AI REDGIO 5.0

ADOPTING AI TOOLS IN MANUFACTURING PROCESSES

A collection of pilot experiments

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Introduction

The transition to Industry 5.0 marks a pivotal era where advanced technologies - Artificial Intelligence, IoT, and Edge Computing - merge with human expertise to create smarter, more resilient, and sustainable manufacturing systems. AI REDGIO 5.0 acts as the catalyst for this transformation. With a laser focus on Small and Medium-sized Enterprises (SMEs), the project bridges the critical gap between digital potential and shop-floor reality, strengthening the competitiveness of European industry.

At its core, the initiative champions experimentation, collaboration, and replicability. This booklet presents the tangible results and actionable lessons learned from 41 unique experiments, offering a roadmap for innovation across three strategic pillars:

- **Productivity & Agility**: 7 SME-driven experiments demonstrating how real-world AI applications can drastically enhance operational speed, quality control, and flexibility in diverse manufacturing environments.

- **Human-Centric Innovation**: 14 "test-before-investing" experiments conducted in Didactic Factories. These pilots go beyond technology to assess the ethical, regulatory, and human dimensions of AI, ensuring solutions are safe, compliant, and truly supportive of the workforce.

- **Sustainability & Circular Economy**: 20 SME-driven experiments deploying cutting-edge Edge AI solutions specifically designed to minimize waste, optimize energy consumption, and drive the transition toward circular production models.

Through these success stories, AI REDGIO 5.0 demonstrates that the factory of the future is not just a concept, but a tangible reality achievable today.

How to read the booklet

Each experiment is presented using a common structure, which makes it easier to compare contexts, solutions and outcomes.

Every fact sheet includes:

- **Keywords** – main concepts and technologies addressed by the experiment.
- **Payoff** – a short statement that captures the core value of the solution.
- **Description** – an overview of the industrial context, the problem addressed and the AI-based solution implemented.
- **Innovative aspects** – the main technological and organisational innovations introduced by the experiment.
- **Responsible AI** – how ethical, legal and human-centric aspects have been considered.
- **The Team** – the organisations involved in the experiment.
- **Lesson learnt** – key insights and takeaways emerging from the experiment.

Productivity & Agility
7 SME-driven experiments

1. COMPOSE - Control & Monitoring for Production Non-Conformances
2. CHAMOis - Customized Helping-tool for Agility in Manufacturing Operations
3. SustGain - AI at the Edge for Zero-Defect Cheese Production
4. AGRIDRIVE - AI-Enhanced Agricultural Safety
5. CVS-Pi - Contextualised Vision System for Process Improvement
6. Smart Fashion - AI-Powered Quality Assurance
7. MouldWatcher - Continuous AI Monitoring for Injection Moulding

Italy

COMPOSE

Control & Monitoring for Production Non-Conformances

Keywords

Artificial Intelligence

Quality Control

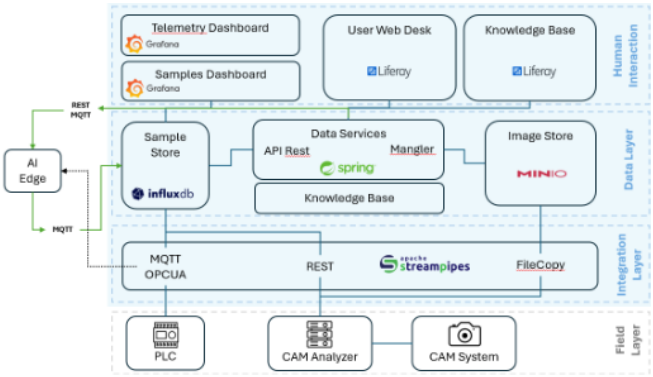
Anomaly Detection

Knowledge Management

Turning production data into shared knowledge to empower operators, prevent failures, and create a more efficient manufacturing process.

Description

At MOLLIS ANTONIO S.r.l. in Italy, a state-of-the-art reconfigurable pressing line developed by SCAMM is at the centre of an innovative experiment. The project combines artificial intelligence with manufacturing expertise to understand how production conditions impact product quality. Using AI to reveal patterns often invisible to traditional methods, the system helps detect anomalies early. Simultaneously, a user-friendly platform allows operators to document and share their problem-solving experiences, transforming personal know-how into a collective asset for more transparent and informed decision-making.



The integrated architecture: bridging the gap between field sensors, AI edge analytics, and human knowledge.

Innovative aspects

The solution introduces a modern, integrated architecture that bridges industrial data and AI:

- Seamless Connectivity: Machines and vision systems communicate via OPC UA and MQTT, while Apache StreamPipes ensures the flexible integration and quality of diverse data sources.
- Scalable Data Management: The platform efficiently handles massive datasets using InfluxDB for time-series data and MinIO for image storage, supported by Spring Boot services.
- Collaborative Intelligence: Liferay portals and Grafana dashboards allow operators to visualize real-time metrics and collaboratively manage knowledge. Crucially, an AI Edge component runs predictive models on-site for immediate decision support.

TRL: 6

Responsible AI

The experiment is a benchmark for Industry 5.0 principles. It prioritizes Human-Centricity by using AI to support, not replace, the worker. The system reduces the physical risks associated with electronic waste handling while keeping the human in control of the process. Furthermore, by simplifying robot interaction through voice, it promotes inclusivity. Crucially, the system architecture is designed to be fully compliant with the EU AI Act, ensuring transparency, safety, and robust risk management for human-robot collaboration.

The Team

- **INTELLIMECH** (Davide Pasanisi, Alissa Zaccaria)
- **SCAMM** (Fabrizio Mazzoleni)
- **SMC** (Alessandro Cecconi, Mauro Mariuzzo)
- Supported by **AFIL**

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Lesson learnt

The experiment highlighted two critical success factors. First, flexibility is paramount: in variable production contexts like SCAMM, systems must be modular and updatable to adapt to frequent process changes. Static solutions quickly become obsolete. Second, early stakeholder engagement is vital. In traditional manufacturing, the true operational know-how often resides with shop-floor technicians, not just managers. Involving operators from day one ensures that their invaluable, experience-based knowledge is captured and integrated into the AI system effectively.

CHAMOis

Customized Helping-tool for Agility in Manufacturing Operations

Groupe Pernoud

France

Keywords

Production Scheduling

CAD Feature Extraction

Encoder-Decoder LSTM

Decision Support System

A customized AI tool that extracts features from CAD files to predict manufacturing sequences, enabling agile scheduling and reducing production delays.

Description

Groupe Pernoud, a specialist in molds for plastic injection and composites, faces a unique challenge: every product is a prototype, never manufactured twice. This variability makes traditional manual planning inefficient and reactive. To address this, the CHAMOis experiment introduces an AI-driven approach. By analyzing the geometry and functionality of 3D CAD models, the system predicts the necessary manufacturing sequences and estimates times. This allows the company to plan activities dynamically, reducing the "fog" caused by fluctuating market demands and optimizing Overall Equipment Effectiveness (OEE).

From CAD to Prediction: the AI pipeline transforming 3D model features into optimized manufacturing schedules.

Innovative aspects

The solution replaces manual estimation with a sophisticated data-driven pipeline:

- CAD Feature Extraction: A novel algorithm analyzes 3D CAD files, identifying surfaces based on color definitions linked to specific functionalities. Using the Python OCC library, it extracts geometric features (e.g., color repartition per face) to "understand" the part to be manufactured.
- Sequence Prediction AI: These geometric features feed an Encoder-Decoder model with LSTM (Long Short-Term Memory). This neural network is trained on historical data to predict the most probable manufacturing sequence and processing times for new, unseen prototypes.
- Automated Scheduling: The predicted sequences are integrated into Speed Ordo, an automatic scheduling tool. This moves the organization from static planning to dynamic, real-time optimization, capable of reacting to shop floor changes instantly.

TRL: 5

Responsible AI

The system is designed as a Human-Centric decision support tool. It processes strictly technical data (CAD files, task times, costs) with no personal information involved. The AI suggests optimal sequences to save time, but the human planner retains full authority to accept, modify, or reject the schedule. This approach enhances the operator's capabilities without automating the final decision, adhering to ethical principles of transparency and human oversight.

The Team

- **Groupe Pernoud** (Valentin Charreton, Sebastien Noroy, Hugues Ferre, Patrice Jacquet, Bibek Paudyal)
- Supported by **Polymeris** and **TXT Group**

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Lesson learnt

The project highlighted that SMEs, starting with a generalized solution—even if it requires more initial planning—is more sustainable than building rigid, highly specific tools. Crucially, the experiment showed that data quality is paramount: employees must be trained on the strictness required for data management to feed AI models effectively. Finally, embedding AI specialists directly within the industrial team proved to be a decisive factor in accelerating technology adoption and bridging the gap between R&D and shopfloor reality.

SustGain

AI at the Edge for Zero-Defect Cheese Production

Spain

Keywords

AI-Edge

Smart Manufacturing

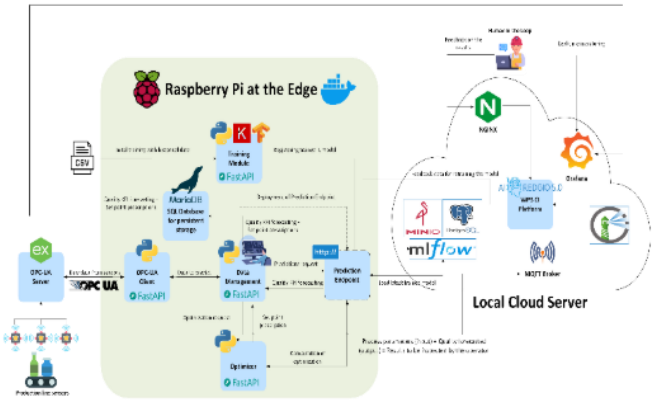
Prescriptive Quality Control

Waste Reduction

Optimizing cream cheese texture and minimizing waste through real-time, AI-driven monitoring directly on the production line.

Description

Quescrem, an innovative Spanish dairy SME specializing in cream cheese, partnered with the technology center Gradiant to launch the SustGain experiment. The goal is to tackle a common challenge in food manufacturing: maintaining consistent product quality while minimizing waste. By deploying sensors and AI algorithms directly on the production line ("Edge Computing"), the system monitors critical variables like temperature, pressure, and nutritional characteristics in real-time. This allows for the instant prediction of the final product's hardness—a key quality indicator—enabling operators to adjust the process on the fly, ensuring perfect texture and reducing the need for reprocessing.



The Edge-Cloud architecture: real-time prediction on the factory floor with centralized model management.

Innovative aspects

The experiment combines advanced process modelling with a robust, cloud-native tech stack:

- AI-Edge Incremental Learning: The core innovation is a model developed using Keras and TensorFlow that monitors cream cheese pasteurization in real-time. It uses Incremental Learning to forecast the final product's hardness (a key quality KPI), updating itself continuously to distinguish between "good" and "out-of-spec" batches.
- Cloud-Native Orchestration: The system utilizes Docker Compose for orchestration and Harbor for secure artifact management. This ensures that the AI models running on the edge are scalable, secure, and easily updatable across the factory.

- Interoperable Data & MLOps: The platform ensures secure data exchange between devices via OPC-UA and Mosquitto, while MLflow manages the entire machine learning workflow. Real-time insights are then visualized on Grafana dashboards, providing operators with immediate process visibility.

TRL: 6

Responsible AI

The system operates on purely technical data—monitoring temperatures, pressures, and nutritional characteristics of ingredients—ensuring total privacy and eliminating any risk of bias. Designed as a Human-Centric decision support tool, the AI prescribes optimal production parameters but takes no automated actions. The human operator retains full authority over the final decision, ensuring the system complies with the EU AI Act as a low-risk application that empowers rather than replaces the worker.

The Team

- **Quescrem** (Daniel Estrada, Rocío Lamas)
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Lesson learnt

The experiment delivered a tangible impact: the shift to predictive and prescriptive quality control is expected to reduce non-compliant cream cheese batches by 12%, optimizing the hardness KPI. However, achieving this result highlighted that data quality is non-negotiable: having well-structured, interconnected datasets is critical for training effective AI models. While deploying AI at the Edge offers significant speed and privacy benefits, it operates under strict hardware constraints. Finally, the project proved that high replicability and scalability are achievable: the solution can be easily adapted to other products within Quescrem or leveraged by Gradiant for companies in different sectors with minimal customization.

AGRIDRIVE

AI-Enhanced Agricultural Safety

Italy

Keywords

Driving Help

Field Safety

Vision Systems

Edge AI

Agriculture 4.0

A "plug-in" driving assistant that upgrades existing agricultural vehicles with AI vision to prevent accidents and save lives in high-risk environments.

Description

Agricultural fields are high-risk environments where accidents are frequent and often fatal. To address this, GPALMEC developed AGRIDRIVE, a pilot experiment focused on retrofitting agricultural vehicles with advanced safety features. Instead of requiring brand-new expensive machinery, the project created a "plug-in" system capable of bringing autonomous driving aid to existing tractors. By installing a suite of mobile sensors and edge computing units, the system monitors the terrain and vehicle inclination in real-time, helping the machine navigate safely, avoid obstacles, and follow three lines autonomously.

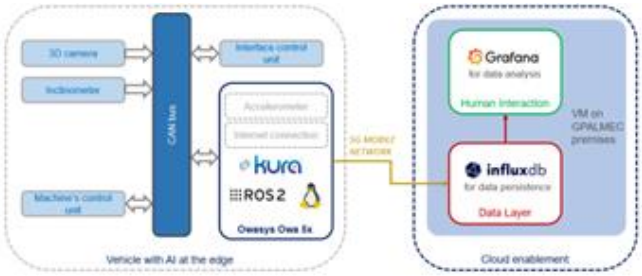
The AGRIDRIVE setup: retrofitting a standard tractor with 3D cameras and inclinometers for smart navigation.

Innovative aspects

The solution introduces a modular approach to modernize agricultural fleets:

- Plug-and-Play Interoperability: The core innovation is a "plug-in" hardware kit designed to interface with the central control unit of any agricultural vehicle. It uses robust mobile devices capable of withstanding harsh conditions (vibrations, humidity, temperature extremes).
- Sensor Fusion at the Edge: The system combines data from a Mobile 3D camera, accelerometers, and inclinometers. This multi-sensor approach allows the AI to understand complex terrains (frontal and lateral inclination) that affect traction and stability.
- Post-Process Analytics: Beyond real-time control, a dedicated analysis tool (developed with SMC) evaluates the driving logic performance offline, allowing for continuous fine-tuning of the steering and

speed algorithms based on recorded field data.



System Architecture: connecting on-board sensors via CAN bus to Edge AI and Cloud analytics.

TRL: 6

Responsible AI

AGRIDRIVE is designed with a Safety-First and Human-Centric philosophy. Its primary goal is not to replace the farmer, but to act as a "guardian angel" that prevents life-threatening accidents caused by distraction or difficult terrain. The system operates as a driving help, meaning the human operator can always intervene. Furthermore, by retrofitting existing machines, it promotes sustainability (circular economy) by extending the lifecycle of older vehicles rather than forcing premature scrapping.

The Team

- **HIT** – Hub Innovazione Trentino
- **SMC** (Post-process analysis tool provider)
- **GEIER Srl** (Machine provider)

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Lesson learnt

The experiment demonstrated that implementing a plug-in driving help system on existing agricultural machinery is feasible and yields promising results. Tests confirmed the system's ability to autonomously drive towards obstacles, steer to avoid collisions, maintain a set distance along walls, and execute emergency stops. However, a key lesson is that the driving logic must be strictly tailored to the vehicle's specific characteristics. Different traction types (wheels vs. tracks) significantly influence machine handling, while terrain inclination (frontal and lateral) critically affects the controllers for tree line following and speed maintenance. Finally, while data collection for post-process analysis was successful, full commercial uptake requires further fine-tuning. The pilot tests were conducted at limited speeds; therefore, future trials must validate the system's robustness in real-world environments with higher speeds and varied terrain conditions.

CONTROL 2K
everything in control

CAP Engineering Services Ltd

United Kingdom

CVS-Pi

Contextualised Vision System for Process Improvement

Keywords

Automated Quality Inspection

Process Efficiency

ANDON Alerting

Edge AI

Environmental Monitoring

An intelligent quality control system that combines computer vision with environmental data to detect anomalies and trigger immediate corrective actions in high-speed production.

Description

In high-speed automated production, ensuring consistent quality without slowing down for visual inspection is a critical challenge. The CVS-Pi experiment, developed by CAP Automation and Control 2K (C2K), addresses this by creating a "context-aware" inspection tool. Unlike standard vision systems, CVS-Pi correlates with real-time machine data with environmental conditions (temperature, dust). When the AI detects instability, it doesn't just log an error; it actively triggers corrective actions via the Industreweb platform—such as turning on cooling systems or alerting operators to inspect parts—creating a responsive, self-correcting manufacturing loop.

The CVS-Pi inspection station: integrating an industrial camera directly onto the automated assembly line for real-time quality control.

Innovative aspects

The solution is built on a robust, multi-layered technology stack designed for interoperability:

- Integrated Tech Stack: The system utilizes SQL and MongoDB for flexible data storage, while Industreweb™ serves as the central data collector, backend, and visualization engine (Display).
- Universal Connectivity: It ensures seamless communication between diverse shopfloor devices using standard protocols including MQTT, REST, OPC-UA, and Bluetooth.
- Advanced Asset Modelling: A dedicated framework allows users to define data models for specific production assets. Special aggregation components monitor MQTT streams from Edge nodes, inserting

them into a MongoDB schema optimized for querying contextualized data.

