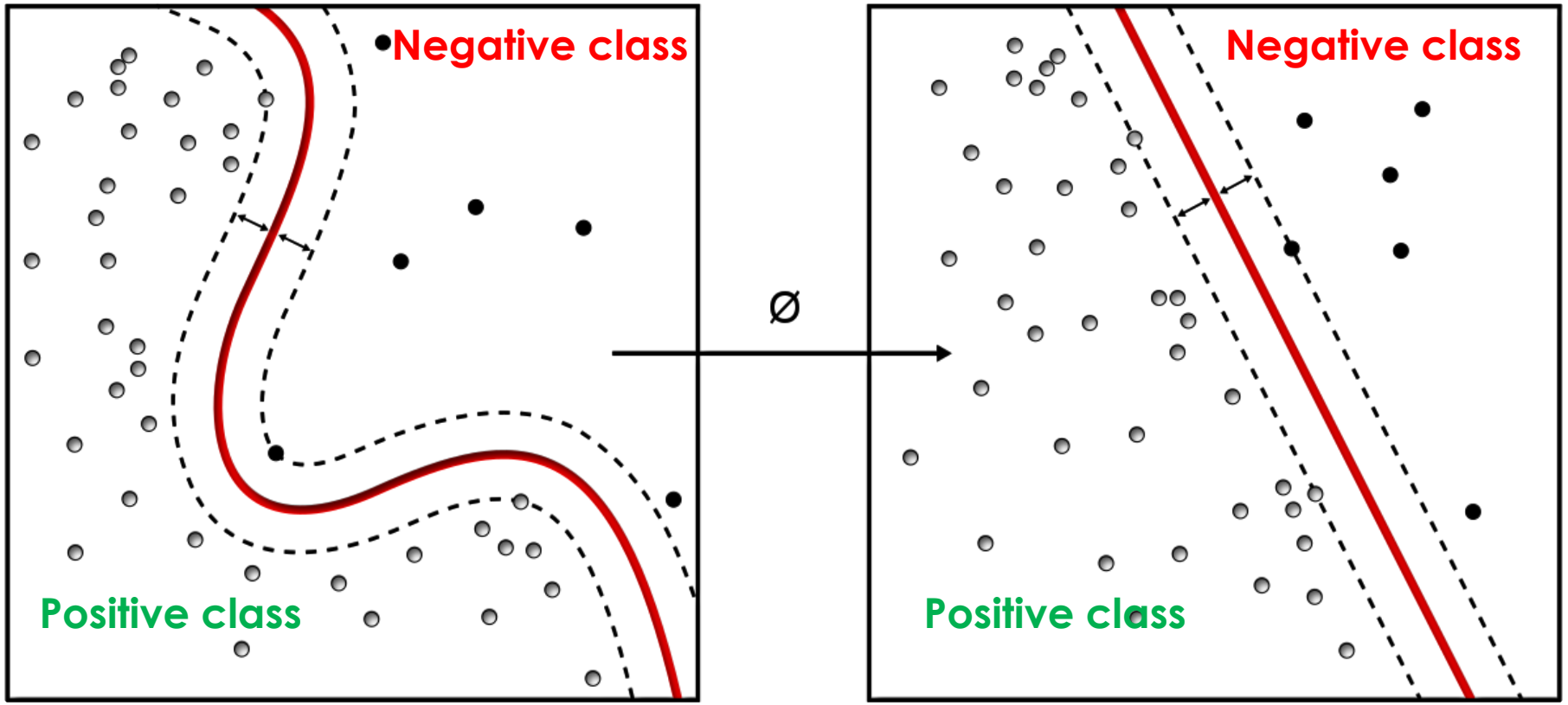


Multi-Model Data Fusion in Manufacturing

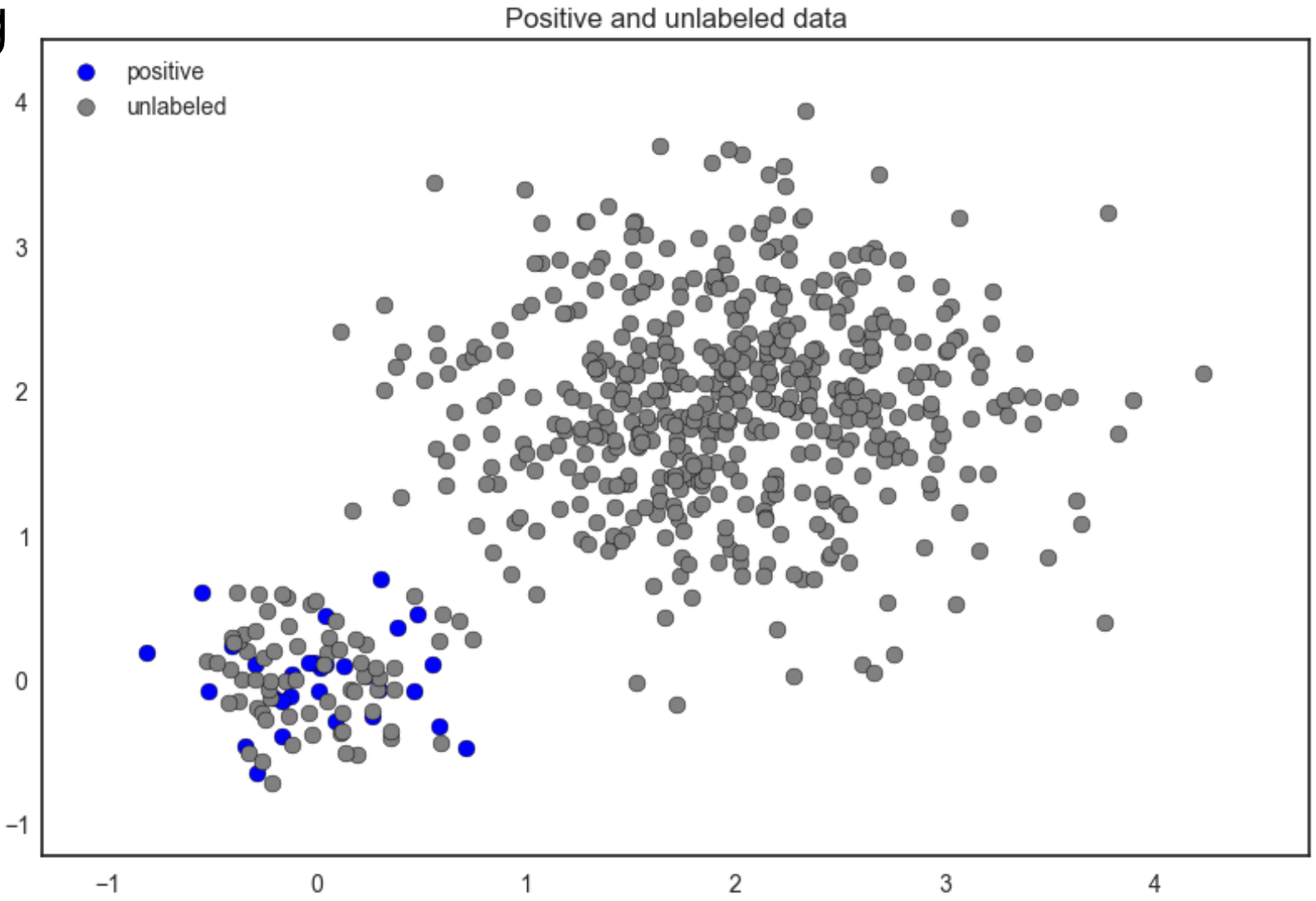
- **Multisenory systems:**
  - Audio & visual
- **Biomedical, Healthcare:**
  - EEG & fMRI
- **Autonomous vehicles:**
  - LiDAR, radar,
- **Manufacturing:**
  - Sensor data
  - Controller data
  - Design data (CAE/CAM)
  - Production data
  - …



