Politecnico di Torino

MANUFACTURING AS A MACHINE LEARNING PRACTICE: CHALLENGES AND OPPORTUNITIES

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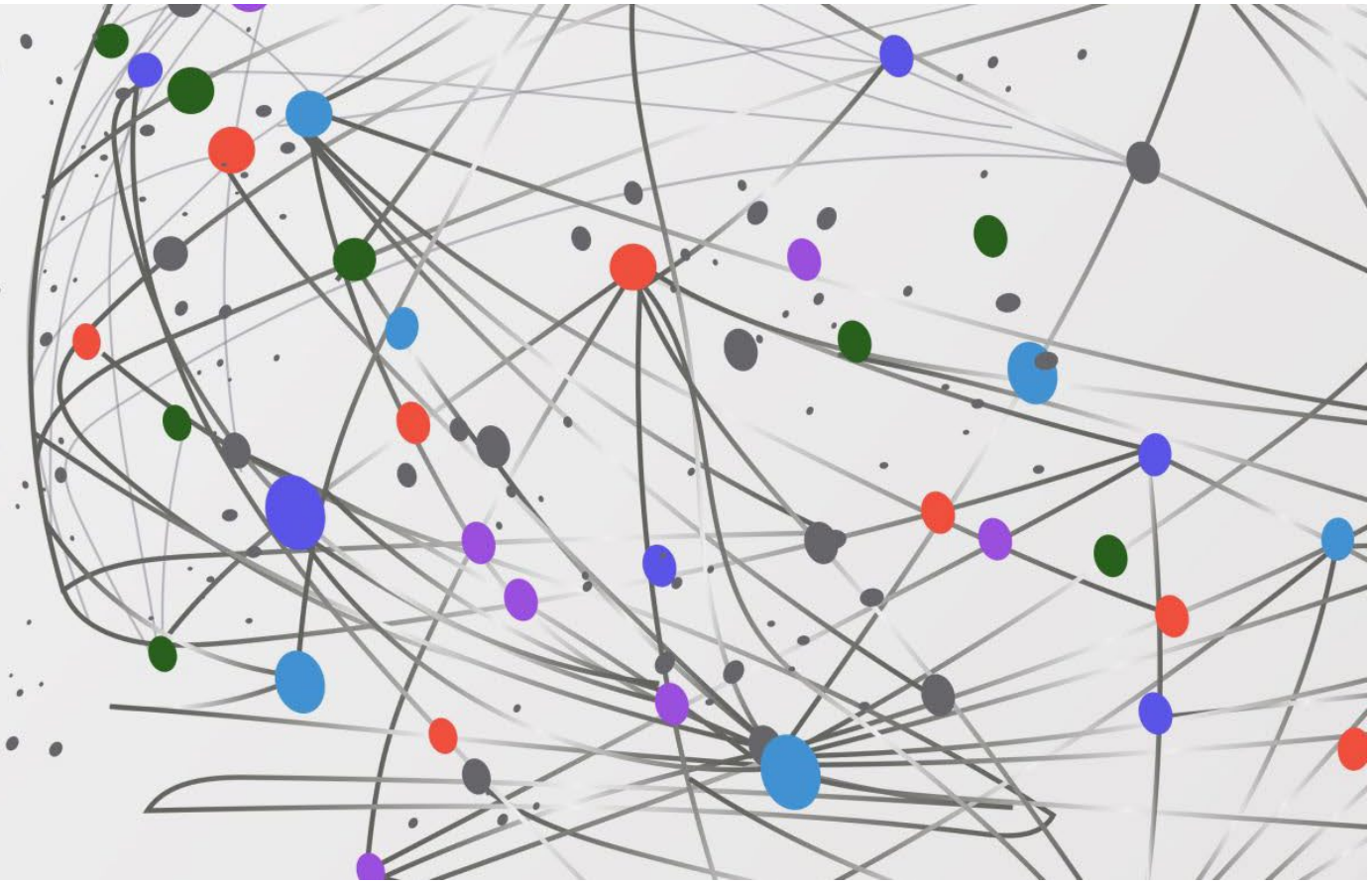
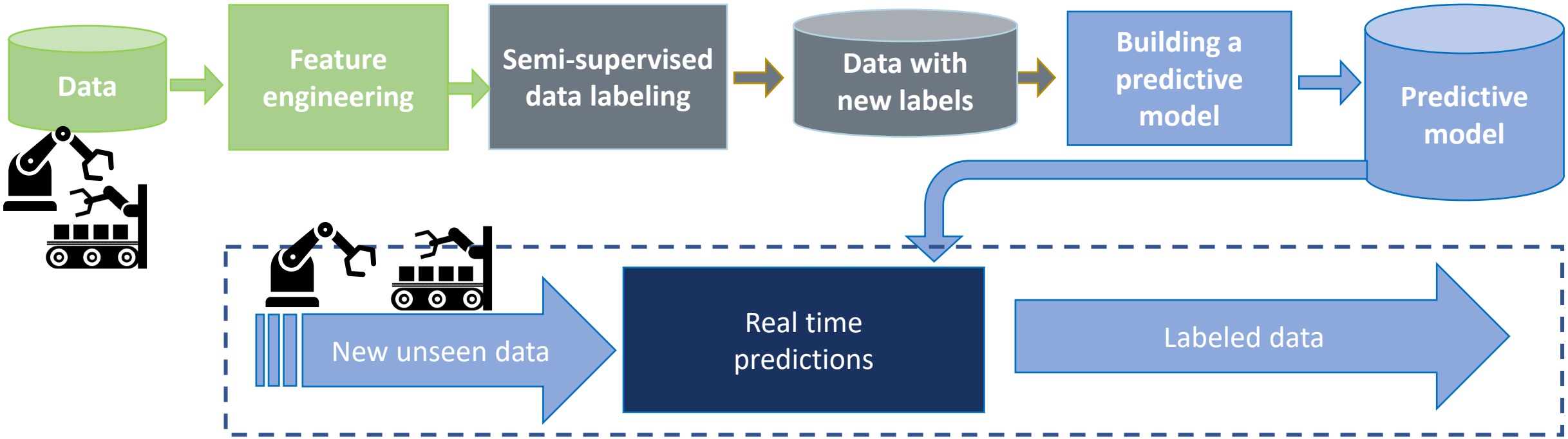
OUTLINE