- AI Integration: The architecture incorporates the DATA4AI model (along with WP4 & 5 tools) to analyse these aggregated streams, detecting anomalies that trigger the feedback loop.

TRL: 6

Responsible AI

The CVS-Pi system is designed to upgrade the human role from labor-intensive visual inspection to a cleaner, safer supervisory position. Classified as a Low Risk AI application, it processes purely anonymous production data, ensuring no personal information is used. Crucially, while the system provides advanced real-time monitoring via a Digital Twin, all critical decisions regarding product validation require human intervention, keeping the operator firmly in charge of the process.

The Team

- **CAP Automation** (Ceri Pritchard)
- **Control 2K (C2K)** (Simon Osborne, Kai Tey, Will Simpson)

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Lesson learnt

The experiment proved effective in speeding up quality checks and improving workforce safety. However, success relied heavily on critical data strategies. The first iteration revealed that generating high volumes of data is ineffective without a structured Asset Modelling framework to organize it. Technically, adopting the Asset Administration Shell (AAS) standard was decisive, allowing the system to connect seamlessly with external AI modules (DATA4AI) and scheduling frameworks (ArrowHead). Finally, the use of TERESA facilities accelerated prototyping, leading to a direct positive impact: the participating SME recognized the value of Edge AI and is now exploring further applications.

Smart Fashion

AI-Powered Quality Assurance

Romania

Keywords

Automated Quality Assurance

FashionTech

Mask R-CNN

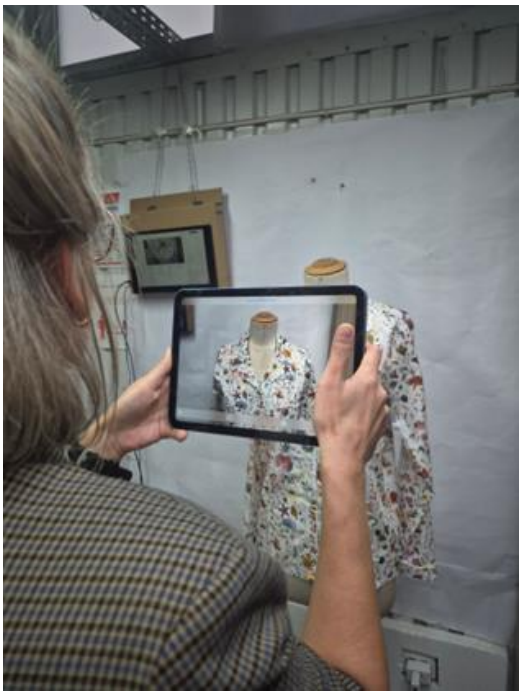
Edge AI

Cloud-Native Automation

A fully integrated, edge-powered defect detection system that brings high-speed, AI-driven quality control to the fashion production floor.

Description

Katty Fashion, a forward-looking garment manufacturer in Romania, implements the industrial version of the AI defect detection system. Moving beyond prototyping, this experiment integrates the tool directly into the factory's Quality Assurance (QA) workflow. The system captures high-resolution images of garments and processes them instantly using an embedded AI engine. By aligning the analysis with the product's original design specifications, it identifies subtle manufacturing flaws—such as stitching errors or fabric defects—and automatically alerts QA personnel, ensuring that every item meets strict fashion standards before shipping.



AI on the runway: the automated inspection station verifying garment quality in real-time.

Innovative aspects

The experiment elevates defect detection from research to industrial reality through a fully integrated pipeline:

- Optimized Edge AI: After benchmarking multiple architectures (including Fuzzy-AI and YOLO), the team selected a fine-tuned Mask R-CNN model. Optimized with NVIDIA TensorRT and running on a Jetson Orin NX, it delivers high-performance inference for complex fabric segmentation directly on the device.

- Real-Time Interactive Streaming: Unlike static alerts, the solution streams live video and inference results via WebRTC and WebSockets. This allows operators to visualize defects instantly and interact with the system through a web-based interface.
- Automated MLOps Pipeline: A cloud-native infrastructure supports continuous improvement. Data is stored in MinIO (with Cloudflare R2 archival) and processed via Apache Spark for automated training. Updated model weights are versioned and deployed automatically, ensuring the production line always runs the most accurate model.

TRL: 7

Responsible AI

The system is designed to empower the predominantly female workforce in the garment sector. Rather than replacing human expertise, the AI acts as a "digital assistant" that handles the repetitive strain of visual inspection, allowing human workers to focus on complex decision-making and craftsmanship. The interface is user-centric, designed to be intuitive for non-technical personnel, and ensures that the final judgment on quality remains in human hands.

The Team

- **Katty Fashion** (Caterina Ailiesei, Julia Butucă, Cezara Zbanca, and technical team)
- **Technical University of Iasi (TUIASI)** (Scientific Research Team)

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Lesson learnt

The experiment demonstrated significant improvements in the QA workflow, proving that AI-driven quality assurance is both feasible and impactful. The solution successfully achieved real-time detection of visual defects like **asymmetries and misaligned seams**, significantly reducing manual inspection time and rework rates. Crucially, the project highlighted that a scalable data pipeline is essential for continuous model improvement. Strategic lessons emphasize that future uptake requires **enhancing dataset diversity** to handle new garment types and integrating the system with **MES/ERP** tools for end-to-end traceability. Ultimately, this setup serves as a core enabler for the **Fashion Factory of the Future**, merging automation with human expertise.

MouldWatcher

Continuous AI Monitoring for Injection Moulding

Slovenia

Keywords

Predictive Maintenance

Injection Moulding

Edge AI

Quality Control

EUROMAP

A shop-floor wide monitoring system that integrates moulding machine data via EUROMAP standards to detect process degradation and prevent unplanned stoppages.

Description

Polycom, an innovative provider of technical products for the automotive industry, operates a massive manufacturing floor with over 110 injection moulding machines. To maximize availability and efficiency, these distributed assets require continuous supervision. The MouldWatcher experiment addresses this by deploying an Edge AI solution. Using standard protocols (EUROMAP, OPC-UA), the system collects operational data from the entire shop floor. Advanced algorithms then analyze this stream in real-time to detect deviations in critical process parameters, identifying early signs of degradation before they lead to machine failure or defective products.

The MouldWatcher edge device: visualizing real-time process parameters directly on the moulding machine.

Innovative aspects

The experiment modernizes legacy and modern equipment through a standardized, tech-driven approach:

- Standardized Data Integration: The pilot achieves shop-floor wide integration using EUROMAP and OPC-UA protocols. This ensures that data from over 110 diverse moulding machines is collected uniformly, creating a robust foundation for analytics.
- Edge-Cloud Orchestration: The system runs on Raspberry Pi edge nodes for local

processing and visualization. Crucially, data processing pipelines are managed and integrated using Apache Airflow, ensuring reliable and scalable data flows across the factory.

- Collaborative Intelligence & Visualization: Beyond automated detection, the solution collects operator feedback to contextualize machine status. Insights are visualized via Grafana and Node-Red dashboards, enabling quick identification of typical faults and process changes directly on the line.

TRL: 6

Responsible AI

The MouldWatcher system is designed as a Collaborative Intelligence tool. It empowers operators by collecting their feedback on process conditions, integrating human expertise into the digital loop. The algorithms are designed to be "insensitive" to legitimate manual adjustments made by operators, ensuring that the AI supports rather than conflicts with human decision-making. Furthermore, the system processes only technical machine data (pressures, cycle times), ensuring complete anonymity and compliance with privacy standards.

The Team

- **Polycom** (Mateja Karničar Šenk, Luka Podgoršek, Sebastjan Sternad) - Pilot Lead
- **Jožef Stefan Institute** (Miha Glavan, Žiga Stržinar, Dejan Gradišar) - Technical Support

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Lesson learnt

The experiment highlighted that moulding is a dynamic process where operators frequently adjust parameters; therefore, algorithms must be robust enough to distinguish these intentional changes from actual faults.
Technically, while systematic on-line monitoring proved useful for detecting fault sources, data acquisition posed challenges on specific machines. For wider uptake, the roadmap implies improving detection accuracy and integrating laboratory quality results. Strategically, deployment should initially target process managers to validate stability before rolling out the solution to line operators.

Human-Centric Innovation
14 Test-before-investing experiments

1. Politecnico di Milano - Smart WEEE Disassembly: AI and Cobots for Circular Economy
2. ACTEMA - E2Mech: Edge-Computing Enabled Mechatronics
3. Jožef Stefan Institute – E2Lab: Self-evolving monitoring systems for assembly production lines
4. Brainport Industries – CarbonInsight: Automated Calculation of Carbon Footprint using AI
5. MADE Competence Center - BEhAI: Adapting Quality Inspection to Human Behavior
6. University of Twente – ISB: Smart Box: A Unified IIoT System for SMEs
7. Fondazione Bruno Kessler - i4.0Lab: A Didactic Factory for Industrial IoT
8. Flanders Make - PM 50: Predictive Maintenance 5.0: An AI-on-the-Edge Didactic Factory
9. Digital Manufacturing Innovation Hub Wales – IWOK: Industreweb-X Operational Knowledgebase
10. Technical University “Gheorghe Asachi” - QUAD-AI@E: Real-World AI for Clothing Manufacturing
11. Czech Institute of Informatics, Robotics, and Cybernetics - X-MONITOR: Explainable Monitoring of Robotic Assembly in Dynamic Production
12. Aalborg University – D2IoT: The Data-Driven IoT Suitcase
13. AM-LAB – SunSync: AI for Optimised Industrial Recycling
14. Gradiant – GalicianDF: Galician Didactic Factory: AI at the Edge for Additive Manufacturing

POLITECNICO MILANO 1863

INDUSTRY4.0 lab

Italy

Smart WEEE Disassembly

AI and Cobots for Circular Economy

Keywords

Circular Economy

Human-Robot Collaboration

AI Safety

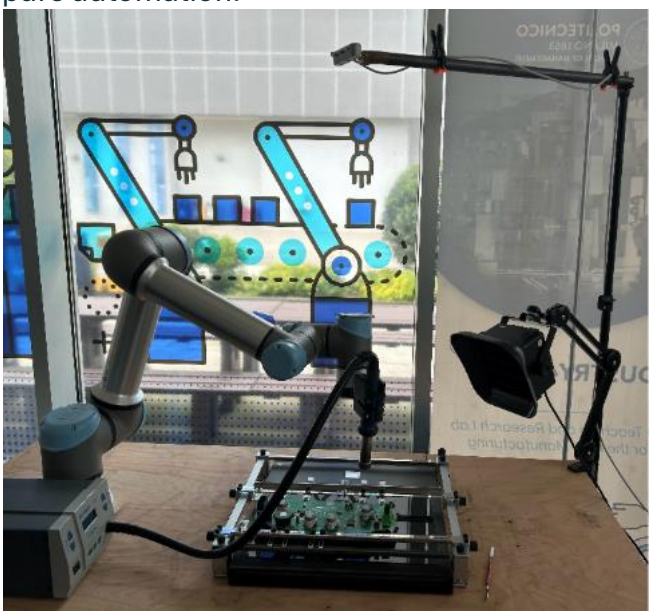
Voice Control

Industry 5.0

A human-centric disassembly line where operators and robots collaborate safely using natural voice commands to recover valuable electronic components.

Description

To tackle the growing challenge of electronic waste (WEEE), Politecnico di Milano (POLIMI) utilizes its Industry4.0Lab to demonstrate a smart disassembly process. The experiment focuses on recovering components from Printed Circuit Boards (PCBs), a task that requires human dexterity but involves hazardous steps. The solution creates a collaborative environment where a robot assists the operator. By integrating advanced Computer Vision for safety and Large Language Models (LLMs) for interaction, the system allows operators to control the robot using natural speech, ensuring a seamless and safe workflow that prioritizes human well-being over pure automation.



The collaborative workstation, a cobot assists the human operator in disassembling electronic boards safely.

Innovative aspects

The experiment introduces a new level of interaction in industrial recycling by integrating specific cutting-edge AI tools:

- AI-Enhanced Safety: Going beyond standard safety measures, the system employs MediaPipe Hand Landmarker technology to detect and track human hands in real-time. This ensures total safety even when the operator works closely with hazardous tools, such as hot air nozzles.
- Voice-Controlled Robotics: A major innovation is the integration of OpenAI Whisper for voice transcription and Ollama LLM for intent recognition. This

allows operators to control the robot using intuitive voice commands (e.g., "heat this component") instead of complex programming, making the system accessible to non-technical users.

- Precision Perception: To identify specific electronic components on the boards, the system utilizes YOLOv8 neural networks. This enables the robot to precisely locate items like chips or capacitors, optimizing the disassembly workflow.

The AI interface, combining computer vision for component detection with voice command feedback.

TRL: 4-5

Responsible AI

The experiment is a benchmark for Industry 5.0 principles. It prioritizes Human-Centricity by using AI to support, not replace, the worker. The system reduces the physical risks associated with electronic waste handling while keeping the human in control of the process. Furthermore, by simplifying robot interaction through voice, it promotes inclusivity, allowing workers with diverse technical backgrounds to operate advanced machinery.

The Team

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Lesson learnt

The experiment highlighted that despite advances in automation, human expertise remains irreplaceable for complex tasks like identifying valuable components in electronic waste, where robots cannot yet match human problem-solving skills. Technically, the combination of Speed and Separation Monitoring with safety-rated cameras proved effective for physical safety. However, a decisive factor for future uptake is finding the right balance between the cobot's pace and the operator's comfort. A safe and intuitive system must prioritize smooth interaction over raw speed to build the necessary trust between operators and machines.

E²Mech

Edge-Computing Enabled Mechatronics

Italy

Keywords

Edge Computing

Condition Monitoring

Predictive Maintenance

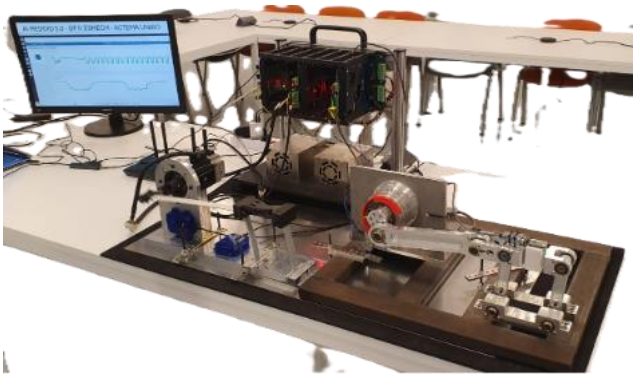
Smart Mechatronics

Hybrid AI

A smart mechatronic system that combines physical models and AI to enable reliable predictive maintenance, even with limited fault data.

Description

To modernize industrial automation, the University of Bologna (ACTEMA Group) developed the E²Mech experiment. While consumer electronics generate abundant data, industrial machines often lack historical datasets on failures ("thin data"), making standard AI training difficult. This "Didactic Factory" addresses the challenge by creating a flexible mechatronic benchmark equipped with a custom Edge Computing platform. The system demonstrates a complete journey from sensor data gathering to advanced Condition Monitoring and Prognostics (CM&P), proving that predictive maintenance can move from theoretical ambition to factory floor reality by analyzing data locally and efficiently.



The E2Mech experimental setup, a flexible mechatronic system used to benchmark edge-AI algorithms for predictive maintenance.

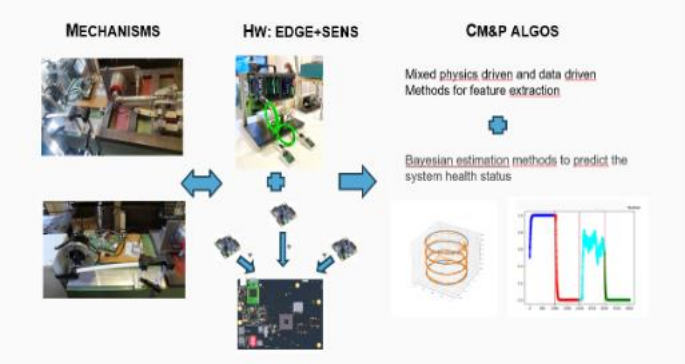
Innovative aspects

The experiment introduces a sophisticated "Hybrid" approach to solve the data scarcity problem in manufacturing:

- Hybrid AI Framework (Physics + Data): Unlike standard "black box" AI that requires massive datasets, this solution roots statistical learning in physical insights (using a rough model of the system). This allows for automatic feature extraction and reliable anomaly detection even when historical fault data is limited or incomplete.
- Dual-Purpose Edge Computing: The hardware innovation lies in a custom proprietary unit (based on the STM32MP2 processor) that performs two critical tasks simultaneously: it executes complex diagnostic algorithms and directly drives the machine with accurate position control. This

integration drastically reduces hardware complexity and latency.

- Robust Data Pipeline: The system implements a seamless flow from commercial vibration sensors (STWINKB1) to the cloud. Data is processed at the edge for immediate diagnostics and then transferred to a dashboard for long-term trend analysis.



Fhe Hybrid Architecture, combining custom Edge hardware with physics-driven AI algorithms for precise fault diagnosis.

TRL: 3-4

Responsible AI

The E²Mech experiment prioritizes Reliability and Transparency. By anchoring AI predictions to physical models, the system avoids the unpredictability of pure data-driven approaches, ensuring that diagnostic outputs are explicable and trustworthy for engineers. The solution acts as an advanced support tool, visualizing health indexes on a dashboard to help human operators anticipate failures without removing their decision-making power.