Class-imbalanced Data Learning for Fault Detection



Anomaly Detection with Positive and Unlabeled (PU) Learning



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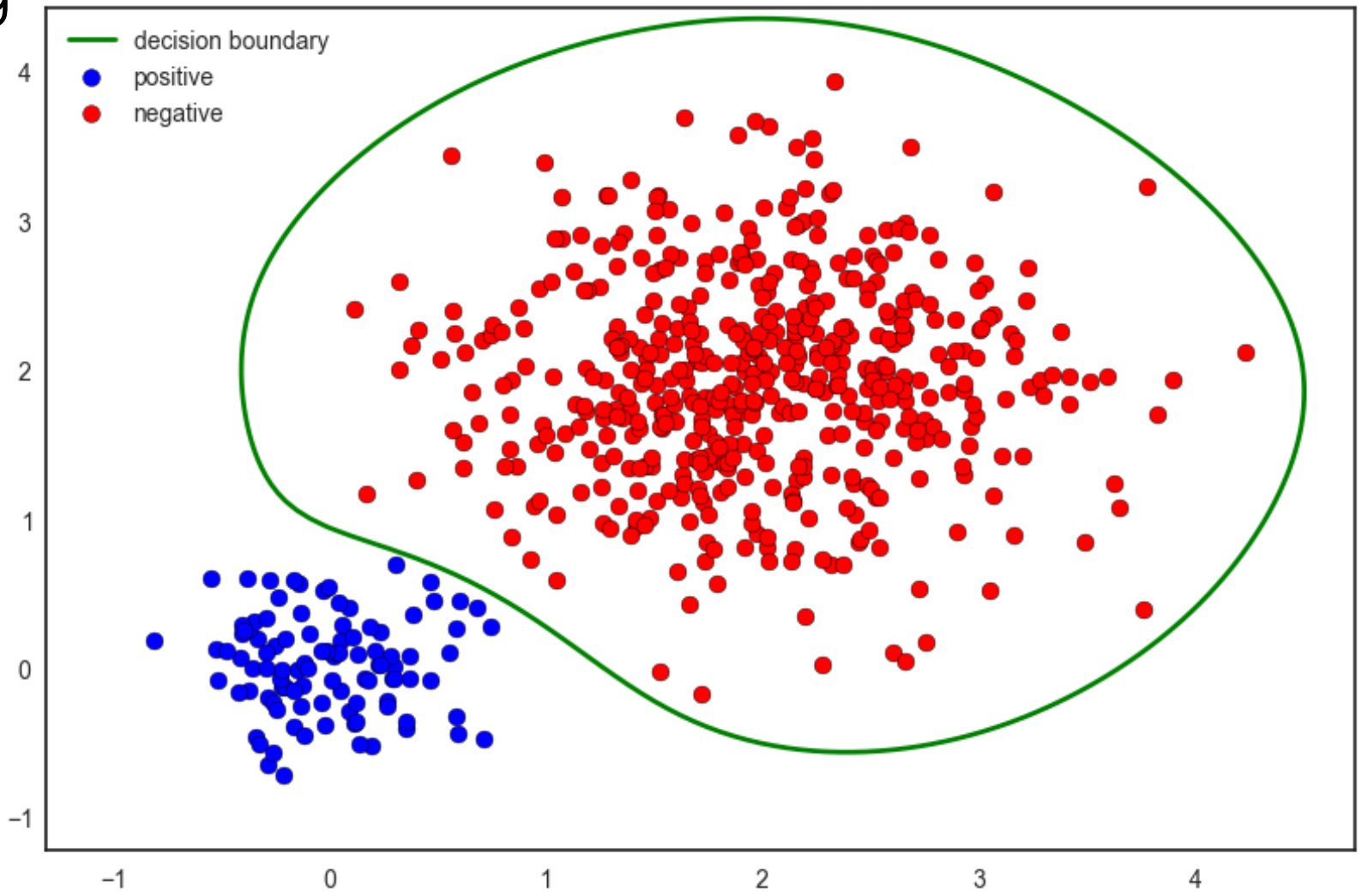