- A data-driven pipeline
- Open issues on ML in manufacturing
- Guiding principles for developing AI solutions to improve safety and security
- Next steps for integrating guiding principles into ML applications

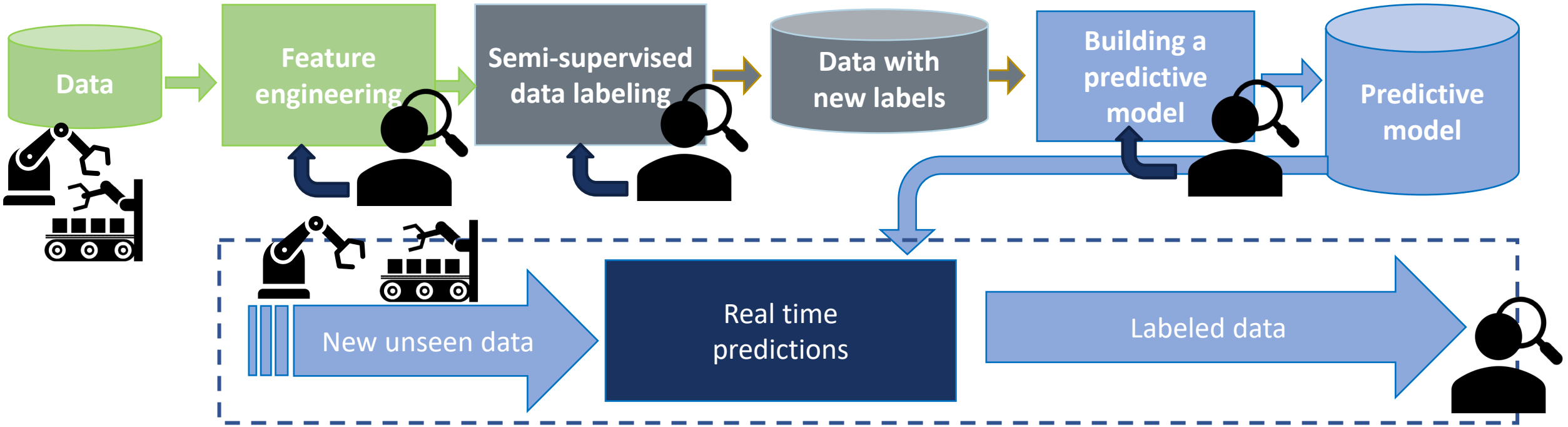


A DATA-DRIVEN PIPELINE



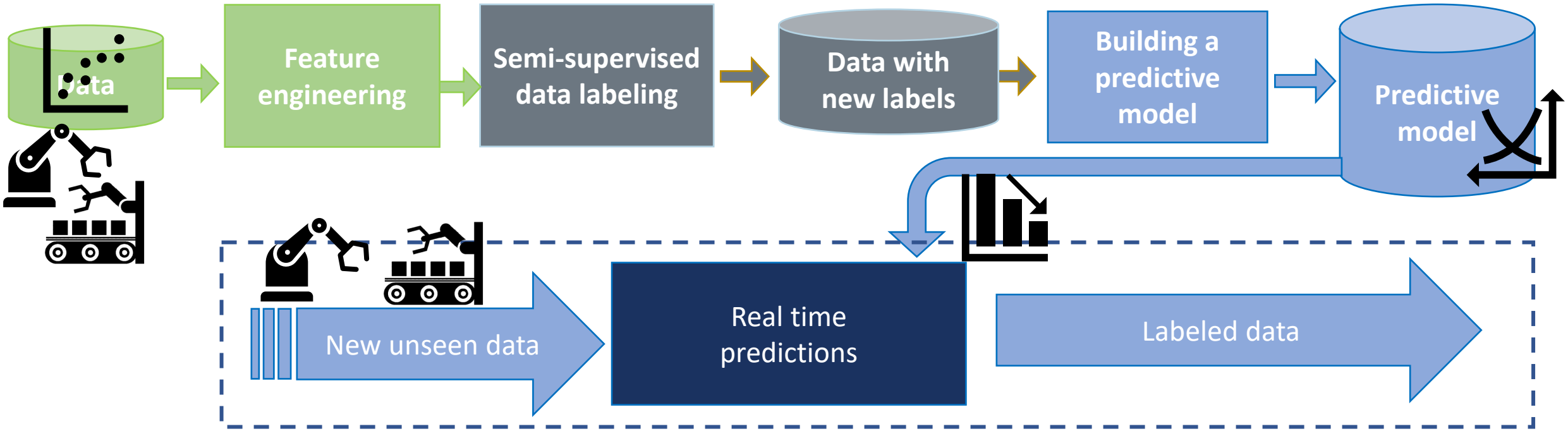
T. Cerquitelli *et al*., "Manufacturing as a Data-Driven Practice: Methodologies, Technologies, and Tools," in *Proceedings of the IEEE*, vol. 109, no. 4, pp. 399-422, April 2021, doi: 10.1109/JPROC.2021.3056006.

A DATA-DRIVEN PIPELINE



Exploiting Human-Knowledge

A DATA-DRIVEN PIPELINE



Data and Model evolution over time

J. Lu, A. Liu, F. Dong, F. Gu, J. Gama and G. Zhang: **Learning under Concept Drift: A Review**, in *IEEE Transactions on Knowledge and Data Engineering.*