The Team

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Lesson learnt

The experiment delivered a major breakthrough for industrial uptake: the ability to train algorithms only on healthy data. By using a Bayesian classifier to produce an easy-to-interpret "health index", the system overcomes the scarcity of fault data that typically hinders AI adoption in automation. Strategically, the project demonstrated that developing custom edge computing solutions can significantly reduce costs while maintaining high performance, a key tradeoff to "unleash" advanced diagnostics in the mass market. Finally, the robust data pipeline established serves as a validated model ready to be shared with regional industrial partners to foster innovation.

Jožef Stefan Institute
Ljubljana, Slovenia

University of Ljubljana

kcstv
kompetenčni center za sodobne tehnologije vodenja

Slovenia

E2Lab

Self-evolving monitoring systems for assembly production lines

Keywords

Manufacturing

Minimal-invasive monitoring

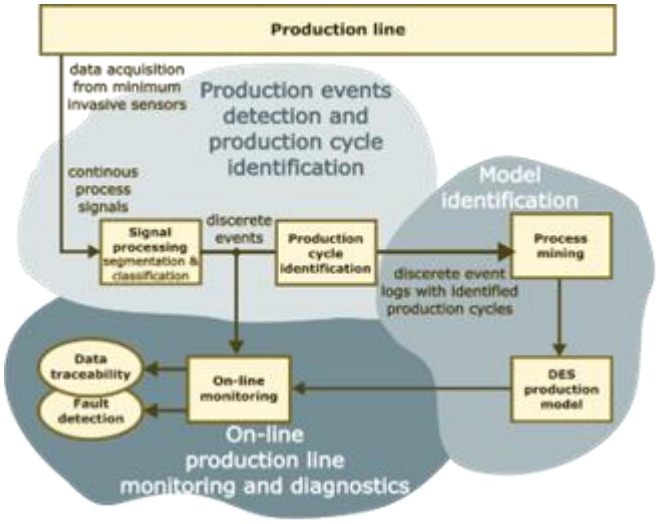
Predictive maintenance

Early defect detection

A self-learning monitoring system that uses non-intrusive sensors to predict equipment failures and reduce downtime without interrupting production workflows.

Description

The experiment, coordinated by the Jožef Stefan Institute in collaboration with the University of Ljubljana and the Competence Centre for Advanced Control Technologies, establishes a testbed for monitoring repetitive assembly processes. The primary goal is to create a system capable of "self-learning" in the standard operations of a production line to automatically characterize and detect deviations.



The self-learning process: how the system transforms raw sensor data into automated fault detection.

By employing a minimal-invasive approach, the solution provides deep insights into the production state and process of health without requiring complex integration or invasive modifications to existing machinery.

Details of the custom hardware unit and the non-intrusive 'clip-on' sensors used for data collection.

Innovative aspects

The experiment introduces three key innovations to simplify predictive maintenance:

- Minimal-Invasive Hardware: The system utilizes "clip-on" sensors that attach externally to machinery and custom-developed hardware. This allows for accurate data collection and signal processing without the need to drill into equipment, modify control loops, or void warranties.
- Self-Learning AI: Unlike traditional monitoring systems that require manual programming of thresholds, this solution uses advanced analytics to autonomously learn repetitive data patterns from historical operations. The algorithms adapt to the machine's natural rhythm to identify anomalies.
- Standardized Virtualization: The setup implements the Asset Administration Shell (AAS) standard, effectively creating a virtual representation (Digital Twin) of the monitored assets. This ensures standardized data sharing and interoperability with other factory systems.

The Asset Administration Shell (AAS) implementation: creating a standardized digital twin for the quality control process.

TRL: 5

Responsible AI

The experiment leverages AI to transform complex time-series data into clear, understandable event logs for human operators. By modeling discrete production events, the system identifies deviations in sequences and timings, such as component wear or occasional faults. This approach keeps the human in the loop, providing maintenance teams with actionable insights to make informed decisions rather than automating the control process entirely, thereby enhancing safety and operational transparency.

The Team

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- **University of Ljubljana**, Faculty of Electrical Engineering (Laboratory of Automation and Cybernetics)
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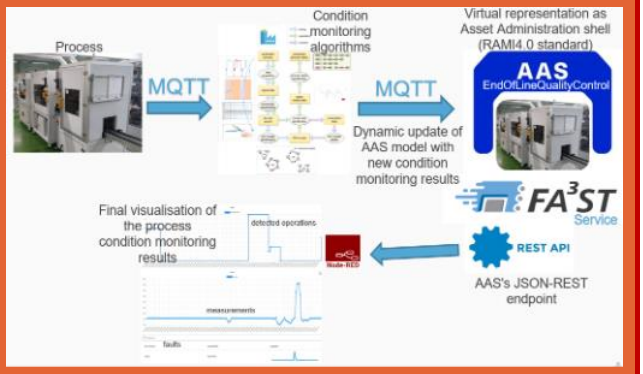
Lesson learnt

The experiment confirmed that minimal-invasive sensors provide rich enough data to detect subtle production issues. Specifically, the algorithms successfully identified slowly increasing deviations—such as the slow wear of actuators—and occasional operational faults. This capability allows for the quick identification of causes behind line stoppages, significantly improving maintenance efficiency. However, real-world testing also highlighted that production lines frequently switch operational modes (e.g., different products). Therefore, future algorithms must be robust enough to distinguish these normal variations from actual defects. To support wider uptake, development will focus on handling this variability and improving scalability using cost-effective edge nodes (e.g., Raspberry Pi) for secure data sharing.



Visualisation of results: the system successfully detects operational faults and deviations in real-time.

CarbonInsight

Automated Calculation of Carbon Footprint using AI

Brainport Industries

The Netherlands

Keywords

Product Carbon Footprint (PCF)

Manufacturing Supply Chain

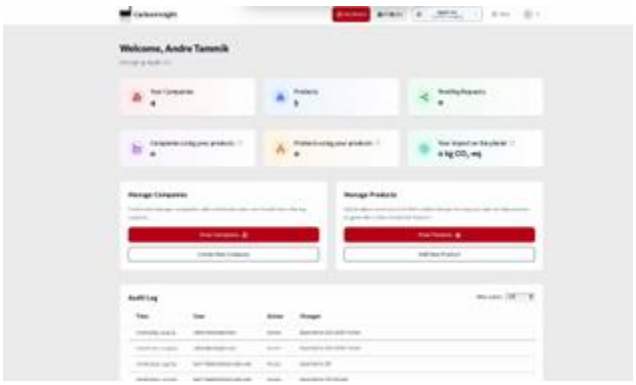
Asset Administration Shell (AAS)

AI-driven Sustainability

An automated, AI-powered platform that calculates Product Carbon Footprints and suggests actionable reduction strategies for the manufacturing supply chain.

Description

The experiment, led by Brainport Industries, introduces CarbonInsight™, a web-based solution designed to automate the complex calculation of Product Carbon Footprints (PCF). By processing manufacturing data and supply chain inputs, the system not only calculates the current environmental impact but also utilizes Artificial Intelligence to actively suggest reduction strategies. The tool ensures full interoperability by exporting data in standard formats like the Asset Administration Shell (AAS), facilitating integration with Digital Product Passports and financial reporting. The platform enables organizations to share data securely, fostering a more transparent and sustainable manufacturing ecosystem.



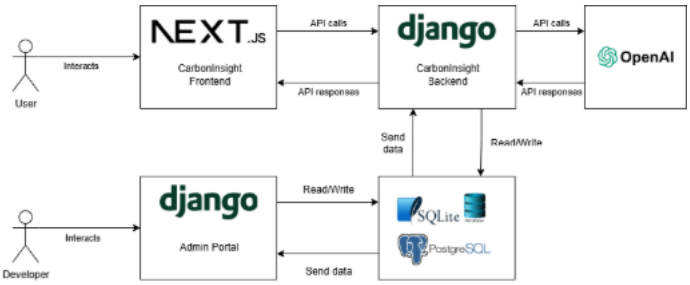
The CarbonInsight interface, a centralized dashboard for managing company data, products, and carbon footprint calculations.

Innovative aspects

The experiment leverages advanced web technologies and AI to transform environmental reporting:

- Automated & AI-Driven Insights: The platform replaces manual spreadsheets with an automated system that calculates Product Carbon Footprints (PCF) using standardized inputs. Beyond mere calculation, it integrates AI models to analyze the data and proactively suggest concrete reduction strategies, acting as an intelligent sustainability consultant.

- Standardized Interoperability: By adopting the Asset Administration Shell (AAS) standard and identifying protocols like MQTT, the tool ensures that carbon data is not siloed. It creates a "digital twin" of the product's environmental impact that can be easily shared across the supply chain and integrated with Digital Product Passports.
- Scalable Web Architecture: Built on a robust stack (Django backend, React frontend), the solution is designed as a scalable, cloud-ready web application. This ensures that complex calculations are handled efficiently and that the tool can easily grow to support more companies and larger datasets.



The system architecture, connecting user interfaces with powerful AI and database backends for seamless calculation.

TRL: 5

Responsible AI

The experiment adopts a forward-looking approach to data sovereignty and ethical AI. While the initial Proof of Concept utilizes general AI models to demonstrate feasibility, the roadmap explicitly targets the integration of European-based, open-source Large Language Models (LLMs), such as Aleph Alpha. This strategic shift ensures that sensitive manufacturing and environmental data remain within European jurisdiction, aligning with strict privacy standards and reducing reliance on non-sovereign technologies. By prioritizing open-source solutions, the platform also fosters greater transparency and trust in the automated reduction advice provided to users.

The Team

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Lesson learnt

The rapid development of the Proof of Concept highlighted the contrast between fast prototyping—achieved through dedicated academic collaboration—and the significant resources required for long-term software maintenance and commercial scaling. A key takeaway is the necessity of structural partnerships, particularly with the Smart Connected Supplier Network (SCSN), to ensure financial and technical sustainability. Future uptake depends on validating calculation methods with official bodies (e.g., EcoVadis) and conducting extensive user testing with manufacturing SMEs. Additionally, the tool's scope should expand beyond carbon to include Environmental Cost Indications and Circularity Indices, providing a holistic sustainability picture.

BEhAI

Adapting Quality Inspection to Human Behavior

Italy

Keywords

Operator Wellbeing

Human-Centric AI

Biometric Data

Adaptive Automation

Industry 5.0

An intelligent quality inspection system that adapts machine behaviour to the operator's psychophysical state, maximizing both individual well-being and business productivity.

Description

The MADE Competence Center in Milan leads the BEhAI experiment, a pioneering initiative in Industry 5.0. The project explores the direct relationship between environmental, biomechanical, and biometric data and the operator's condition. Unlike traditional rigid automation, this system monitors the human worker during quality control tasks. By analyzing real-time data, it dynamically adapts the robot's behavior to match the operator's current psychophysical state—slowing down if stress is detected or optimizing pace for comfort—ensuring a symbiotic and safe collaboration between human and machine.

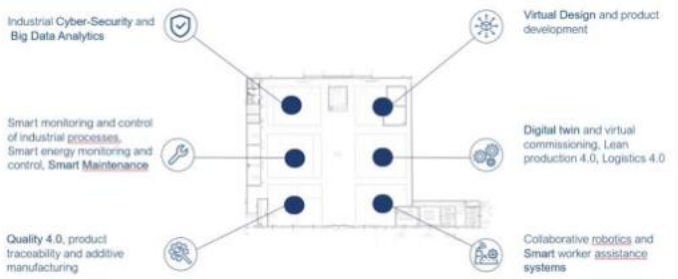
The adaptive workstation: a collaborative robot that adjusts its speed based on the operator's biometric feedback.

Innovative aspects

The experiment introduces a paradigm shift towards "Cognitive Automation," where the machine understands the human:

- Multimodal Psycho-Physical Sensing: The system goes beyond standard metrics by fusing diverse data sources—including heart rate, thermal imaging, acoustic levels, and air quality. This creates a real-time, holistic picture of the operator's physiological and environmental context.
- Adaptive Machine Pacing: Utilizing an ExtraTreesClassifier model, the AI predicts operator stress levels and automatically translates them into adaptive control signals. Practically, this means the robot slows down if the worker is stressed or fatigued, and optimizes the pace when the operator is focused, reducing errors and accidents.
- Cognitive Feedback Loops: The unique contribution is the creation of a bidirectional loop where the

manufacturing process actively adjusts to promote an inclusive work environment, validating the technology in a relevant environment (TERESA Sandbox).



The testing facility: an industrial scenario equipped to monitor both process efficiency and human well-being.

TRL: 5-6

The first iteration achieved a major milestone: the successful validation of a heart rate-based stress prediction model (ExtraTreesClassifier) in the TERESA Sandbox, which demonstrably improved safety and reduced errors. However, this success revealed a critical lesson: relying on unimodal AI models (single data sources) is insufficient for complex real-world scenarios. Consequently, the project identified that multimodal feature fusion and robust data harmonization are mandatory to generalize these results from the lab to the factory floor, ensuring the system remains reliable despite daily physiological variations.

Responsible AI

The BEhAI experiment exemplifies Human-Centric AI in its purest form. Instead of forcing the operator to keep up with a rigid machine cycle, the technology adapts to the human condition. This approach directly enhances individual well-being and safety by preventing cognitive overload and burnout. The system is designed to support the worker, boosting confidence in interacting with collaborative robots while respecting privacy through secure data handling.

The Team

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Lesson learnt

UNIVERSITY OF TWENTE. | FRAUNHOFER INNOVATION PLATFORM FOR ADVANCED MANUFACTURIN

ISB

Smart Box: A Unified IIoT System for SMEs

Netherlands

Keywords

IIoT & Connectivity

Digital Twinning

Edge AI

SME Digitalization

A cost-effective, plug-and-play IIoT "Smart Box" that brings AI-powered monitoring and analytics to manufacturing SMEs.

Description

To bridge the digitalization gap for Small and Medium-sized Enterprises (SMEs), the Fraunhofer Innovation Platform for Advanced Manufacturing at the University of Twente (FIP-AM@UT) has developed a cost-effective solution. The team created a unified, lightweight "Smart Box"—based on accessible hardware like Raspberry Pi—those functions as an Industrial Internet of Things (IIoT) gateway. This device connects to machine sensors to collect real-time data such as temperature, vibration, current, and sound. By combining "AI at the Edge" (processing data directly on the box) with cloud capabilities, the system provides immediate insights into machine status and energy efficiency without requiring expensive infrastructure overhauls.

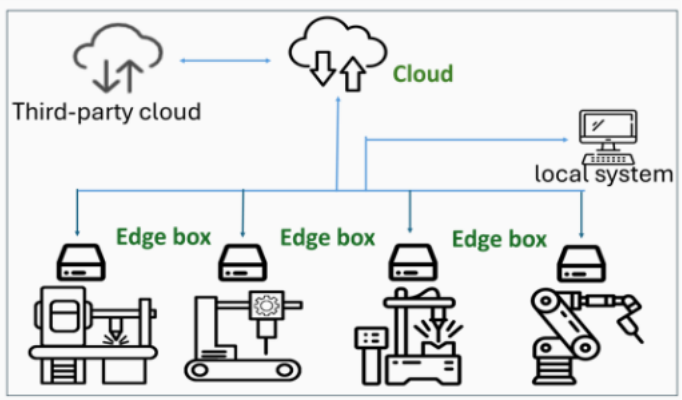
The IIoT Smart Box installed on a legacy machine, bridging the gap between physical operations and digital analysis.

Innovative aspects

The experiment introduces a streamlined approach to industrial connectivity:

- Plug-and-Play Edge Hardware: The solution centers on a lightweight "Smart Box" built with accessible components (Raspberry Pi), capable of collecting and processing multi-sensory data (current, vibration, sound) directly at the edge ("AI at the Edge").
- Hybrid AI Architecture: By combining local edge processing with cloud-based analytics, the system offers the best of both worlds: immediate real-time monitoring for machine safety and deeper, long-term analysis for OEE (Overall Equipment Effectiveness) and energy efficiency.
- Open Interoperability: Unlike proprietary "black box" solutions, this platform relies on open standards (OPC UA, MQTT) and containerized software

(Docker). This ensures easy integration with third-party software and prevents vendor lock-in for SMEs.

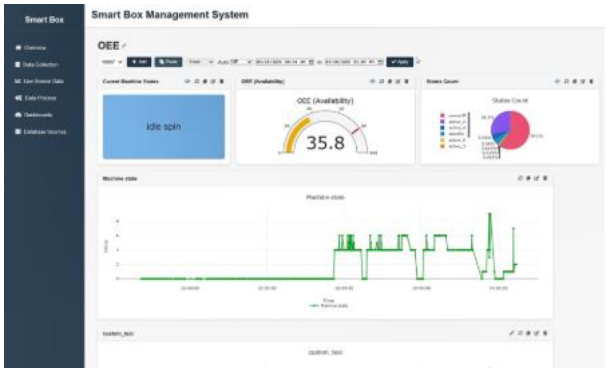


The hybrid architecture: Edge Boxes collect data locally and sync with the Cloud for comprehensive analysis.

TRL: 3-6

Responsible AI

The experiment adopts a flexible algorithm framework that supports both supervised and unsupervised learning. This duality is crucial for Responsible AI: it allows the system to detect anomalies (using models like SVM, CNN, or Autoencoders) even in environments with unlabeled data, which is common in SMEs. By processing data locally at the edge, the system minimizes data exposure risks. Furthermore, the focus on interpreting unsupervised model outputs ensures that AI findings remain understandable to human operators, supporting them in decision-making rather than replacing them.



The Smart Box dashboard: translating complex algorithm outputs into clear metrics like OEE and machine status for operators.