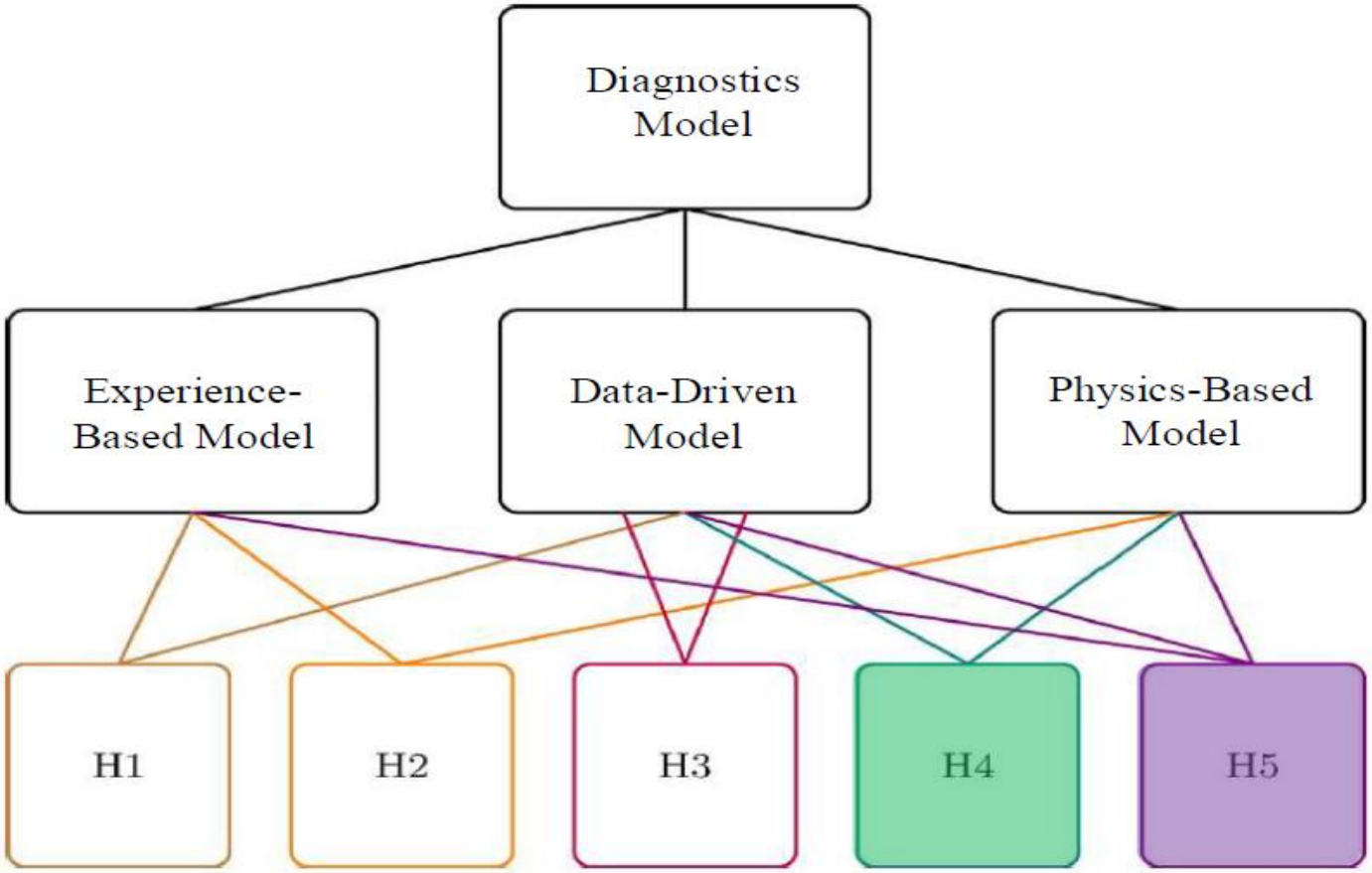
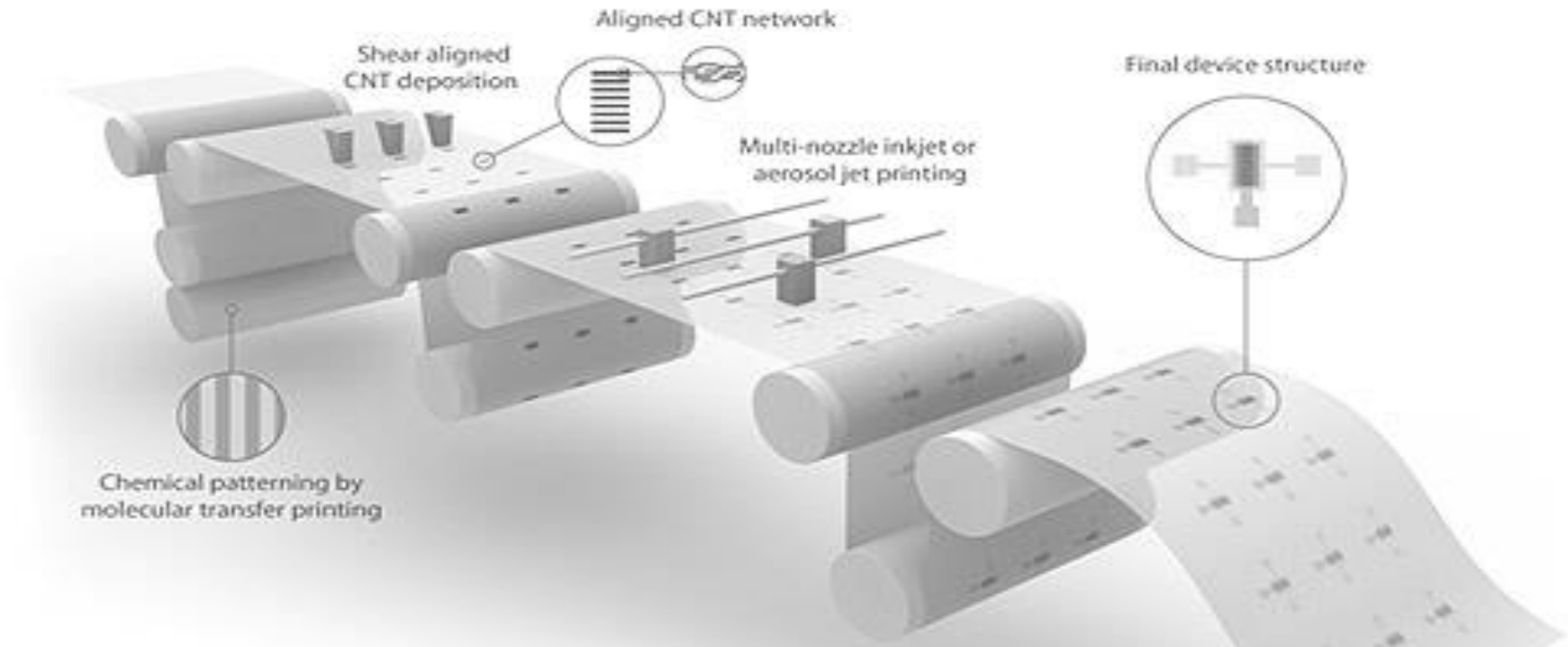