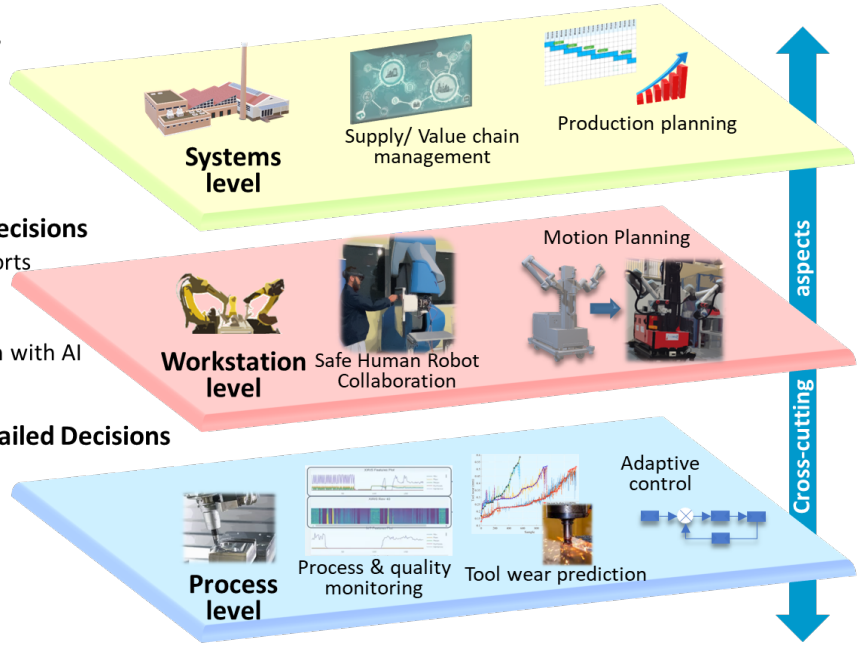
[2] Žliobaitė, Indrė & Pechenizkiy, Mykola & Gama, João. (2016). An Overview of Concept Drift Applications.

OPEN ISSUES

Systems level – Strategic Decisions
- Design Resilient production systems
- Efficient logistics and material flow
- Optimized throughput and flexibility
- Optimized resource utilization

Workstation level – Operational Decisions
- Reduce programming and setup efforts
- Efficient and Safe workplaces
- Waste elimination
- Simplify visualization and interaction with AI

Manufacturing Process level – Detailed Decisions
- High energy efficiency
- Inline Quality Inspection & Control
- Process & Material Optimization
- Zero Defects Manufacturing



OPEN ISSUES

- Focusing on **DATA**
  - Poor data quality
  - Limited data and knowledge sharing
  - Concept drift over time
- Focusing on **DATA-DRIVEN MODELING**
  - Customized solutions developed for each production environment
  - Minimal human control that compromises trust and safety when using AI solutions
  - Limited human understanding of algorithm decisions
  - Underutilization of physical knowledge in data-driven modeling