The Team

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Lesson learnt

The first iteration confirmed that the "Smart Box" is a cost-effective and secure platform for IIoT. However, a significant challenge emerged regarding data availability: most industrial sensor data is unlabeled, making traditional supervised training difficult. Consequently, the experiment shifted focus to unsupervised learning. A key lesson learned is that unsupervised models may classify patterns differently than human logic; therefore, bridging this "interpretability gap" and employing multimodal data fusion are essential steps to ensure the system provides reliable, actionable insights for factory operators.

i4.0Lab

A Didactic Factory for Industrial IoT

Italy

Keywords

Industrial IoT (IIoT)

Edge AI

Performance Monitoring

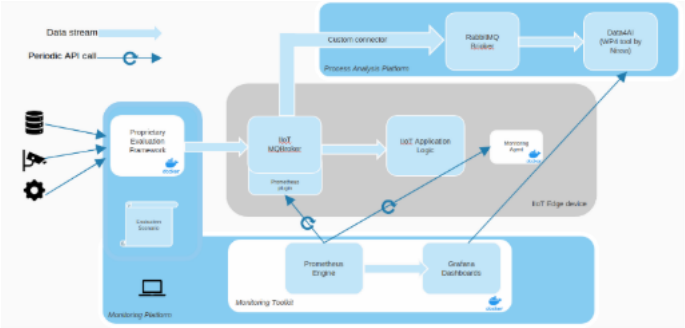
Tech Transfer

Interoperability

An advanced testing facility that accelerates Industry 4.0 adoption by validating Edge-to-Cloud applications in a secure, repeatable environment.

Description

To support the digital transformation of SMEs, the OpenIoT Research Unit at Fondazione Bruno Kessler (FBK) offers the i4.0Lab, a specialized didactic factory and testbed in Trentino, Italy. This facility is designed to bridge the gap between research prototypes and industrial deployment. It allows companies to co-design, prototype, and rigorously test Industrial IoT (IIoT) applications on real edge-to-cloud infrastructures. By simulating factory conditions with repeatable scenarios—ranging from data ingestion to complex process analysis—the lab validates system performance, security, and low-latency capabilities before solutions are deployed in live production environments.



The i4.0Lab architecture: a comprehensive framework for testing, monitoring, and analyzing industrial IoT applications.

Innovative aspects

The experiment distinguishes itself through a comprehensive testing methodology that ensures industrial reliability:

- Reproducible Evaluation Framework: Unlike standard testbeds, the lab utilizes a proprietary framework to run deterministic stress tests and "replay" real or synthetic plant data. This allows for fair, repeatable benchmarking of applications without needing to interrupt live production lines.
- Deep Full-Stack Observability: The platform closes common visibility gaps by coupling industrial message brokers (RabbitMQ, Kafka, MQTT) with advanced monitoring engines (Prometheus). This provides granular real-time metrics on throughput and system load, enabling engineers to instantly detect bottlenecks and root causes.
- Privacy-First AI Analytics: By integrating the Data4AI platform, the system can

detect complex process outliers and anomalies directly on-premise. This "privacy-by-design" approach ensures that sensitive trade secrets remain within the secure testing perimeter while still benefiting from advanced AI diagnostics.

TRL: 5-6

Responsible AI

The experiment integrates "secure-by-design" principles to ensure full compliance with the EU Data Act and emerging regulations. By offering on-premise analytics options, the system guarantees that sensitive industrial data is protected and processed locally, respecting data sovereignty. Furthermore, the project emphasizes inclusivity by prioritizing training and designing interfaces that make complex AI applications understandable for non-technical workers, ensuring technology supports rather than alienates the workforce.

The Team

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Lesson learnt

The experiment highlighted that a structured, "three-layer" monitoring approach (broker, system, and application) is essential for quickly pinpointing bottlenecks. A key technical takeaway is the value of scenario-driven testing, which allows for rigorous benchmarking without disrupting live plants. Strategically, the project demonstrated that secure-by-design principles must be integrated from day one to ensure compliance with the EU Data Act. Finally, to foster uptake among SMEs, the experiment emphasized the need for inclusivity: simplifying complex AI tools for non-technical workers and supporting stakeholders through targeted training and infrastructure access.

PM 50

Predictive Maintenance 5.0: An AI-on-the-Edge Didactic Factory

Belgium

Keywords

Predictive Maintenance 5.0

AI-on-the-edge

Condition Monitoring

Acoustic Analysis

Vibration Analysis

A portable, AI-driven diagnostic platform that detects machinery faults using vibration and sound, bringing advanced maintenance capabilities directly to the factory floor.

Description

The experiment, led by Flanders Make (Belgium), establishes a specialized "Didactic Factory" designed to familiarize technicians and engineers with Industry 5.0 technologies. The facility features a fleet of seven drivetrains equipped with a comprehensive range of sensors to simulate and detect bearing faults. The core of the solution is a portable "AI-on-the-edge" measurement box that processes data locally. This system allows visiting companies to experience firsthand how artificial intelligence can transition from the cloud to the edge, enabling real-time diagnostics and predicting equipment failures without relying on heavy external infrastructure.

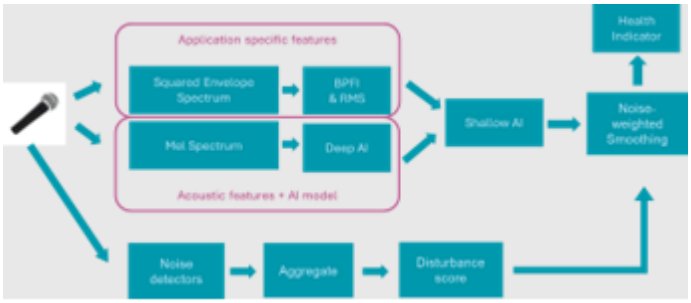
The Didactic Factory setup: a fleet of drivetrains used to simulate faults and train AI models for predictive maintenance.

Innovative aspects

The experiment introduces two advanced implementations of condition monitoring, both deployed on a portable "AI-on-the-edge" platform:

- Vibration-Based Smart Maintenance: The first implementation uses accelerometers to measure over 30 distinct features from rotating components. Through AI processing, these features are converted into a consolidated Health Indicator (HI), allowing operators to diagnose component condition and estimate Remaining Useful Life (RUL). To demonstrate flexibility, five different AI models run in parallel as API endpoints directly on the edge box.

- Noise-Robust Acoustic Monitoring: The second implementation utilizes microphones to detect anomalies in rotating elements, offering an alternative where vibration sensors are impractical. A key innovation is the combination of a Deep Neural Network with a noise-aware smoothing step, which successfully filters out industrial background noise to eliminate false positives and ensure robust early failure detection



The acoustic monitoring pipeline: transforming microphone signals into clear health indicators using Deep AI and noise filtering.

TRL: 5-7

Responsible AI

The experiment prioritizes human empowerment through its "Didactic Factory" approach. Rather than aiming for full automation that replaces workers, the project focuses on educating maintenance technicians and engineers, familiarizing them with Industry 5.0 technologies. Furthermore, by utilizing an "AI-on-the-edge" architecture, data processing occurs locally on the device. This "privacy-by-design" feature ensures that sensitive production data remains within the company's premises, addressing security concerns associated with cloud-based storage.

The Team

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Lesson learnt

Operating the Didactic Factory revealed that while deep neural networks require massive amounts of labeled data, the technical results of the "AI-on-the-edge" approach were significant. Vibration-based monitoring achieved fault detection weeks to months in advance under operational conditions. Similarly, the acoustic approach proved robust, completely eliminating false positives caused by background noise.
However, bridging the gap to industrial adoption remains a challenge. The main obstacle is the scarcity of historic data in companies. Consequently, the experiment recommends focusing market uptake efforts on companies that already recognize the limitations of traditional monitoring methods—specifically those struggling with inaccurate diagnoses due to process variations. Finally, feedback showed that companies prefer actionable insights (determining the optimal maintenance moment) over abstract estimates of Remaining Useful Life (RUL).

Bridging the gap, the portable AI platform being tested in the lab (top) and deployed in a real industrial environment (bottom).

IWOK

Industreweb-X Operational Knowledgebase

United Kingdom

Keywords

AI-based Prediction

Fault Resolution

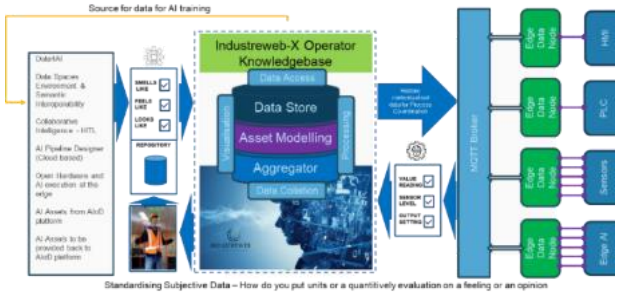
Contextualised Data

Human-Centric AI

A cyber-physical knowledgebase that digitizes human sensory input - what operators see, feel, and smell - combining it with machine data to speed up fault resolution.

Description

To address the gap between machine data and human intuition, the Digital Manufacturing Innovation Hub Wales (DMIW) developed the Industreweb-X Operational Knowledgebase (IWOK). This cyber-physical concept recognizes that experienced operators often detect issues - like a burning smell or unusual noise - long before sensors trigger alarms. IWOK captures this subjective human input, standardizes it, and merges it with live telemetry and environmental data. The result is a contextualized repository of "man + machine" intelligence that helps staff troubleshoot complex problems by calculating the probability of specific fault scenarios.

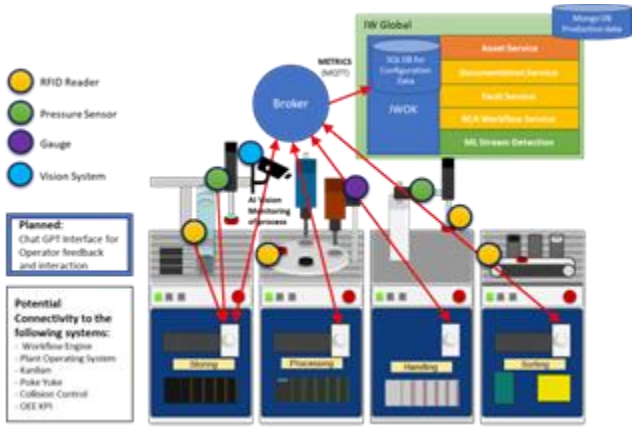


Digitizing subjective data, the system creates a holistic view by merging human sensory observations with hard sensor data.

Innovative aspects

The experiment introduces a unique framework to digitize tacit knowledge:

- Digitization of Subjective Data: The core innovation is the ability to quantify subjective human feedback (e.g., "feels like excessive vibration") into measurable units. This allows AI to process human "feelings" alongside traditional sensor readings.
- Hybrid AI Decision Support: Utilizing an XGBoost regressor model, the system analyzes the combined dataset to predict the risk factor of failures. It acts as an intelligent assistant, identifying the most probable resolution for a fault scenario based on historical patterns.
- Interoperable Data Aggregation: The platform employs a versatile stack (MQTT, REST, OPC-UA) to ingest data from diverse edge nodes. This ensures that data from machines, environments, and humans is unified in a central broker for real-time analysis.



System Architecture, collecting data from sensors, vision systems, and human operators into a central broker for AI analysis.

TRL: 3-4

Responsible AI

The IWOK system represents a prime example of Human-Centric AI. It is designed not to replace the operator but to augment their capabilities, keeping the human firmly in the decision-making loop. By validating human sensory data, it empowers workers to contribute their tacit knowledge to the digital process . Furthermore, the experiment adheres to strict privacy standards: all human input is anonymized, and the system processes only production-related data, ensuring no personal information is used.

The Team

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Lesson learnt

The experiment revealed a critical insight: automation often increases the difficulty of identifying faults based on machine data alone. Consequently, the experience of the operator becomes vital to supplement machine intelligence. However, because human experience varies by individual and region, the key challenge—and solution—lies in parameterizing subjective data into measurable units . Technologically, the project highlighted that integrating existing market-ready AI tools is more sustainable than building from scratch. Finally, creating "plug-and-play" solutions ensures higher adoptability for SMEs, whereas generic Generative AI requires deep contextualization to be effective on the shop floor.

QUAD-AI@E

Real-World AI for Clothing Manufacturing

Romania

Keywords

AI Edge Computing

Computer Vision

Textile Quality Control

Defect Detection

An intelligent vision system that automates quality control in the textile industry, detecting defects in real-time using advanced edge computing.

Description

To modernize quality assurance in the clothing industry, the Technical University "Gheorghe Asachi" from Iasi (TUIASI) developed the QUAD-AI@E solution. This experiment focuses on an automated defect detection system designed to identify manufacturing flaws—such as missing buttons, broken seams, or stains—directly on the production line. By integrating high-resolution cameras with embedded AI (running on Jetson Nano devices), the system analyzes garments in real-time. It utilizes advanced algorithms, including YOLO (You Only Look Once) neural networks and fuzzy logic, to classify defects and instantly alert quality assurance personnel, ensuring high standards without slowing down production.

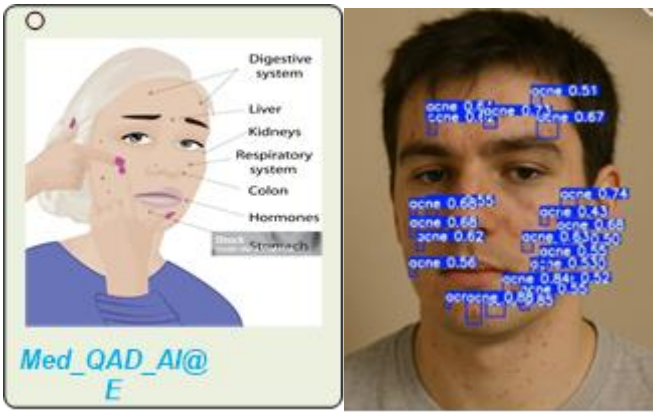
The QUAD-AI@E prototype, a smart inspection station using computer vision to detect garment defects in real-time.

Innovative aspects

The experiment demonstrated the versatility of AI inspection through successive iterations:

- Novel Defect Detection Architecture: The system integrates embedded AI (Jetson Nano) into a unique constructive prototype designed specifically for the clothing industry. Unlike standard solutions, it uses a reference model comparison approach to distinguish complex design features from actual defects (e.g., distinguishing a pleat from a wrinkle).
- Edge Computing Optimization: By training YOLO neural networks on augmented datasets (handling rotation, scaling, lighting), the model runs efficiently on edge devices without needing heavy cloud infrastructure. This ensures low-latency detection directly on the factory floor.

- Cross-Sector Scalability: The technology developed for textiles showed remarkable potential for transferability. The experiment successfully designed conceptual adaptations for the Health sector (a smart mirror for identifying facial skin conditions like acne) and Agriculture (monitoring diseases in crops), proving the robustness of the core vision algorithms.



Scalability beyond textiles, adapting the vision algorithms for health applications to detect skin conditions.

TRL: 4

Responsible AI

The system is designed as a support tool for Quality Assurance (QA) personnel, not a replacement. It sends alerts to human verifiers, ensuring a human-in-the-loop workflow where the operator makes the final judgment on nuanced textile defects. Furthermore, the shift towards edge computing ("AI on the device") enhances data privacy, as images are processed locally without constantly streaming sensitive production data to external clouds.

The Team

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Lesson learnt

The project successfully validated a prototype that achieved reliable real-time detection of key defects—such as stains, misaligned buttons, and broken seams—using edge computing. However, the experiment highlighted that distinguishing intentional design features from defects remains complex due to the diversity of garments. A critical technical lesson was the impact of illumination: poor lighting significantly reduced accuracy, emphasizing the need for controlled environments. For commercial uptake, future steps include industrializing the hardware and validating the system against textile quality standards like ISO 18890 and ISO 15487.

CZECH INSTITUTE OF INFORMATICS ROBOTICS AND CYBERNETICS CTU IN PRAGUE

Czech Republic

X-MONITOR

Explainable Monitoring of Robotic Assembly in Dynamic Production

Keywords

Explainable AI

Anomaly Detection

Robotic Assembly

Force–Torque Monitoring

Human-in-the-Loop (HITL)

The solution delivers reliable, transparent AI that reduces human inspection effort and lowers escape rates while maintaining production speed. It supports operators through explainability and adapts robustly to changing production conditions.

Description

The DFXI experiment demonstrates an explainable, adaptive AI system designed to monitor robotic assembly processes under dynamic manufacturing conditions. Moving beyond initial fault detection, the project evolved into a comprehensive pipeline that detects non-OK assembly states by analyzing force-torque time series data. The solution empowers operators with graphical and textual explanations while adapting to process changes through continuous model monitoring. By integrating human-in-the-loop validation, the system increases trust and efficiency, enabling the analysis of 100% of assembled parts with rapid operator feedback.

The robotic assembly workstation at CTU Prague, utilizing force-torque sensors for real-time, explainable anomaly detection in dynamic production.

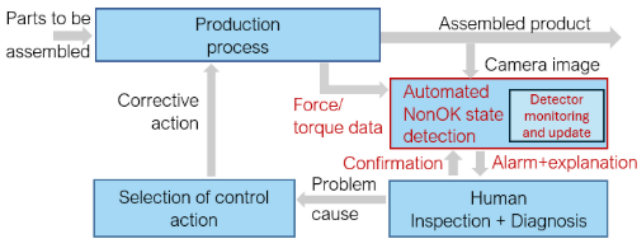
Innovative aspects

The experiment introduces a transparent and adaptive approach to industrial quality control by integrating specific monitoring and explanation tools:

- Multivariate Anomaly Detection: The system integrates Force-Torque (FT) based anomaly detection using dynamic time warping and prototype-based models to identify specific assembly issues.
- Operator-Centric Explanations: A major innovation is the provision of graphical highlight-based explanations alongside textual summaries, allowing operators to quickly visualize where and why a fault occurred.
- Adaptive Intelligence: To handle the reality of dynamic production, the

system employs model monitoring with change-point detection and adaptive model updating to correct for process drift.