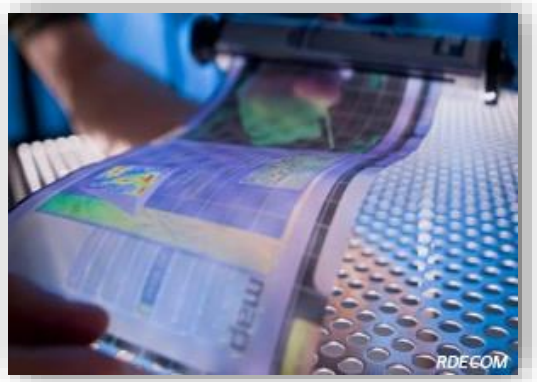
Physics-based Model + Data-driven Approach

An integrated physics-based and data-driven prognostics for degradation modeling of vehicle sub-systems under different environments, each dynamic.



Case Study I

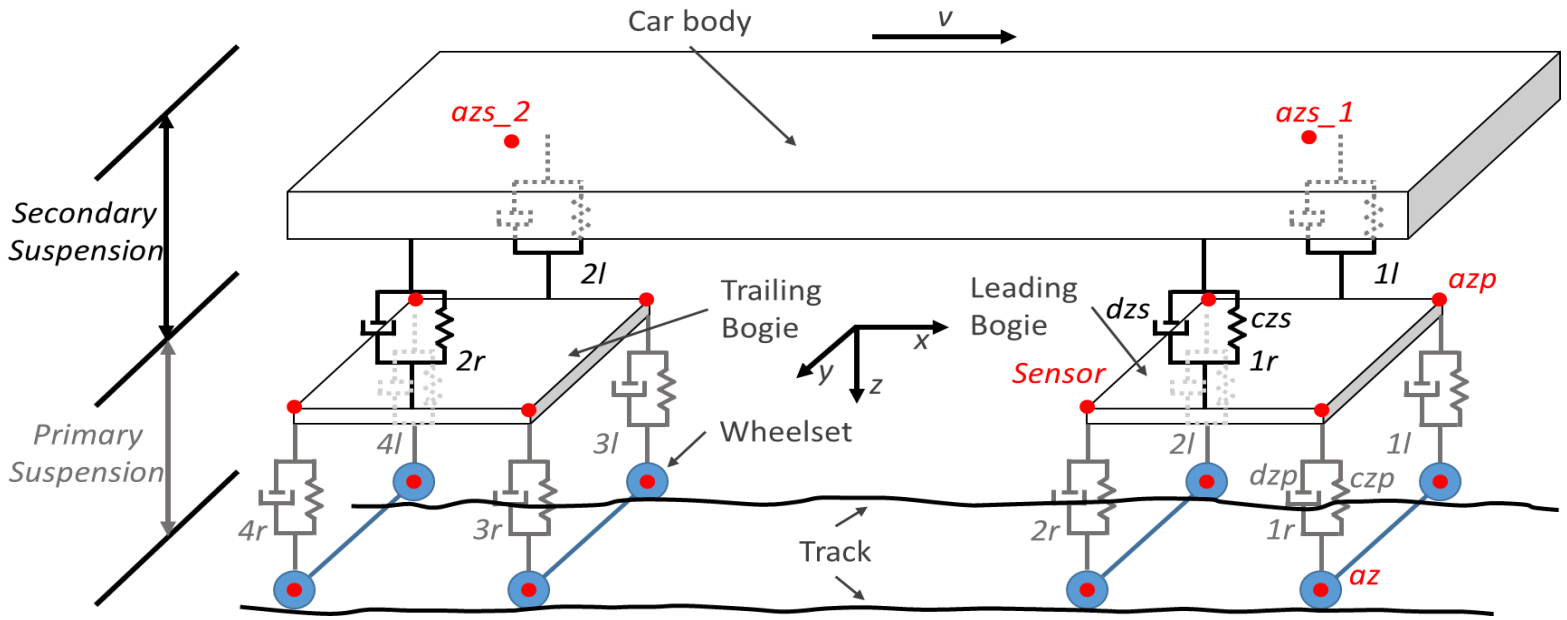


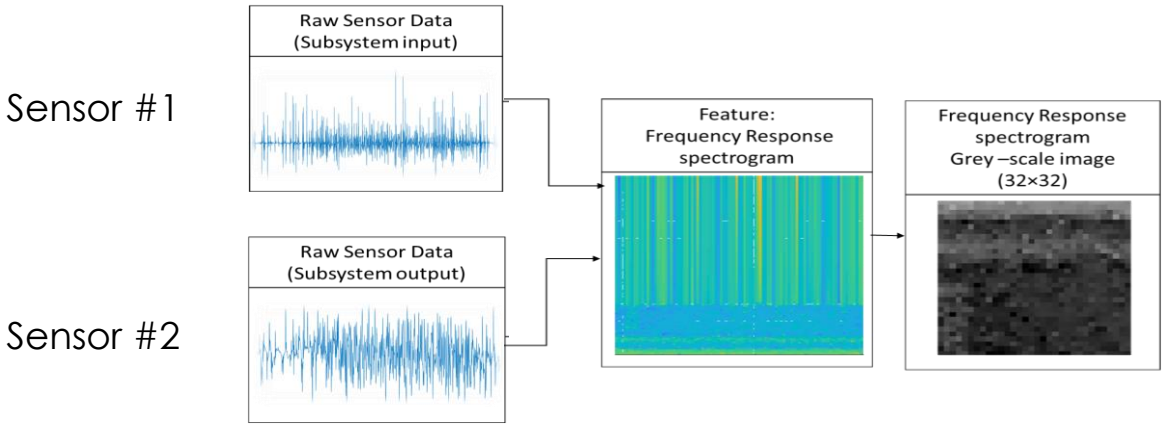


Roll-to-Roll (R2R) printing process for high-volume electronics printing

- High speed, scale-up manufacturing techniques
- High-resolution requirement for build devices "on-the-fly".
- Sensor-based process monitoring
- Process optimal control and performance assurance

