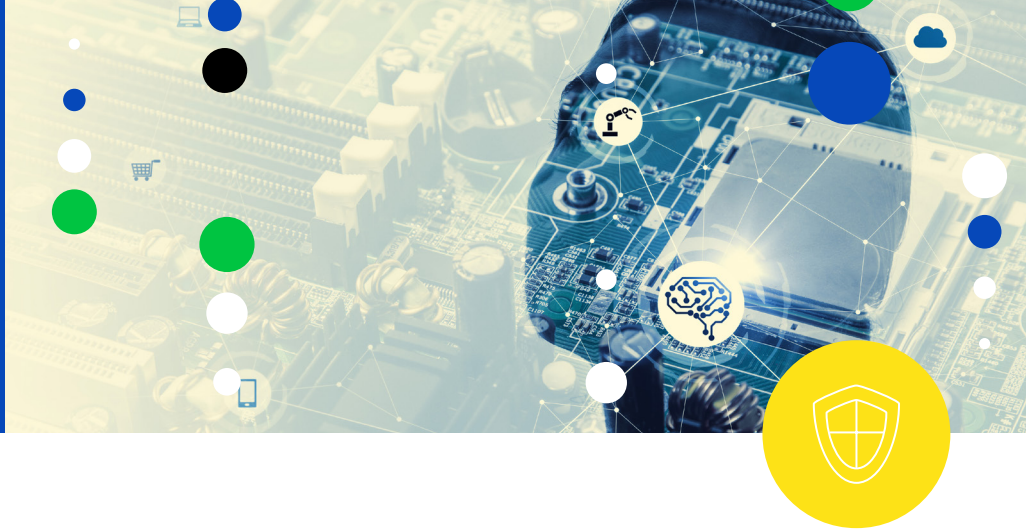
ITEA 4

Project Results



IML4E

Making MLOps easier for European enterprises

The ITEA project IML4E (Industrial Machine Learning for Enterprises) increases the accessibility of artificial intelligence (AI) and machine learning (ML) automation by providing MLOps tools, methods and a platform to create and maintain AI/ML solutions.

Smart software solutions involving AI/ML have shown great potential to automate processes for which this was previously impossible. However, fundamental AI/ML engineering activities and processes differ from traditional software development, rendering it unclear how AI/ML can be integrated into existing industrial-grade software development processes. A solution lies in the combination of DevOps and ML (MLOps), but its implementation requires significant resources, expertise and infrastructure. Incorrect decisions and expectations can quickly lead to failure, especially for organisations without an established DevOps and ML culture.

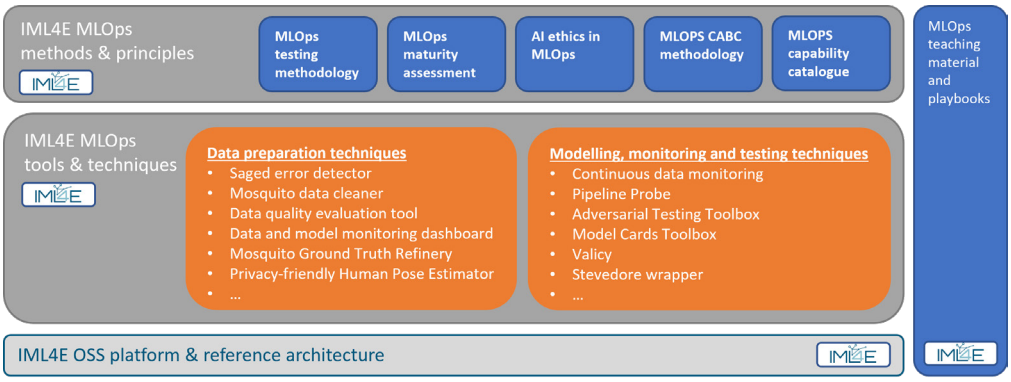
IML4E aims to leverage MLOps' capabilities to boost Europe's position in the highly competitive AI market. To achieve this, it developed a framework consisting of a platform layer, a technology layer and a methodology layer that simplify MLOps adoption by European enterprises. This offers them a better market position via new AI-enabled services and MLOps consulting services, as well as high product delivery capabilities through the fast and efficient deployment and maintenance of ML products and MLOps tooling. The project will also deliver its platform and a large part of its tools as open source, allowing a wider community to benefit.