- Real-World Integration: The solution utilizes OPC-UA for robust data acquisition directly from real robot hardware, facilitating immediate feedback loops.



The Human-in-the-Loop workflow: the AI detects potential faults and generates explanations, while the operator retains final decision-making power for diagnosis and confirmation.

TRL: 6

Responsible AI

The experiment follows EU Trustworthy AI principles by ensuring transparency, human oversight, and an operator-centric design. It prioritizes human agency by allowing operators to confirm or reject AI results, ensuring the human remains in control of the quality process. Furthermore, the system adheres to data minimization principles, ensuring that only necessary data are used to train and operate the monitoring models.

The Team

- **Czech Institute of Informatics, Robotics, and Cybernetics (CTU in Prague),** Intelligent systems for industry research group, Testbed for Industry 4.0

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Lesson learnt

The experiment proved effective in reducing human inspection effort and lowering escape rates without compromising production speed. However, operator acceptance relied heavily on realism and clarity: utilizing real-world data rather than synthetic faults was essential for building trust, and operators explicitly valued clear graphical explanations over textual summaries.

Technically, the choice of model was decisive. Simple statistical models often outperformed complex AI when dealing with small datasets, significantly improving deployability at the Edge. Finally, the project emphasized that dynamic production requires continuous model monitoring and adaptive mechanisms to ensure robustness against changing conditions.

AALBORG UNIVERSITY

Denmark

D2IoT

The Data-Driven IoT Suitcase

Keywords

Data-driven manufacturing

Predictive Maintenance

AI/Machine Learning

IoT

Industry 4.0

A modular, plug-and-play "IoT Suitcase" that empowers SMEs to adopt predictive maintenance by collecting and analysing multimodal production data.

Description

To unlock the potential of data-driven manufacturing for SMEs, Aalborg University (AAU) developed the D2IoT experiment. The core of this solution is the "AAU IoT Suitcase," a mobile and modular toolkit designed to be easily deployed on existing production cells. By collecting multimodal data - ranging from acoustic signals to sensor readings - the system applies machine learning to extract actionable insights. This approach addresses common barriers such as system integration and data quality, demonstrating how SMEs can implement predictive maintenance and performance optimization strategies with limited in-house expertise and affordable hardware.

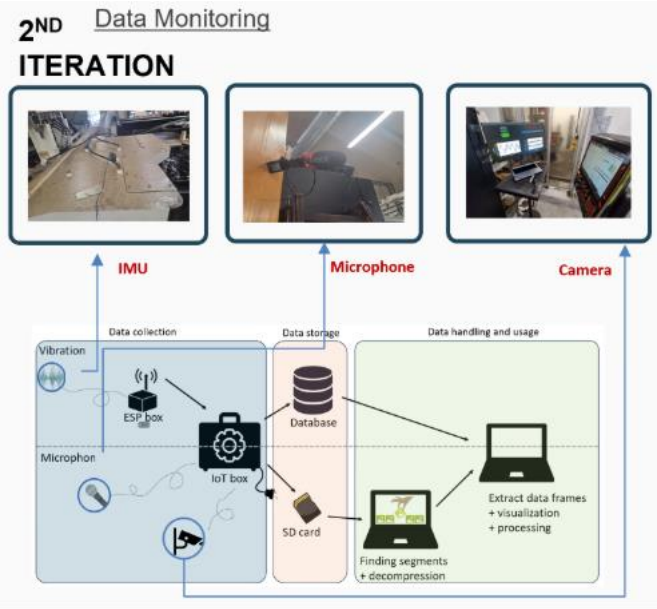
The IoT Suitcase in action: a portable edge device collecting data directly from the production line.

Innovative aspects

The experiment advanced through two iterations to refine edge-based monitoring:

- Modular IoT Architecture: The solution centers on the "AAU IoT Suitcase," a portable unit containing microcontrollers (ESP box), microphones, and cameras. It serves as a plug-and-play gateway that SMEs can attach to existing machinery without complex integration.
- Multimodal Sensor Fusion: The system combines diverse data sources - unidirectional microphones, IMUs (Inertial Measurement Units), and cameras - to capture a complete picture of the machine's health. This allows for high-fidelity acoustic and vibration analysis to detect tool wear or anomalies.
- Lightweight vs. Deep Learning: The experiment tested a range of AI models, from lightweight classical algorithms

(Random Forest) for resource-constrained setups to advanced Deep Learning for complex time-series analysis. This flexibility ensures the right balance between accuracy and computational load for the specific use case.



The data pipeline, collecting vibration and audio signals via the IoT Suitcase for real-time analysis.

TRL: 2-3

Responsible AI

The experiment embeds responsible AI principles by prioritizing transparency and data quality. Instead of "black box" solutions, it favors interpretable, lightweight algorithms suitable for resource-constrained environments. Data collection is rigorously designed with labeled samples and controlled test conditions to minimize bias. Crucially, human oversight remains central: AI acts as a decision-support tool, providing insights to operators rather than taking autonomous control of the machinery.

The Team

- **Aalborg University (AAU)**
- **D2IoT Team**

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Lesson learnt

The experiments successfully demonstrated that sensor-rich, AI-driven monitoring can detect tool wear and process anomalies using affordable, off-the-shelf hardware. However, three key lessons emerged for successful implementation. First, thorough planning is essential to match the edge device's computing power with the workload. Second, sensor selection must align perfectly with environmental conditions to ensure high-quality data. Third, model choice is critical: while lightweight models offer efficiency for basic tasks, complex scenarios benefit significantly from deep learning approaches. Strategically, it is recommended that SMEs start with a single-machine pilot using plug-and-play solutions like the IoT Suitcase. Future work will focus on developing user-friendly dashboards to further lower the expertise barrier.

SunSync

AI for Optimised Industrial Recycling

Hungary

Keywords

Solar Energy Forecasting

AI-based Prediction

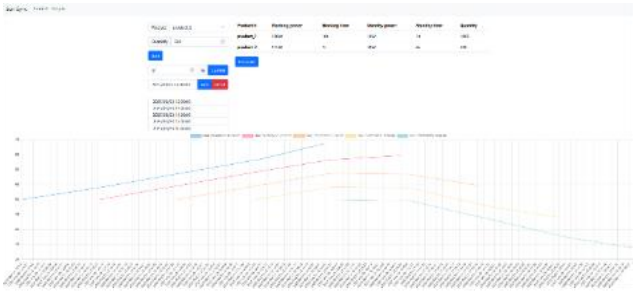
Energy Efficiency

Smart Recycling

An AI-driven system that synchronizes industrial energy consumption with solar power availability to optimize recycling processes and reduce carbon footprint.

Description

To address the high energy intensity of industrial recycling, AM-LAB (PBN) in Hungary developed the SUNSYNC experiment. The core concept is to maximize the usage of renewable energy by intelligent scheduling. The system collects real-time data from solar panels and recycling machinery, using AI to forecast solar energy generation and compare it with future consumption plans. By identifying the optimal "green windows," the system suggests when to run energy-intensive recycling tasks, thereby promoting sustainability and reducing reliance on the grid.



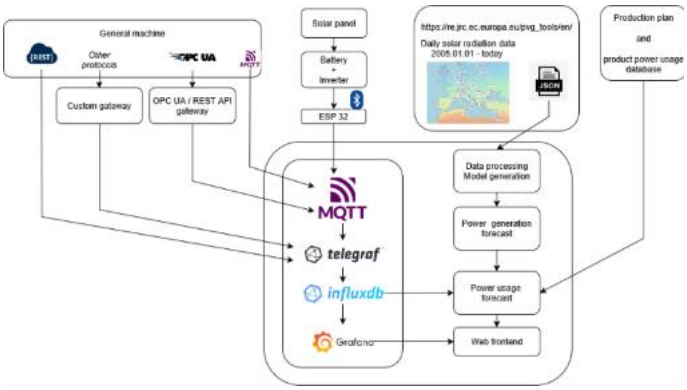
The SUNSYNC dashboard: visualizing solar energy forecasts against production plans to optimize power usage.

Innovative aspects

The experiment relies on a modern, containerized software stack to handle time-series data effectively:

- Advanced Predictive Modelling: Instead of traditional statistical methods, the system employs the XGBoost regressor model. This algorithm proved to be superior for predicting solar power generation curves, outperforming classic approaches like moving averages or ARIMA in estimating probable behavior.
- Scalable Time-Series Architecture: To manage the high frequency of energy data, the platform uses InfluxDB as a specialized time-series database and Telegraf for efficient data collection. This ensures that massive amounts of sensor data are stored and retrieved with low latency.
- Containerized & Standardized Deployment: The entire solution is built on Docker containers and utilizes open

protocols (MQTT, REST, OPC-UA). This "microservices" approach allows for easy deployment, scaling, and integration with various industrial machines regardless of the manufacturer.



System Architecture, integrating solar inputs and machine data via MQTT to forecast power usage.

TRL: 2-3

Responsible AI

The SUNSYNC experiment is a clear application of "Green AI" or "AI for Sustainability". By optimizing the timing of energy-intensive recycling processes to align with solar peak production, the system directly contributes to reducing the industrial carbon footprint. The AI model (XGBoost) is used specifically to forecast renewable energy availability, ensuring that decision-making is driven by environmental efficiency rather than just speed.

The Team

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Lesson learnt

The project offered valuable insights into software development for industry. Strategically, it demonstrated that starting with a generalized solution—while initially more time-consuming—is ultimately more efficient and adaptable than developing highly specific approaches. From a technical standpoint, XGBoost proved to be the winning algorithm, outperforming classical statistical methods like ARIMA in estimating curve behavior. The resulting predictive model forecasts upcoming power needs and identifies optimal decision states. For commercial uptake, this implementation is crucial as it enables organizations to streamline energy usage, improve resource planning, and achieve a better alignment of generation with consumption.

GalicianDF

Galician Didactic Factory: AI at the Edge for Additive Manufacturing

Spain

Keywords

Didactic Factory

AI-Edge

Quality Control

Early Defect Detection

Additive Manufacturing

A collaborative testbed where companies can experiment with AI-at-the-Edge technologies to monitor additive manufacturing processes and detect defects before they happen.

Description

The Galician Didactic Factory is a collaborative initiative established by Gradiant, AIMEN, GAIN, and the DATAlife EDIH at AIMEN's advanced manufacturing pilot facility. It serves as a safe, realistic environment for testing Industry 5.0 technologies. Within this facility, Gradiant is developing a flagship experiment: an AI-at-the-Edge system for real-time monitoring of additive manufacturing cells. By analyzing thermal images and process parameters instantly, the system moves quality control from post-production inspection to early defect detection, allowing operators to intervene and correct issues during the manufacturing process itself.

The Galician Didactic Factory: a state-of-the-art additive manufacturing cell equipped for real-time AI experimentation.

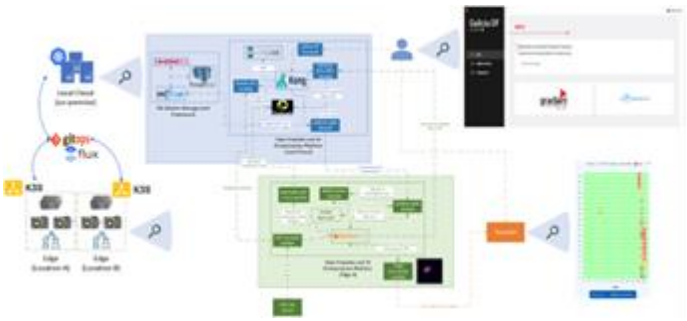
Innovative aspects

The experiment combines advanced metallurgy analysis with a robust cloud-native infrastructure:

- Physics-Informed Feature Engineering: Understanding that defects are bound to heat accumulation, the system monitors critical process parameters (laser power, angles) combined with real-time thermography to train the AI models.
- Advanced Melt Pool Analysis: A specialized image processing algorithm

(using OpenCV) extracts and tracks the melt pool area and center offset from thermal images. These variables are critical for the AI model to detect geometric deformations before they become permanent.

- Cloud-Edge Orchestration: The solution is integrated into Gradiant's Clever platform, utilizing a robust stack (Kubernetes, K3s, MLflow) to manage the AI lifecycle. This ensures interoperability via OPC-UA and allows data to be processed at the Edge for low latency while maintaining centralized orchestration.



System Architecture: a Cloud-Edge orchestration framework using Kubernetes to manage AI services across the manufacturing cell.

TRL: 6

Responsible AI

The system is strictly non-intrusive regarding personal data. The inputs for the AI model are purely technical (laser power, coordinates, thermal data), ensuring no risk of bias against operators. Moreover, the solution adheres to Human-Centric AI principles: the anomaly detection outputs are purely informative. The system provides decision support, but the human operator retains full control over the final decision to stop or adjust the process.

The Team

- **Gradiant** (Technology Provider)
- **AIMEN** (Infrastructure & Use Case Provider)
- **GAIN** (Regional Innovation Office)
- **DATAlife** (EDIH)

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Lesson learnt

The primary outcome extends beyond the technical use case: the experiment successfully established the Galician Didactic Factory. This initiative created a tangible synergy between the AI REDGIO 5.0 and AI-MATTERS European projects. Consequently, a comprehensive portfolio of services - spanning data, remotization, and skills training - is now available to foster regional economic growth, with the "AI at the Edge" experiment serving as a crucial real-world demonstrator for visitors. However, challenges remain. Strategically, explaining complex concepts like "Testing and Experimentation Facilities" (TEF) to companies requires dedicated communication efforts. Technically, validating anomaly detection in real environments proved difficult, demanding advanced strategies for collecting and preprocessing multimodal data.

Sustainability & Circular Economy 20 SME-driven experiments

1. BeeEdgeAI - AI at the Edge for Smart Beekeeping
2. CogniMaint - AI-Driven Maintenance Optimization for Manufacturing
3. CollaborAIte - Emotional Distress Recognition Systems to Improve Workers' Health
4. COMMIT - Human-Centric Operations in Manufacturing SMEs aided by Generative AI
5. EDGE-MICROFY - AI-Powered Automated Microscopy for Agrifood
6. EHINA - Intelligent Measurement of Tool Wear at the Edge
7. GreenMould - Monitoring Environmental-friendly Quality in Plastic Injection Moulding
8. HAWK4Label - Human-Enhanced Weak Supervised Learning for Data Labeling
9. HCE - Human-Centric Environment for Sustainable Bakery Production
10. SWARM-DC - Demonstrating the Synergy of Edge and Cloud Computing
11. ADEPT - AI-Powered Edge Anomaly Detection and Decision Support
12. AIPack - AI-Driven Packaging Defect Detection System
13. AI-Vision - Real-Time Monitoring and Analysis of Oven Movements
14. Antenna-I - AI-Enhanced RF Testing and Fault Classification System
15. COMATEX 5.0 - Collaborative Sewing Automation for Inclusive and Sustainable Textile Manufacturing
16. EdgeAI4Beer - Optimizing Microbrewery Processes through Edge AI Analytics
17. FurnAIce5.0 - Collaborative AI-powered Open Furnace Control Systems for Net-Zero Aluminium Recycling
18. GEDAIM - Generative and Enhanced AI-driven Intelligent Mining of Manufacturing Processes
19. GreenChemAI - AI-Enabled Sustainability for Chemical Manufacturing
20. Harmony - AI-Driven Catalyst Manufacturing for Sustainable Materials Production

BeeEdgeAI

AI at the Edge for Smart Beekeeping

Slovenia

Keywords

AI-at-the-Edge

Smart Beekeeping

Predictive Maintenance

Product-as-a-Service

Sustainable Agriculture

A sustainable monitoring system that uses Edge AI to process data directly inside the hive, extending battery life by 300% and turning raw data into actionable insights for beekeepers.

Description

Standard beehive monitoring systems generate massive amounts of data, draining batteries and inflating connectivity costs. This makes long-term monitoring unsustainable and limits subscription-based models. BeeEdgeAI addresses this by applying AI-at-the-Edge: instead of transmitting every measurement, the device processes data locally and sends only meaningful updates. This approach ensures beekeepers receive clear insights while manufacturers gain predictive maintenance data, significantly lowering operating costs and environmental impact.

Innovative aspects

The experiment transforms a passive sensor into an intelligent edge device through specific innovations:

- Edge Intelligence: The system processes raw data locally, turning it into meaningful insights before transmission.
- Drastic Data Reduction: By transmitting only relevant events (3-10 updates/day instead of 144), the system reduces data volume by 50% and extends battery life up to threefold.
- Predictive Maintenance: An integrated health-check system allows the manufacturer to monitor device status remotely, preventing costly hardware failures.
- Business Model Enablement: The efficiency gained makes a "Product-as-a-Service" subscription model financially viable and sustainable.

Responsible AI

The project champions sustainability and human-centricity. By processing data at the edge, it adheres to data minimization principles, transmitting only what is strictly necessary. For the user, it shifts the paradigm from "data overload" to "actionable knowledge," reducing the cognitive load on beekeepers. Furthermore, by extending device lifespans significantly, it reduces electronic

waste associated with battery replacement and device maintenance.