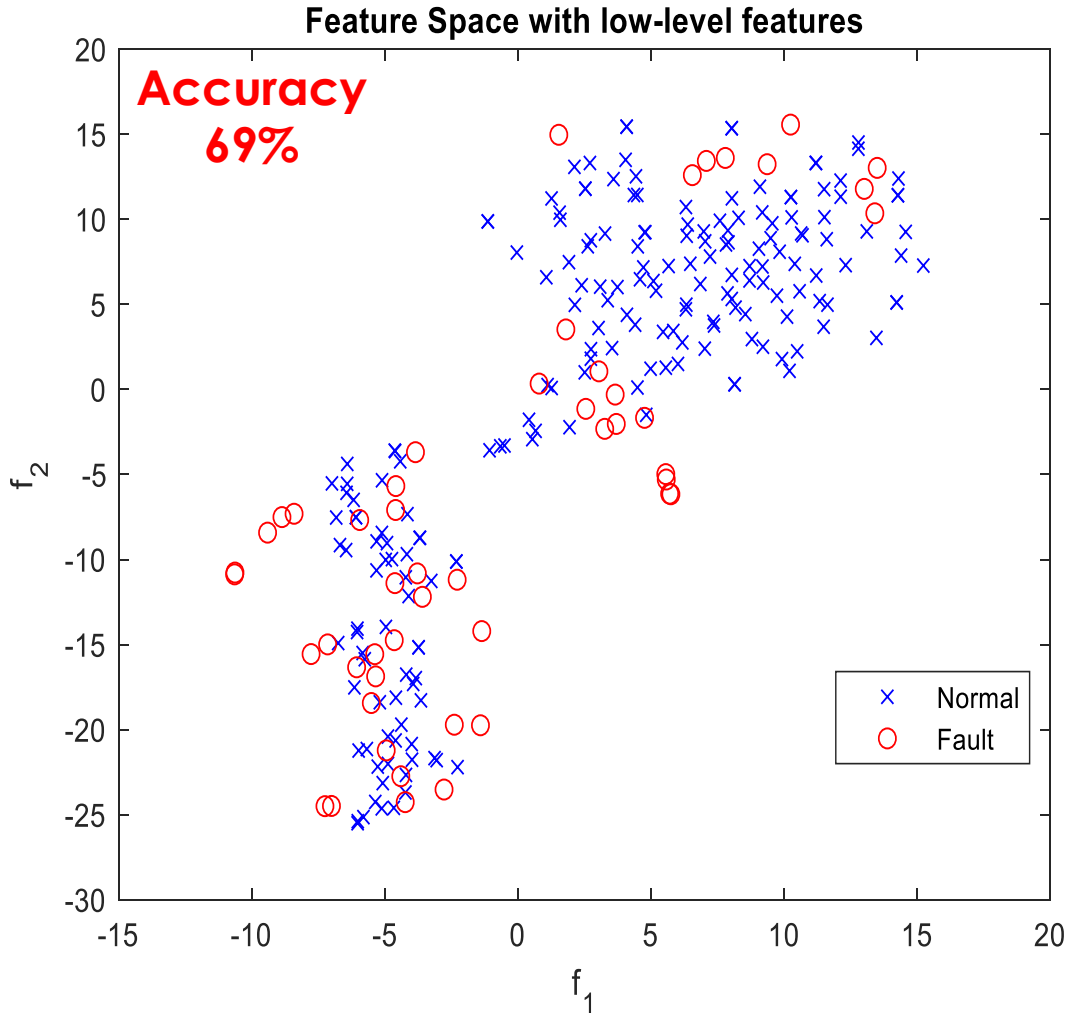
Case Study II - Suspension System Anomaly Detection