Human-Centered Machine Learning

Trustworthy and Explainable AI

Knowledge-Guided Machine learning

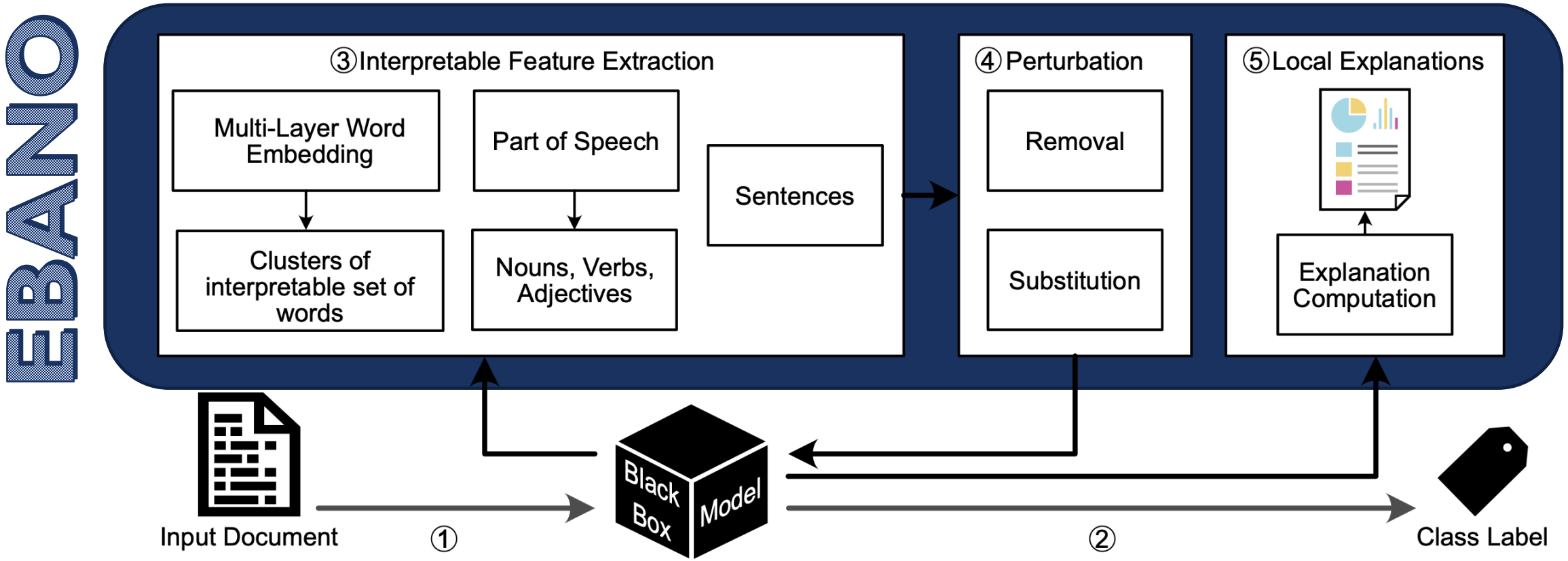
Safe Machine Learning

Sustainable Machine Learning

X-Driven Algorithms

GUIDING PRINCIPLES: DATA-DRIVEN MODELING

EBANO: EXPLAINING BLACK-BOX MODELS

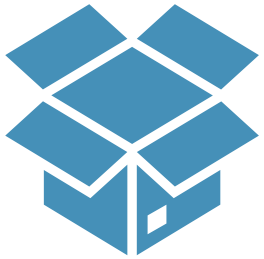


F. Ventura, S. Greco, D. Apiletti, T. Cerquitelli. **Explaining deep convolutional models by measuring the influence of interpretable features in image classification.** Data Min Knowl Disc (2023).

F. Ventura, S. Greco, D. Apiletti, T. Cerquitelli. **Trusting deep learning natural-language models via local and global explanations.** Knowl. Inf. Syst. 64(7): 1863-1907 (2022)

Data Policy and standards

Data Governance



Data and knowledge sharing

Concept-Drift management

Data evolution

GUIDING PRINCIPLES: DATA

DRIFT LENS: CONCEPT DRIFT DETECTION

"An unsupervised real-time drift detection and characterization methodology based on per-label embedding distribution distances"