The Team

- **Senso4s d.o.o.** (Slovenia) - Innovative manufacturing SME specializing in smart measurement systems.
- **Jožef Stefan Institute** (Research Partner)

Lesson learnt

The experiment proved that domain expertise combined with accessible tools (like Edge Impulse) allows manufacturing SMEs to successfully adopt AI without needing deep data science teams. Technically, choosing flexible languages like Python was practical, though integrating non-standardized data (like beekeepers' diaries) remains a challenge. Most importantly, the project confirmed that Edge AI is a dual-benefit technology: it simplifies the user experience for the customer while reducing maintenance costs for the manufacturer.

CogniMaint

AI-Driven Maintenance Optimization for Manufacturing

Slovenia

Keywords

AI-Driven Maintenance

Knowledge Preservation

Maintenance Copilot

Human-Centred Digitalization

Resilient Manufacturing

An AI-supported "Maintenance Copilot" that preserves expert knowledge, guides technicians through complex repairs, and reduces unplanned downtimes by prioritizing critical tasks.

Description

Blaj Fasteners operates over 40 types of precision machines, but high staff turnover and an aging workforce make it difficult to retain specific maintenance expertise. To address this, the project introduced CogniMaint, a system that features a Maintenance Copilot. By capturing expert know-how into digital workflows, the solution guides personnel through repair tasks and helps prioritize critical issues. This approach accelerates the onboarding of new workers, improves decision-making, and significantly reduces the stress on maintenance teams.

Innovative aspects

The experiment transforms traditional maintenance into a resilient, digitalized process:

- AI Copilot: The system encodes expert know-how into an AI assistant that supports technicians step-by-step during repairs.
- Intelligent Prioritization: AI is used to prioritize maintenance tasks based on real-time machine health, historical data, and production plans.
- Knowledge Preservation: A dynamic knowledge base retains expertise, ensuring continuous learning and preventing information loss due to turnover.
- Increased Resilience: The solution aims to reduce unplanned breakdowns by up to 15%, making the production process more sustainable.
- Workforce Attraction: By providing intuitive digital tools, the system makes maintenance jobs more attractive for the new generation of workers.

Responsible AI

CogniMaint prioritizes human-centricity by using AI to support, rather than replace, the workforce. It focuses on preserving critical know-how to reduce dependence on scarce experts, creating a healthier and less stressful

work environment. The development followed a user-focused approach: through close collaboration with staff, the system was refined to deliver detailed vendor instructions (which workers valued most) rather than just raw data, ensuring the technology genuinely empowers the human operator.

The Team

- **Blaj Fasteners** (Slovenia) – Specialist manufacturer of high-quality fasteners.
- **Metronik** – Partner in industrial automation and digitalization.

Lesson learnt

The project highlighted that successful AI deployment relies heavily on data quality; creating clean datasets proved time-consuming, demonstrating the value of a centralized data lake for production records. From an operational perspective, **iterative** problem discovery was crucial: working closely with maintenance staff revealed that they preferred detailed vendor instructions over short internal notes. Ultimately, the experiment proved that a user-focused approach is essential to create resilient workplaces and ensure AI adds real value.

CollaborAIte

Emotional Distress Recognition Systems to Improve Workers' Health

Ireland

Keywords

Human-Centred Digitalization

Emotional Distress Recognition

AI-Driven Process Monitoring

Wearable Sensors

Stress Resilience

A human-centric system that leverages AI-at-the-Edge to detect worker stress and emotional distress in real-time, prioritizing well-being and privacy while improving production efficiency.

Description

The CollaborAite experiment integrates Emotional Distress Recognition Systems (EDRS) into SME production processes to prioritize worker well-being. By utilizing wearable sensors and AI-at-the-Edge, the solution reduces stress and fatigue, enhancing safety and flexibility. Unlike traditional monitoring, this system focuses on fostering inclusivity and cultivating acceptance: it ensures workers retain full control over their data through privacy-by-design principles, ultimately improving both product quality and the human experience on the shop floor.

Innovative aspects

CollaborAite transforms the factory environment into a supportive ecosystem through specific innovations:

- Real-time Stress Detection: The system uses AI-at-the-Edge to detect signs of stress and emotional distress instantly, processing data locally to ensure privacy and trust.
- Gesture Recognition: Workers can use simple hand movements to signal stress, request assistance, or control assembly instructions, making interaction seamless.
- Privacy-by-Default: The architecture is built on human-centered design principles, ensuring that sensitive biometric data never leaves the device without user consent.
- Resilience Dashboards: Real-time alerts support resilience and risk reduction, improving the collaboration between people and machines.
- Efficiency Impact: Test scenarios demonstrated that capturing emotional feedback can improve assembly efficiency by over 20%.

Responsible AI

The project is a benchmark for trustworthy AI. It places the worker at the center, using technology to foster healthier and safer workplaces rather than for surveillance. By processing data locally (Edge AI), it guarantees privacy preservation, addressing one of the main barriers to adopting wearable tech in manufacturing. The system is designed to be non-intrusive, building confidence and ensuring that technology supports the human operator's resilience.

The Team

- **iBreve** (Ireland) – Health-tech innovator specializing in wearable sensors and breathing pattern analysis.

Lesson learnt

The experiment highlighted that making workplaces truly human-centric depends on trust and usability, not just technology. Workers embraced the system because local data processing reassured them about privacy. Operational lessons showed the importance of non-intrusive design: gesture-based interactions allowed workers to signal issues without disrupting their workflow. Technically, the team proved that streamlining AI models makes them efficient enough to run smoothly on simple edge devices, confirming that emotional awareness drives both well-being and productivity.

Ce.S.I. Centro Studi Industriali

Italy

COMMIT

Human-Centric Operations in Manufacturing SMEs aided by Generative AI

Keywords

Generative AI

Retrieval-Augmented Generation (RAG)

Human-Centric Manufacturing

Predictive Maintenance

Digital Transformation

A Generative AI virtual assistant that leverages Retrieval-Augmented Generation (RAG) to provide accurate, domain-specific maintenance guidance, reducing operational errors and automating routine documentation.

Description

Large Language Models (LLMs) like ChatGPT offer immense potential but often lack domain-specific accuracy, making "out of the box" use risky in sensitive manufacturing environments. COMMIT addresses this limitation by applying a Retrieval-Augmented Generation (RAG) approach tailored to SMEs. By combining Generative AI with company-specific knowledge libraries, the system delivers trustworthy, context-aware responses. It supports operators with real-time maintenance assistance and automated reporting, ensuring human-centric operations that prioritize accuracy and safety.

Innovative aspects

The experiment brings safe and effective Generative AI into the shopfloor through specific innovations:

- RAG Architecture: Unlike generic models, the system uses Retrieval-Augmented Generation to ground AI responses in verified company manuals and history, significantly reducing hallucinations.
- Virtual Assistant: A real-time copilot provides operators with step-by-step maintenance instructions, making complex tasks more accessible.
- Anomaly Detection: Integrated AI identifies irregular machine behavior early, supporting predictive maintenance strategies to prevent breakdowns.
- Automated Administration: The system handles repetitive tasks like writing maintenance reports and ordering spare parts, freeing workers for higher-value activities.
- Efficiency Impact: The solution demonstrated 25-30% time savings in operations and improved adherence to best practices.

Responsible AI

COMMIT places the human operator at the centre of the loop. By using RAG, it addresses the ethical concern of AI "hallucinations," ensuring that guidance is grounded in verified facts rather than statistical guesses. The system is designed to augment human capabilities, not replace them: it takes over tedious documentation tasks and provides decision support, while ensuring that human expertise remains central to final decision-making. This cooperation improves safety and reduces the cognitive load on workers.

The Team

- **Ce.S.I. Centro Studi Industriali S.p.A**. (Italy) – Specialized in advanced engineering, digital innovation, and machine tools.

Lesson learnt

The experiment confirmed that adapting AI to domain-specific contexts is crucial for industrial reliability. The RAG approach proved decisive in reducing hallucinations and building trust among operators. Operational testing highlighted that integrating anomaly detection adds significant value by enabling proactive maintenance. Ultimately, the project demonstrated that for AI to be accepted in manufacturing, it must prioritize trustworthiness, customization, and usability, ensuring that human-AI cooperation leads to tangible efficiency gains.

EDGE-MICROFY

AI-Powered Automated Microscopy for Agrifood

Spain

Keywords

AI Microscopy

Honey Quality

Bee Health

Edge AI

Food Safety

A fully autonomous, AI-driven microscope that performs lab-grade quality control on-site, reducing analysis time from days to minutes while ensuring data privacy.

Description

Microscopy is central to food manufacturing but remains slow, costly, and dependent on scarce experts. To solve this, Microfy developed Honey.AI, an intelligent microscope for automated honey quality control, and evolved it into Nosem.AI, a fully autonomous device for detecting bee diseases. By migrating the AI pipeline to the Edge, the solution enables manufacturers to identify contaminants and perform pollen analysis directly at their site, eliminating the delays of outsourced labs and allowing for real-time decision-making.

Innovative aspects

The experiment combines robotized hardware with advanced AI to democratize microscopic analysis:

- Edge Intelligence: The Nosem.AI device runs fully autonomously on the NVIDIA Jetson Orin Nano, eliminating the need for external computers or cloud connectivity.
- Automated Pipeline: The system integrates a robotized microscope with AI image processing to detect pollen, measure crystallization, and count yeast cells with minimal operator intervention.
- Hybrid Architecture: While Honey.AI optimizes cloud efficiency, Nosem.AI operates 100% offline, ensuring that sensitive data remains private and reducing reliance on high-bandwidth internet.
- Accessibility: The solution makes advanced quality control affordable, offering lab-grade precision at a fraction of the traditional cost.

Responsible AI

The project promotes the democratization of technology by making advanced diagnostic tools accessible to SMEs and individual producers (like beekeepers) who previously could not afford in-house labs. By processing data at the Edge (Nosem.AI), it adheres to privacy-by-design principles, ensuring that proprietary production data never leaves the user's facility. Furthermore, the system significantly reduces the carbon footprint

associated with shipping physical samples to external laboratories.

The Team

- **Microfy Systems** (Barcelona, Spain) – Deep-tech company designing intelligent microscopes for the food processing industry.

Lesson learnt

The project confirmed that balancing speed and accuracy are critical challenges for Edge AI. Lightweight models (like YOLO) proved fast but lacked the precision for microscopic detail, while robust models (Mask R-CNN) demanded stronger hardware. This highlighted the need for careful model selection. Additionally, validation showed that usability is paramount: operators embraced the technology not just for its accuracy, but because of the standalone, touchscreen interface made it easy to use without technical expertise.

EHINA

Intelligent Measurement of Tool Wear at the Edge

Spain

Keywords

Tool Condition Monitoring

Edge AI

Cloud Learning

Predictive Maintenance

Industry 5.0I

A collaborative Edge-to-Cloud system that optimizes tool life by combining real-time sensor data with collective machine learning, reducing downtime and material waste.

Description

In machining, unplanned downtime due to tool wear represents up to 12% of production costs. Tools are often changed too early, wasting useful life, or too late, causing failures. Traditional monitoring systems struggle to adapt to the variety of factory conditions. EHINA addresses this by combining Edge intelligence with Cloud-based learning. Sensors capture real-time data which is processed instantly at the edge to give operators recommendations. Simultaneously, new cases are shared with the cloud, where models improve collectively: "what one machine learns, all machines learn".

Innovative aspects

EHINA transforms Tool Condition Monitoring Systems (TCMS) through a collaborative architecture:

- Edge-to-Cloud Architecture: Unlike rigid models, the system enables continuous adaptation across different tools and processes by sharing learning updates globally.
- Reinforcement Learning: The solution incorporates operator feedback and new data to refine predictions continuously, allowing it to classify unknown cases.
- Resource Efficiency: By predicting tool wear accurately, the system extends tool usage closer to 90% of its true life, significantly reducing scrap and waste.
- Scalability: The system uses operational edge-cloud communication with low latency, ensuring efficient data flow for high-volume production (e.g., 80,000 keys daily).

Responsible AI

The experiment aligns with Industry 5.0 goals of resilience and sustainability. By optimizing tool usage, it directly reduces material waste and energy consumption associated with manufacturing replacements. Furthermore, the system is designed around trustworthy AI principles: it keeps the human in the loop by relying on operator contextual information and feedback to validate the model, ensuring

technology supports skilled workers rather than replacing them.

The Team

- **Industrias Mail** (Spain) – National leader in precision cutting tools.
- **IMH Campus** – Digital Innovation Hub specialized in machine-tool technologies.

Lesson learnt

The experiment confirmed that flexible and iterative development is crucial in industrial AI; transitioning to tools that integrate with existing workflows (like GitLab) proved valuable. A critical challenge was data diversity: low variability in machining references made it difficult for models to generalize, underscoring the need for broader datasets or synthetic data. Finally, the project highlighted that open communication with industrial partners about the iterative nature of AI is essential to foster trust and manage expectations.

GreenMould

Monitoring Environmental-friendly Quality in Plastic Injection Moulding

Serbia

Keywords

Sustainable Manufacturing

Plastic Injection Moulding

AI-Driven Process Monitoring

Energy and Emissions Reduction

Digital Transformation

An AI-driven monitoring system that embeds sustainability directly into the production process, reducing energy consumption and emissions by 10% through real-time anomaly detection.

Description

Plastic injection moulding is an energy-intensive industrial process characterized by high consumption and carbon emissions. To address this, the GreenMould project leverages the AI REDGIO 5.0 reference architecture to enhance sustainability through digital transformation. Unlike solutions that rely solely on green energy sources, this system embeds eco-efficiency into the process itself. It combines advanced sensors and AI analytics to detect anomalies, predict issues, and recommend process improvements in real-time, balancing environmental impact with production performance.

Innovative aspects

The experiment makes plastic injection moulding smarter and greener through specific technological innovations:

- Multi-Parametric Sensing: The system integrates sensors to monitor not just machine performance (voltage, current) but also environmental conditions (noise, air quality) to get a holistic view of the factory footprint.
- Eco-Centric AI: The data pipeline utilizes AI to understand the relationship between process parameters and environmental impact, offering recommendations specifically designed to reduce waste and emissions.
- Accessible Visualization: Complex data is transformed into simple, visual dashboards that allow operators and managers to understand performance without needing a technical background.
- Low-Cost Infrastructure: The solution proves that digitalization relies on flexible, low-cost hardware, making it easily scalable for other SMEs.

Responsible AI

GreenMould aligns with Industry 5.0 goals by prioritizing sustainability and human-centricity. Environmentally, it achieved a tangible 10% reduction in energy usage and harmful emissions. Socially, it empowers the workforce: by presenting clear, actionable insights via user-friendly dashboards, it enables operators to make informed decisions without being overwhelmed by raw data, fostering a culture of continuous improvement.

The Team

- **POLLINO PLAST d.o.o.** (Serbia) – Plastic manufacturing company specialized in injection and extrusion technologies for the agricultural sector.

Lesson learnt

The experiment demonstrated that digital transformation does not have to be costly or complex; flexible infrastructure can be effectively deployed even in SMEs. A key operational lesson was the value of digitalizing process knowledge: capturing real-time data allows for easy retrieval and early warnings, which reduces dependence on external maintenance. Ultimately, the project showed that empowering SMEs to use their internal data smartly boosts their resilience, making them more self-reliant in a fast-changing industry.

IT+Robotics

Italy

HAWK4Label

Human-Enhanced Weak Supervised Learning for Data Labeling

Keywords

Auto-Labelling

Human-in-the-Loop AI

Machine Vision

Robotic Depalletization

Edge AI

A collaborative auto-labelling framework that reduces manual annotation effort by combining weak supervision with human feedback, enabling fast and cost-effective dataset creation.

Description

Training deep learning models for industrial vision requires massive datasets, but manual labelling is costly, slow, and requires specific expertise. HAWK4Label addresses this by introducing a "Human-in-the-Loop" approach tailored for robotic depalletization. The system captures images during normal production, automatically generates initial annotations using AI, and presents them to operators for quick validation via an intuitive interface. This collaborative process allows machines to handle the heavy lifting while humans ensure accuracy, building robust datasets without disrupting production.

Innovative aspects

The experiment transforms the data annotation process through a hybrid Edge-Cloud framework:

- Human-in-the-Loop Framework: Instead of static datasets, the system creates a continuous improvement cycle where real-time acquisitions are refined by operator feedback.
- Weak Supervised Learning: The AI generates preliminary labels automatically, significantly reducing the time and effort required for manual entry.
- Hybrid Architecture: It leverages the EyeT+Flex vision system for edge-based real-time performance, while using centralized cloud infrastructure for secure storage and model training.
- Interactive Refinement: A modular user interface allows operators to validate and adjust masks/labels with minimal effort, accelerating the transfer learning process.

Responsible AI

HAWK4Label empowers the workforce by removing the repetitive burden of manual data entry. By keeping the human in the loop, it ensures that the AI remains under operator supervision, validating the quality of the output. This approach enhances the operator's role

from passive observer or manual labeller to "AI Supervisor," ensuring high-quality standards while making the interaction with advanced robotics more accessible and less tedious.

The Team

- **IT+Robotics srl (ITR)** (Italy) – Leader in 2D/3D machine vision and robotic integration.

Lesson learnt

The project highlighted that flexibility in system design is essential: when initial tools (like StreamPipes) underperformed, a modular architecture allowed for quick adaptation without stalling the project. Strategically, the experiment proved the value of a centralized cloud infrastructure for streamlining workflows and ensuring data integrity. Finally, operator involvement was decisive: providing user-friendly interfaces for feedback was the key to refining annotations and ensuring the datasets truly reflected real-world production needs.