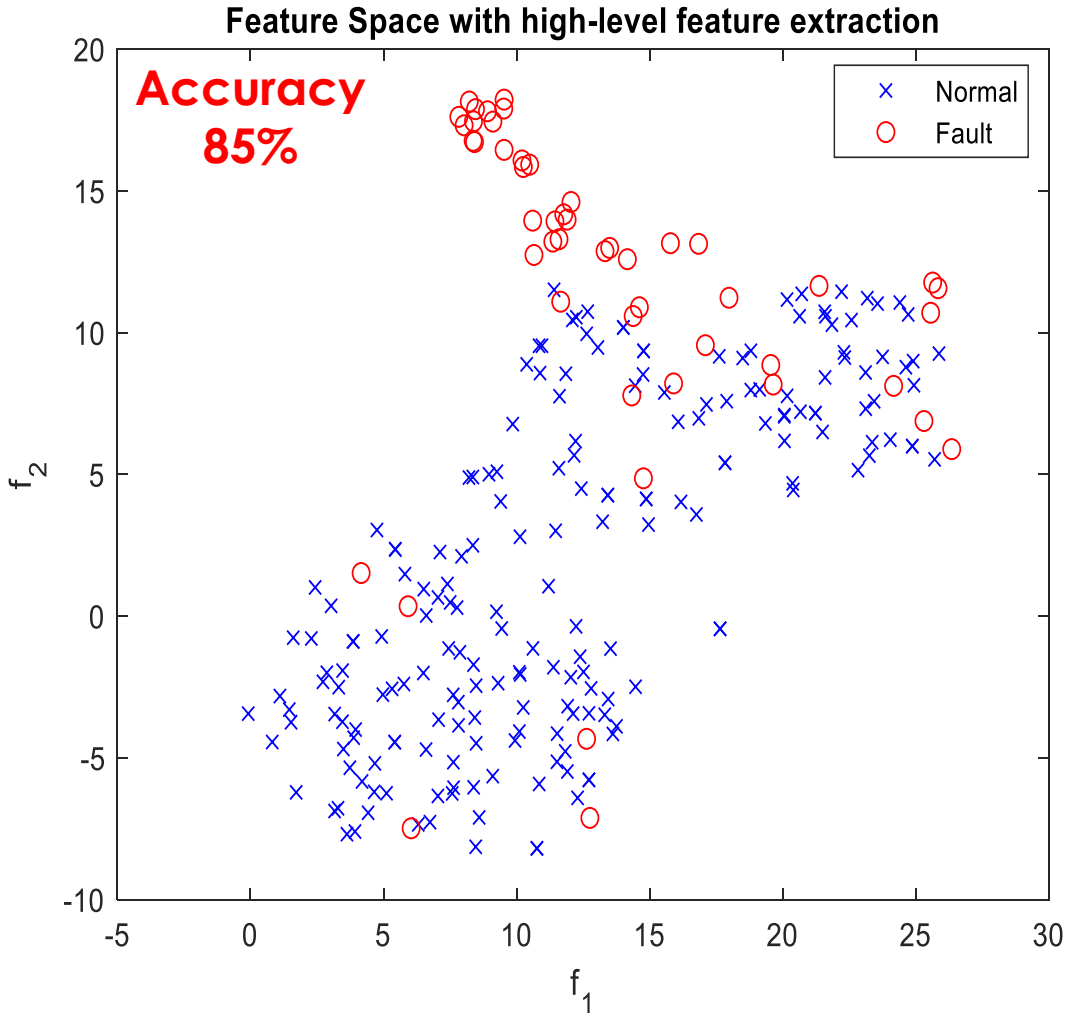




- ❑ Physics-based feature extraction (low level)
- ❑ ML-based feature reconstruction (high level)

Results


Feature Space with low-level features
Accuracy
69%
Normal
Fault
f_1
f_2


Feature Space with high-level feature extraction
Accuracy
85%
Normal
Fault
f_1
f_2

CHALLENGES & OPPORTUNITIES

- ❑ Imbalanced data
- ❑ learning with unlabeled or weak-labeled data
- ❑ Senor fusion (vibration, energy type of measurements)
- ❑ Lack of understanding degradation mechanism
- ❑ Sampling Strategy (static, dynamic, event-driven)
- ❑ Physics-based or Data-driven methods fusion and interface design
- ❑ …