Unsupervised

Distribution Distance

Real-Time

Embedding Representations

Drift-Detection

Per-Window Drift Prediction

Drift-Characterization

Per-Label Drift Quantification

.S Greco, T. Cerquitelli: **Drift Lens: Real-time unsupervised Concept Drift detection by evaluating per-label embedding distributions.** ICDM (Workshops) 2021: 341-349

WHAT'S NEXT?

Characterizing guiding principles with **a broad range of manufacturing use cases**

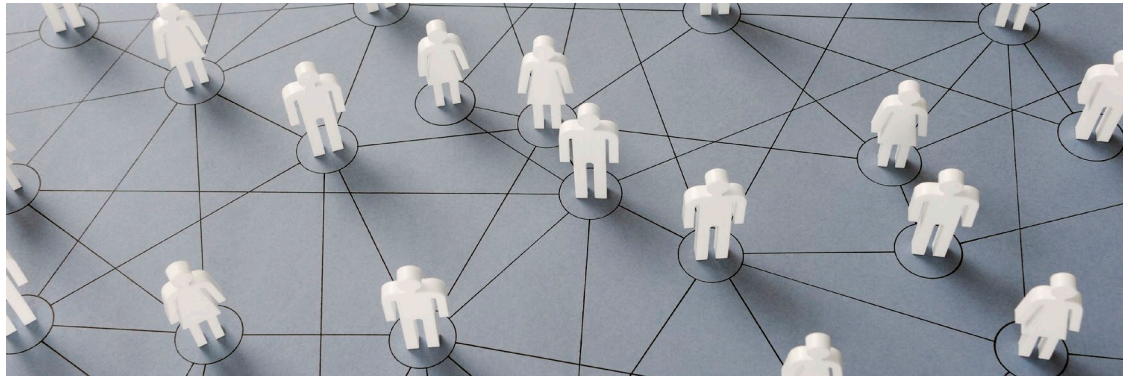
Enriching guiding principles with **algorithms, policy and standards**

Standardization of the process for verifying compliance with the guiding principles during the design of ML applications

Design and development of **a tool for monitoring** ML applications to verify compliance with the guiding principles during design, development and deployment of ML applications

ARE YOU INTERESTED?

Let's discuss it



Join the team

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Q&A

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