HCE

Human-Centric Environment for Sustainable Bakery Production

Italy

Keywords

Human-Centric IoE

Industry 5.0

Workplace Safety

Smart Automation

Bakery Production

A human-centric IoE ecosystem that integrates wearables and AI to monitor worker well-being in real-time, dynamically rebalancing workloads to prevent fatigue and ensure safety.

Description

Bakery production is physically demanding, exposing workers to high temperatures and repetitive tasks that lead to long-term health risks. To address this while maintaining competitiveness, the HCE experiment introduces a human-centric Internet of Everything (IoE) system. By integrating smartwatches and environmental sensors, the system captures real-time data on worker stress (heart rate, blood pressure) and ambient conditions. AI algorithms then process this data to predict stress levels and dynamically reassign tasks, ensuring production efficiency prioritizes human well-being.

Innovative aspects

The experiment applies Industry 5.0 principles to a traditional sector through specific innovations:

- Active Well-being Monitoring: Unlike conventional automation, the system actively monitors the physical and mental state of workers via wearables to prevent overload.
- Predictive Stress Algorithms: A novel feature that anticipates high-stress conditions with over 80% accuracy, suggesting preventive actions before fatigue sets in.
- Dynamic Task Assignment: The module balances production needs with worker health, automatically reallocating tasks when stress markers are detected.
- Advanced Stream Reasoning: The integration of DP-sr enables continuous decision-making across heterogeneous IoT devices, ensuring interoperability between legacy machinery and modern platforms.

Responsible AI

HCE is a benchmark for ethical automation. It demonstrates that AI can be used to create safer, healthier workplaces rather than just increasing output. The project addressed privacy concerns head-on: while the system collects biometric data, extensive training and awareness sessions were conducted to build trust and ensure workers understood the data

was for their safety, not surveillance. This approach fosters a culture of inclusion and ergonomics.

The Team

- **Target S.p.A.** (Italy) – Industrial bakery combining traditional recipes with modern production.
- **Revelis S.r.l.** – AI-driven software developer.
- **Intellimech** – Didactic Factory consortium.

Lesson learnt

The experiment confirmed that trust sas important as technology: worker training and continuous communication were essential to overcome privacy concerns regarding wearables. Technically, the robustness of hardware proved critical, as extreme heat and humidity in the bakery influenced sensor performance, requiring resilient equipment. Finally, the project highlighted that early involvement of regulatory authorities helps ensure compliance and reinforces worker confidence in the system.

SWARM-DC

Demonstrating the Synergy of Edge and Cloud Computing

SWARM

France

Keywords

Edge-to-Cloud

Predictive Maintenance

Quality Control

Cybersecurity

Didactic Factory

A hybrid Edge-to-Cloud didactic factory that enables SMEs to "test before invest," lowering the barriers to AI adoption through secure, real-time industrial demonstrators.

Description

Many SMEs face high barriers to integrating AI, such as fragmented data, legacy systems, and limited in-house expertise. SWARM-DC tackles these challenges by providing a "Didactic Factory" environment. This solution combines Edge and Cloud computing to create a hybrid infrastructure where data is processed locally for real-time decision-making or in the cloud for advanced analysis. It allows manufacturers to experiment with predictive maintenance and intelligent logistics in a risk-free setting, accelerating digital transformation without high upfront costs.

Innovative aspects

The experiment bridges the gap between research and industrial application through specific architectural innovations:

- Hybrid Infrastructure: A seamless integration of Edge computing (for low latency) and Cloud (for heavy training), solving the dilemma of speed vs. depth in industrial AI.
- "Test Before Invest": A dedicated didactic facility that allows SMEs to validate solutions on real hardware before committing to expensive production changes.
- IT/OT Convergence: Implementation of standardized middleware and secure protocols to connect legacy operational technology (OT) with modern IT systems safely.
- Cybersecurity-by-Design: A multi-layer security strategy specifically designed to protect the vulnerable intersection between industrial machinery and the cloud.

Responsible AI

SWARM-DC focuses on the democratization of AI and workforce empowerment. By offering a "safe sandbox" for testing, it reduces the financial risk for smaller companies, making advanced technology inclusive. Crucially, the project emphasizes human factors: it provided structured training sessions and hands-on demonstrations to upskill SME staff. This

approach reduces resistance to change and ensures that workers understand the benefits of AI, fostering a culture of confidence rather than fear of replacement.

The Team

- **SWARM-DC Consortium** (Auvergne-Rhône-Alpes, France) – Industrial experts and technology providers.

Lesson learnt

The experiment proved that data quality is the absolute foundation of success; noisy inputs from legacy machines significantly limit AI performance. Technically, using standardized middleware was essential to bridge the gap between old equipment and new AI tools. Most importantly, the project highlighted that scalability depends on flexible model design: AI systems must be adaptable to different processes without requiring lengthy reconfigurations. Finally, structured training was key to overcoming cultural resistance on the shop floor.

ADEPT

AI-Powered Edge Anomaly Detection and Decision Support

SCORTA

Italy

Keywords

Edge AI

Large Language Models (LLMs)

Generative AI (GenAI)

Predictive Maintenance

Energy Efficiency

Explainable AI (xAI)

An intelligent edge system that combines anomaly detection with Generative AI to optimize energy efficiency and provide operators with natural-language maintenance guidance.

Description

SCORTA Srl, a European leader in thread-cutting tools, introduces ADEPT to address the challenges of maintaining high-precision machine tools. The experiment integrates advanced AI at the edge to monitor energy consumption and predict unexpected failures in real-time. By combining sensor data with a Generative AI decision-support layer, the system translates complex technical deviations into actionable, natural-language guidance. This enables timely interventions, reduces waste, and minimizes environmental impact, empowering operators to make informed decisions without needing deep data science expertise.

Innovative aspects

ADEPT transforms the maintenance workflow through a hybrid Edge-LLM architecture:

- Hybrid Anomaly Detection: The system combines Autoencoders and Isolation Forests for robust fault identification, alongside RNNs and LSTMs for analyzing dynamic energy patterns.
- RAG-Enhanced GenAI: It utilizes a Retrieval-Augmented Generation (RAG) framework to ground Large Language Models (LLMs) in company-specific manuals, providing context-aware troubleshooting advice.
- Explainable AI (xAI): Techniques like SHAP, LIME, and surrogate Random Forest models are used to make AI decisions transparent and interpretable for non-expert personnel.
- Conversational Interface: User-friendly dashboards and chatbot interfaces allow operators to interact with the machine's status using natural language.

Responsible AI

ADEPT emphasizes a human-centred approach by prioritizing operator safety and cognitive load reduction. By automating routine monitoring and providing clear explanations, it reduces stress and enables informed decision-making. Data privacy is strictly preserved as the system processes only machine operational data, avoiding personal information. Furthermore, the system fosters upskilling by helping workers understand complex machine behaviours through interpretable AI outputs.

The Team

- **SCORTA Srl** (Italy) – European SME leader in thread-cutting tools. The project was fully developed by the internal team, comprising production engineers, maintenance staff, and AI/data specialists .

Lesson learnt

The deployment yielded key insights for industrial AI: Edge AI combined with RAG-LLM significantly improves decision-making without requiring centralized computation. Domain-specific customization was crucial; incorporating internal manuals ensured that AI recommendations were accurate and actionable rather than generic. Finally, the effectiveness of Explainable AI (SHAP, LIME) proved essential for building trust, allowing non-expert users to adopt advanced tools confidently and focus on complex tasks while AI handled the routine monitoring.

TIKPACK

Ukraine

AIPack

AI-Driven Packaging Defect Detection System

Keywords

AI-at-the-Edge

Industrial Visual Inspection

Real-time Defect Detection

Quality Control Automation

Human-Machine Collaboration

An Edge AI visual inspection system that automates quality control on high-speed packaging lines, detecting defects in real-time to prevent rework and ensure full traceability.

Description

TIKPACK addresses the persistent challenge of packaging defects in high-speed pillow-bag production lines, where manual inspection is often too slow and inconsistent. AIPack integrates AI-driven visual inspection with Edge computing to deliver stable, real-time quality control. The system uses an industrial GigE camera and a deployed YOLO model to capture video streams, process images instantly, and trigger automated reject mechanisms for defective units. This approach replaces subjective manual checks with a precise, automated standard, reducing the risk of defective products reaching the customer.

Innovative aspects

The experiment modernizes the quality assurance workflow through specific technical innovations:

- Real-time Detection: The system performs inference with sub-second latency, ensuring continuous operation at high throughput (50 packages/min) without slowing down the line.
- Comprehensive Inspection: It detects various defect types simultaneously, including cutting failures, film misalignment, sealing defects, and product adhesion.
- Automated Intervention: Unlike passive monitoring, the system integrates with a PLC-driven rejector to physically remove defective items or stop the line conditionally.
- Traceability-by-Design: Every inspection generates time-stamped logs and metadata, creating a digital audit trail for process optimization.

Responsible AI

AIPack demonstrates how trustworthy AI can support quality reliability without burdening

operators. By providing transparent detection overlays and image-based logs via a Human-Machine Interface (HMI), the system fosters operator acceptance and keeps the human in the loop for final verification. Furthermore, the use of optimized Edge models (ONNX/TensorRT) improves energy efficiency compared to cloud-heavy alternatives, aligning with sustainable manufacturing goals by reducing rework and material waste.

The Team

- **TIKPACK** (Ukraine) – Agro-processing SME specializing in bulk food packaging.
- **Mind Studios** – Technology provider specializing in AI-driven software solutions.

Lesson learnt

The experiment highlighted that early network optimization is critical for Edge AI: configuring the GigE stack correctly eliminated latency spikes that initially disrupted real-time detection. Operational lessons showed that data scarcity for rare defects is a limitation, requiring targeted data augmentation and iterative retraining. Finally, the project confirmed that a user-friendly HMI is essential for building trust: operators embraced the system because the interface was transparent and allowed for easy manual overrides.

AI-Vision

Real-Time Monitoring and Analysis of Oven Movements

Netherlands

Keywords

Computer Vision

Edge AI

Operator Activity Monitoring

Industrial Process Optimization

Human-Centric Manufacturing

A privacy-preserving computer vision system that monitors roto moulding oven operations in real-time, helping operators reduce scrap and energy consumption through actionable edge-based insights.

Description

Roto moulding operations traditionally rely on manual supervision, which is labour-intensive and prone to human error. To overcome this limitation, Pentas implemented a smart monitoring framework driven by high-resolution PoE cameras and NVIDIA Jetson edge devices. By tracking operator movements, arm positions, and idle times, the system delivers consistent insights that help reduce downtime and energy waste. This approach ensures process precision and supports the workforce by identifying workflow deviations in real-time without replacing the human element.

Innovative aspects

This initiative modernizes the rotomoulding floor through a modular and scalable architecture:

- Edge-Native Inference: Deployment of YOLO-based object detection on NVIDIA Jetson devices ensures real-time tracking of machine states and operator activity.
- Privacy-by-Design: The analysis is strictly limited to machine-relevant zones, deliberately avoiding personal image capture to protect operator privacy.
- Integrated Visualization: Data flows into Victoria Metrics and is visualized via Grafana, transforming raw video feeds into actionable KPIs for immediate consumption.
- Scalability: The infrastructure supports the easy addition of new ovens and cameras without major reconfigurations.

Responsible AI

Human-centred design sits at the core of this solution. By processing video data locally at the edge, the system ensures that sensitive information never leaves the factory floor. It

acts as a supportive tool rather than a surveillance mechanism: clear dashboards and context-aware alerts empower operators to make better decisions, reducing cognitive load while maintaining full transparency and trust in the AI's behaviour.

The Team

- **Pentas Moulding B.V.** (The Netherlands) – Led entirely by in-house experts including production engineers, IT specialists, and process managers.

Lesson learnt

Pragmatism proved superior to theoretical ambition: using pre-trained YOLO models accelerated deployment significantly compared to building complex custom architectures. Infrastructure readiness also emerged as a decisive factor; elements like lighting, camera placement, and network capacity were just as critical for accuracy as the code itself. Furthermore, the team realized that data quality is a continuous battle in industrial environments, where dust and light variations require ongoing calibration to maintain performance.

Antenna-I

AI-Enhanced RF Testing and Fault Classification System

Israel

Keywords

AI-at-the-Edge

RF Signal Analysis

Fault Classification

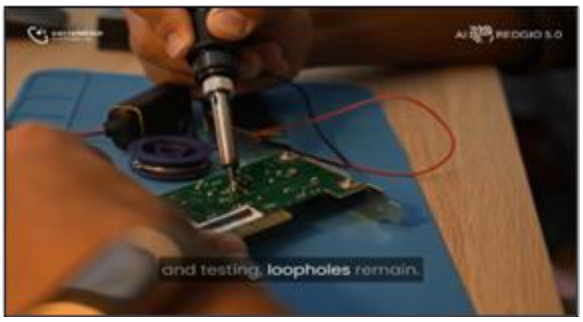
Industrial Quality Monitoring

Human-Machine Collaboration

An AI-driven RF testing system that standardizes quality control in antenna manufacturing, utilizing confidence scoring to assist operators in classifying complex signal faults with consistency.

Description

Traditional RF inspection in antenna manufacturing relies heavily on human expertise, making it time-consuming and prone to variability, especially when dealing with subtle signal deviations. Antenna-I modernizes this process by integrating machine learning models and Edge computing into a structured measurement workflow. The system automates defect classification, ensuring consistent "pass/fail" results. By complementing expert knowledge with AI, it standardizes decision-making and significantly reduces the dependence on subjective manual judgment for borderline cases.



The Edge-based RF measurement unit that processes signals locally, enabling real-time fault classification without cloud latency.

Innovative aspects

The experiment advances industrial RF testing through specific technical innovations:

- Automated Classification: Machine learning models replace manual interpretation, ensuring consistency across different operators and shifts.
- Confidence Scoring: The system provides a confidence metric alongside its decision, supporting Human-in-the-Loop validation and enhancing operator trust.
- Edge-Based Inference: Real-time analysis is performed locally with minimal latency, essential for high-speed production environments.
- Adaptive Workflows: The architecture supports structured dataset expansion and model retraining, allowing the system to learn from new defect types over time.

- Production-Ready UI: A simplified user interface minimizes interaction complexity, reducing the risk of operator error.

Responsible AI

Antenna-I demonstrates trustworthy industrial AI by prioritizing explainability and operator-centric design. The inclusion of transparent confidence scores enables operators to understand when AI decisions are reliable and when human verification is warranted. Furthermore, by processing data locally at the Edge, the system minimizes data exposure, supporting privacy-preserving deployment. This approach ensures that the technology acts as a reliable assistant, augmenting human capabilities rather than replacing them.

The Team

- **Correlation Systems Ltd.** (Israel)
- **Collaboration:** The project was delivered through a joint effort between the manufacturing partner (providing RF infrastructure and domain knowledge) and the technology provider (developing AI models and architecture)

Lesson learnt

The experiment highlighted that model performance in RF testing is heavily dependent on representative datasets, making continuous data collection for rare faults essential. A key operational insight was that confidence scores significantly improved operator trust, particularly for ambiguous, borderline cases. Regarding usability, simplified interfaces proved superior to complex screens, producing far more consistent outcomes. Finally, the project showed that environmental variability in RF conditions requires robust calibration procedures to ensure repeatability.

NILTEXTILE

COMATEX 5.0

Collaborative Sewing Automation for Inclusive and Sustainable Textile Manufacturing

Czech Republic

Keywords

Collaborative Automation

Human-Machine Interaction

Smart Sensing

Workforce Inclusion

Textile Manufacturing

A collaborative, sensor-enhanced sewing system that automates complex tasks like collar attachment, making high-quality textile production accessible to elderly or less-skilled workers.

Description

The COMATEX experiment addresses a critical challenge in textile manufacturing: collar attachment in t-shirts is traditionally a demanding manual task requiring high skill and physical precision. To modernize this process at NIL Textile, the project introduced a semi-automated, human-centric system. By integrating automatic feeding, optical seam detection, and real-time monitoring, the solution allows less-skilled, elderly, or physically limited operators to perform complex tasks. This approach increases consistency and reduces defects while significantly lowering operator fatigue.

Innovative aspects

The experiment demonstrates how Industry 5.0 principles can be practically applied in small textile enterprises through specific innovations:

- Collaborative Automation: The system blends automated feeding with optical seam-detection sensors to stabilize stitch alignment, maintaining human oversight via configurable dashboards.
- Material Adaptability: The technology handles variable materials effectively, ensuring consistent quality even with recycled fibers that have inconsistent mechanical properties.
- Edge Traceability: A lightweight edge-computing layer logs machine use, takt-time, and defects, creating a foundation for digital traceability and predictive insights.
- Inclusive Design: The system reduces reliance on rare high-skill operators, making the workflow replicable and accessible.

Responsible AI

COMATEX is a prime example of human-centric digitalization. Although it uses rule-based logic, the system is designed to keep operators in control, supported by transparent sensor feedback and intuitive HMIs that clarify machine decisions. Privacy is ensured through

local edge processing, which keeps production data on-site. Most importantly, the inclusive design accommodates workers with different physical abilities, improving workplace accessibility and safety.

The Team

- **NIL Textile** (Czech Republic) – Provided the production environment and expertise in recycled materials.
- **Technology Partners:** Juki, Astron, Texcentrum.
- **Digitalization Support:** EDIH Ostrava

Lesson learnt

This initiative proved that collaborative automation is a powerful driver for inclusivity. By simplifying the sewing process, the system expanded operator eligibility from 20% to over 70%, supporting the inclusion of unskilled or elderly workers. Trials confirmed reduced wrist and shoulder strain, proving the value of ergonomic improvements. On the technical side, continuous calibration proved essential due to variable fabric elasticity. Finally, the project sparked a positive cultural shift, as operators increasingly trusted digital tools once they realized the reduction in physical load.

EdgeAI4Beer

Optimizing Microbrewery Processes through Edge AI Analytics

Greece

Keywords

Edge AI

Fermentation Forecasting

Predictive Maintenance

Smart Sensors

Craft Brewing

Industry 5.0

A cyber-physical brewing system that merges artisanal tradition with Edge AI, providing real-time fermentation forecasting and anomaly detection to reduce waste and optimize tank usage.

IoT sensors installed on Paragon Brewery's fermentation tanks capture real-time data, replacing manual sampling.

Description

Paragon Microbrewery faced the typical challenges of craft production: reliance on manual sampling, delayed measurements, and reactive maintenance. EdgeAI4Beer addresses this by bringing real-time AI capabilities directly to the shopfloor. The experiment deployed two complementary tools: a fermentation forecasting model running on an NVIDIA Jetson device and an anomaly-detection module embedded directly into a PLC controlling the boiling phase. This setup provides accurate predictions and early warnings, allowing brewers to streamline production without compromising the craft nature of their beer.

Innovative aspects

The experiment introduces advanced digitization into a traditional sector through specific innovations:

- Hybrid Edge Architecture: The system uses a dual approach: complex regression models run on edge gateways, while lightweight neural networks operate directly on the PLC (Arduino Opta) for immediate boiling control.
- Conformal Prediction: Unlike standard forecasting, the fermentation tool uses ensemble regression with conformal prediction to provide calibrated time estimates and confidence ranges, not just raw numbers.
- Cyber-Physical Environment: It creates a unified loop where IoT sensors and PLC

equipment feed live data into a brewer-oriented dashboard, enabling faster decision cycles.

- Resource Efficiency: By predicting fermentation timelines accurately, the system optimizes tank utilization and reduces the beer loss associated with frequent manual sampling.

The Arduino-based PLC (Opta) embedded with lightweight neural networks to detect boiling anomalies directly at the source.

Responsible AI

The system was strictly designed to support brewers while preserving human oversight, aligning with Industry 5.0. Predictions include confidence indicators and simple explanations, helping operators understand when the AI is reliable and when manual checks are needed. By processing data locally on the Edge, the solution ensures privacy and functionality even without internet connectivity. Crucially, the human-in-the-loop workflow allows brewers to confirm or disregard suggestions, ensuring the "art" of brewing is respected.

The Team

- **Paragon Microbrewery** (Greece) – Provided the brewing environment and operational expertise.
- **EnakronIC** – Edge AI startup responsible for model design and system architecture.

Lesson learnt

Technically, Edge AI proved well-suited for brewing, but real operational data was essential to refine models beyond initial synthetic datasets. On the human side, confidence scores were the key to building trust: knowing how sure the AI was made operators more comfortable using it. Operationally, the reduction in manual sampling directly saved labor and minimized product loss. Finally, the project demonstrated that a collaborative approach - involving brewers in dashboard design - is vital to reduce resistance and preserve the craft identity.

FurnAIce5.0

Collaborative AI-powered Open Furnace Control Systems for Net-Zero Aluminium Recycling

Spain

Keywords

Edge AI

Human-in-the-Loop

Aluminium Recycling

Furnace Optimization

Operator Decision Support

Industry 5.0

A collaborative Edge AI assistant that optimizes aluminium recycling furnaces by interpreting complex operational signals in real-time, guiding operators to improve energy efficiency and process stability.

Description

In aluminium recycling, operators must manage highly variable conditions influenced by scrap quality and combustion behaviour, often relying on tacit knowledge to make critical decisions. FurnAIce5.0 transforms this workflow by deploying an Edge AI system capable of interpreting these noisy signals to infer underlying material states. Rather than automating the furnace, the system acts as an intelligent co-pilot, providing actionable recommendations during charging, melting, and casting. Validated over 50 production batches, this approach enables repeatable, data-driven decision-making while keeping the human in control.

Innovative aspects

The experiment moves beyond traditional monitoring to true Industry 5.0 collaboration through specific innovations:

- Context-Aware Interpretation: The Edge AI system interprets furnace signals in real-time, transforming them into meaningful insights about melting progression or charging readiness.
- Active Feedback Loop: It features a built-in mechanism where operators can accept or reject recommendations, allowing the system to capture human expertise and evolve over time.
- Modular Integration: The design integrates seamlessly with the Beyond Alea platform, ensuring it fits into existing industrial architectures.
- Edge Reliability: By running intelligence directly at the furnace, the solution provides fast guidance even during network interruptions.

Responsible AI

FurnAIce5.0 is built on "responsible-by-design" principles, ensuring that AI enhances operations without reducing operator authority. All recommendations are strictly advisory, leaving the final decision on charging and casting to the human expert. To foster trust, the system provides simple, explainable indicators detailing why a specific suggestion was made. Furthermore, processing data at the Edge guarantees data sovereignty and privacy.

The Team

- **GHI Smart Furnaces** (Spain) – A multidisciplinary team combining the 4.0 engineering group, process specialists, and furnace operators

Lesson learnt

Deploying collaborative AI in heavy industry revealed that adoption depends on people, not just technology. Resistance to change was the primary barrier, which was overcome by clearly positioning the AI as an assistant rather than a controller. Strategically, a dedicated adjustment phase proved critical: a one-month refinement period allowed the team to capture real operational variability and fine-tune the model. Ultimately, the pilot demonstrated that a system operators trust - even if not perfect - delivers far more value than a highly accurate model that users hesitate to adopt.

GEDAIM

Generative and Enhanced AI-driven Intelligent Mining of Manufacturing Processes

Italy

Keywords

Process Mining

Predictive Maintenance

Generative AI (GenAI)

Large Language Models (LLMs)

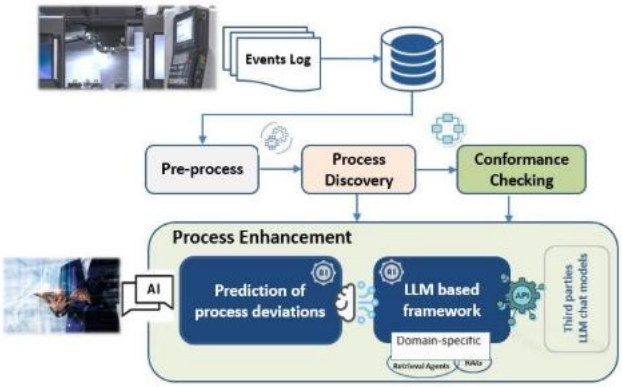
Prescriptive Analytics

Low-Code Platforms

A next-generation maintenance platform that combines Process Mining and Generative AI to predict workflow deviations and provide natural-language prescriptive guidance to operators.

Description

Maintenance service processes often account for 20-30% of total costs. GEDAIM addresses this by leveraging Event Logs from information systems to discover, analyse, and optimize these workflows. The solution orchestrates a three-phase approach: Discovery (mapping existing processes), Conformance (identifying inefficiencies), and Enhancement (predicting issues). By integrating the KNIME® Analytics Platform with LLM-based guidance, the system provides operators with real-time, actionable insights via a web-based interface, enabling rapid adaptation to process deviations.



The GEDAIM workflow: transforming raw Event Logs from the shopfloor into AI-driven Process Enhancement and operator guidance.

Innovative aspects

The experiment pioneers a hybrid approach to industrial maintenance through specific architectural innovations:

- Hybrid Intelligence: It combines Process Mining (to understand what is happening) with Generative AI (to explain why and how to fix it).
- RAG-Enabled Assistance: A Retrieval-Augmented Generation (RAG) framework grounds Large Language Models in company-specific knowledge, delivering context-aware recommendations rather than generic outputs.
- Prescriptive Analytics: Beyond predicting failures, the system provides actionable recommendations (WHAT, WHEN, HOW), enabling proactive process improvements.

- Low-Code Accessibility: The use of KNIME workflows allows for rapid deployment and ensures the solution is accessible to non-programming users.

Responsible AI

GEDAIM ensures AI decisions are transparent, explainable, and auditable. To address privacy concerns, event logs are anonymized before processing. The system is designed to empower teams rather than replace them: by automating the analysis of complex logs, it achieved a 25.3% reduction in human process time and improved process conformity from 0.64 to 0.91. This demonstrates that AI can foster operator trust and safer decision-making by acting as a reliable, knowledgeable assistant.

The Team

- **AXIRO** (Italy) – SME specializing in AI, data analytics, and process engineering. The project was executed by a multidisciplinary internal team combining AI/data scientists, domain engineers, and maintenance operators to ensure continuous human-AI collaboration.

Lesson learnt

The integration of process mining with AI fundamentally transforms maintenance from reactive to prescriptive. A key insight was that Generative AI and LLMs deliver context-aware insights that traditional analytical tools cannot match. However, the experiment also highlighted that data quality is critical; consistent logs are the prerequisite for accurate modeling. Finally, the use of low-code implementations proved to be a significant accelerator for adoption and cross-functional collaboration.

Rchemie International

GreenChemAI

AI-Enabled Sustainability for Chemical Manufacturing

Türkiye

Keywords

Viscosity Control

Artificial Neural Networks (ANN)

Large Language Models (LLMs)

AI-at-the-Edge

Process Optimization

Human-Centric Manufacturing

A hybrid AI system combining Cloud-based predictive modeling with an Edge-deployed LLM to optimize viscosity control, reducing decision delays by up to 60 minutes per batch.

Description

Rchemie International deployed a hybrid AI system at its Tuzla facility to assist operators in real-time viscosity control, a critical quality parameter. The experiment integrated two core technologies: a Cloud-based Artificial Neural Network (ANN) that predicts viscosity trends from over 20 process variables (e.g., base oil composition, temperature), and an Edge-deployed Large Language Model (LLM). The LLM provides context-specific, natural-language corrective suggestions, enabling operators to move away from trial-and-error methods toward data-driven precision.

Innovative aspects

The experiment implements a novel architecture that merges structured sensor data with unstructured reasoning:

- Hybrid Architecture: It combines the heavy lifting of Cloud-based ANN for high-accuracy prediction with the low latency of Edge-based LLMs for immediate operator interaction.
- Natural Language Guidance: Unlike standard alerts, the system offers explainable, human-readable advice, bridging the gap between raw data and operator action.
- Non-Intrusive Integration: The solution works alongside existing PLC and SCADA infrastructure, requiring no hardware replacement.
- Human-in-the-Loop: Operators validate and refine AI recommendations, allowing the system to capture implicit expertise and continuously improve.

Responsible AI

GreenChemAI prioritizes transparency and traceability. The system ensures that every AI suggestion is accompanied by a rationale, making the "black box" of AI explainable to the

workforce. Operational results were significant: the ANN model achieved 93.74% accuracy over 48 validated batches, and real-time guidance reduced decision delays by 30-60 minutes, minimizing waste. All operator inputs and predictions are logged in a structured database to ensure full accountability.

The Team

- **Rchemie International** (Türkiye) – A multidisciplinary SME team comprising chemical engineers, process engineers, and IT/OT specialists handling the full Edge-Cloud deployment.

Lesson learnt

The experiment proved that data integrity is foundational: even minor timestamp mismatches can significantly affect model accuracy, making synchronized data capture mandatory. A key finding was that limited datasets can still yield strong performance: well-designed features allowed for high accuracy despite a small dataset of only 48 batches. Finally, the Hybrid Edge-Cloud architecture proved optimal, balancing the compute requirements of ANNs with the operational reliability needed for real-time LLM interactions.

C2CAT
CARBON & ENERGY CATALYSIS

Netherlands

Harmony

AI-Driven Catalyst Manufacturing for Sustainable Materials Production

Keywords

Catalyst Manufacturing

AI-Optimized Materials

Edge Computing

Human-in-the-Loop

Sustainable Chemistry

Dexcat Platform

A closed-loop digital workflow that uses AI to predict optimal catalyst formulations and detect production anomalies in real-time, reducing reliance on manual trial-and-error.

Description

Traditional catalyst production relies heavily on manual trial-and-error, a process that is slow, resource-intensive, and prone to variability. HARMONY modernizes this workflow at C2CAT's facility in the Netherlands by integrating AI-based formulation prediction and real-time anomaly detection into the production line. Through the Dexcat platform, the experiment connects sensors, edge devices, and machine learning services in a loop that covers planning, manufacturing execution, and quality control. This system proposes formulation windows and accelerates QC, while operators remain fully in control through ergonomic interfaces.

Innovative aspects

The experiment introduces a fully connected, closed-loop digital workflow for chemistry SMEs through specific innovations:

- Structure-to-Property (S2P) Modelling: A key innovation that transforms molecular representations into actionable production parameters, dramatically reducing formulation cycles.
- Hybrid Anomaly Detection: The system blends deterministic rules with ML-based pattern recognition, offering early alerts that adapt to changing process conditions.
- Traceable Pipeline: By using global identifiers (BatchID, RunID), the architecture ensures complete repeatability and auditability from raw material to final product.
- Bounded Automation: The system uses "automation envelopes" where adjustments are automatic only within safe limits, requiring human approval for significant deviations.

Responsible AI

HARMONY is designed around WISE principles (Well-being, Inclusion, Safety, Ergonomics). It follows a strict Human-in-the-Loop approach: all automated adjustments for medium- or

high-severity deviations require explicit operator approval. The system fosters trust by providing transparent explanations for every alert (e.g., "why this alert," "risk level"). Furthermore, ergonomic UI design reduces cognitive load, ensuring that AI acts as a trusted assistant rather than a source of stress.

The Team

- **C2CAT** (Netherlands) – Specialists in catalyst formulation and lab-to-industry scaling. The project team combines chemical engineers with digital developers specializing in structure-to-property modelling and data architecture

Lesson learnt

The experiment highlighted that hybrid anomaly detection (combining rules and Machine Learning) is more reliable than either approach alone. From a human perspective, operators preferred simpler, consolidated screens; reducing navigation significantly lowered cognitive load. Strategically, the team learned that micro-trainings and a sandbox environment were more effective for adoption than long training sessions. Finally, the use of standardized identifiers proved essential for achieving true traceability across events and quality control.

Conclusions

Across the 41 experiments carried out within AI REDGIO 5.0, a coherent pattern of insights emerges, revealing what truly enables the adoption of advanced AI tools in manufacturing environments, especially within SMEs.

1. Data Quality as the foundational enabler.
Every experiment confirms that clean, structured and interoperable data is the essential prerequisite for any AI-based solution. Without reliable datasets - whether captured through standardized protocols, synchronized time-series, Asset Administration Shell models or edge-born signals - AI systems cannot produce meaningful or trustworthy outputs. Data quality is consistently identified as the decisive factor separating successful deployments from fragile prototypes.

2. Hybrid Approaches consistently outperform isolated techniques.
Experiments combining physics-based understanding with data-driven models, or fusing human expertise with machine intelligence, prove to be more robust and adaptable than pure "black box" automation. Hybrid workflows enable accurate analysis even when data is scarce, accommodate process variability, and allow SMEs to benefit from AI without the need for massive historical datasets. This pattern appears across predictive maintenance, anomaly detection, process monitoring, and human–machine cooperation.

3. Trust as the determining factor for real adoption.
Technical performance is necessary but insufficient. The experiments show that adoption ultimately depends on trust; trust in the data, in the algorithms, and in the interaction between humans and digital tools. Voice control, privacy-preserving architectures, explainable alerts, operator-in-the-loop mechanisms and ergonomic interfaces all contribute to a working environment where technology supports, rather than replaces, the human role. When systems ensure transparency, safety and comprehension, workers feel empowered, and AI becomes a credible partner on the shop floor.

Together, these insights demonstrate that the path to Industry 5.0 is not defined solely by technological advancement, but by the ability to combine high-quality data, hybrid intelligence and human-centric design. The 41 experiments collectively show that when these three pillars align, AI becomes a practical, scalable and trustworthy resource for European manufacturing.

Closing Sentiments

A great thank you to all the 41 experiment leaders who have contributed to this Booklet.

We aim to retain the valuable and intensive collaboration born in AIREDGIO5.0 overtime, and that European Manufacturing SMEs can benefit from our experience.

Do you have any questions about the AI REDGIO 5.0 project, the experiments or this Booklet?
Please feel free to let us know:
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AI REDGIO 5.0

AI REDGIO 5.0 is an ambitious EU-funded project, stemming from the Made in Europe Partnership, leading the digital transformation of European manufacturing SMEs through Artificial Intelligence at the Edge. Bringing together 43 partners from 18 countries, the project extends the successful legacy of Horizon 2020's I4MS and AI REGIO initiatives, which empowered SMEs to embrace Industry 4.0 technologies.

AI REDGIO 5.0 has been advancing these achievements toward Industry 5.0, where technology serves people, sustainability, and resilience. By connecting regions, European Digital Innovation Hubs (EDIHs), and manufacturing SMEs, the project creates a powerful ecosystem fostering innovation across Europe.

At its core, the project focuses on experimentation and collaboration. Three types of experiments are conducted. SME-driven experiments demonstrate real-world AI applications improving productivity and agility in factories. Test-before-invest experiments, performed within Didactic Factories, Technology and Regulatory Sandboxes for AI (TERESAs), and Virtual Factories, refine AI tools and assess their ethical, regulatory, and human-centric dimensions. Through Open Calls, 20 additional SMEs are funded to develop cutting-edge solutions in AI-at-the-Edge, circular manufacturing, and sustainable production.

By accelerating the adoption of AI and fostering cross-regional cooperation, AI REDGIO 5.0 paves the way for a smarter, greener, and more inclusive European manufacturing landscape where people and technology thrive together.

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