Technology applied

IML4E's platform layer consists of an OSS platform and a reference architecture. The former is an open, portable, cloud-agnostic platform that enables the creation and execution of ML/AI services by integrating popular MLOps technologies and providing an interface for ML practitioners to easily develop, test, deploy and monitor their work. The OSS platform can be used directly by companies starting from scratch, while the reference architecture can be adapted to a suitable platform when infrastructure exists. The technology layer then offers tools and techniques that can be combined with the platform to enable additional services on data preparation and modelling, monitoring and testing. A particular innovation is the SAGED error detection tool, which holistically and automatically identifies contaminated records in tabular data using semi-supervised ML models. Finally, the methodology layer utilises these tools while offering methods and principles to explain how MLOps is generally implemented. This includes elements like a maturity self-assessment, a capability catalogue to assign tools to necessary AI and MLOps capabilities, and a focus on AI ethics in MLOps that advocates for ongoing assessment and improvement throughout ML product lifecycles.

Making the difference

By offering foundational technologies and methodologies for MLOps, IML4E serves as an innovation enabler that allows companies to focus on their core business with enhanced capabilities. This brings different benefits to different industrial stakeholders. For MLOps tool providers, IML4E offers greater tool customisation and efficient integration, opening up new business avenues.



The IML4E Framework consolidates the IML4E results in a layered architecture

Participation in the project has allowed Software AG, for instance, to submit three patents to the US patent office in fields like automated data preparation for ML and meta-learning for error detection. For consultancy firms, meanwhile, IML4E bridges the gap between silos, consolidates standards and best practices, and allows them to keep pace with rapidly evolving technologies. In turn, this will allow the OSS platform to expand and scale as new technologies emerge.

For smart service providers, the benefits of IML4E include continuous improvements to model performance, increased model quality and

transparency, and streamlined model development. This also demonstrates the project's applicability to disparate domains. For example, Granlund built a scalable ML application to detect building energy consumption anomalies and forecast next-day consumption, while Basware improved automation in its existing SmartPDF service for extracting invoice information from PDFs. Both have achieved impressive results: for Granlund, the minimum historical energy consumption data needed to begin a new building application has dropped from 24 months to 1-6 months via a retraining strategy; for Basware, the number of invoices that SmartPDF can handle per month has risen from 300,000 to 4 million. Additionally, 74% of invoices can be extracted with high accuracy (versus a starting point of 60%) and the time needed to fully train 3.5 million invoices has fallen from 27 person-days to 10.

The future

AI's importance is only set to increase, with the European AI software market predicted to grow from USD 2.09 billion in 2018 to USD 26.52 billion by 2025. This brings a greater emphasis on governance and regulation, especially in light of the EU AI Act and the widespread use of large language models. Cost efficiency and sustainability are also critical considerations as these models require substantial infrastructure for training. In the ITEA project ELFMo, some IML4E partners will therefore focus on extending the project's efforts to large language models and foundational models, with the long-term aim of developing infrastructures and techniques that facilitate their adaptation while minimising energy consumption. In the meantime, IML4E is undertaking standardisation efforts with ETSI and further integrating the project's results into the consortium's industrial applications to improve their competitive advantage. Given the open-source nature of the project, the opportunities of MLOps automation, scalability and guidance are widely available, representing the chance to build a platform with Europe-wide recognition.

Major project outcomes

Dissemination

- 10 journal papers (e.g. in IEEE Software), 23 conference papers (e.g. at WAICOM 22, VLDB 22, AITEST 24), 18 poster & presentations, several white papers and blog posts
- 5 meetups and other dissemination events
- 5 PhD theses and 32 MSc theses

Exploitation (so far)

- VALICY Safety Envelope to validate AI systems for safety-critical applications
- MLOps Maturity Assessment to assess and improve organisations' MLOps maturity
- MLOps testing methodology to systematically apply testing to MLOps processes
- Confidence Calibration: an uncertainty estimation method in machine learning focusing on confidence scores and their calibration
- ML Lineage to holistically capture and connect information about ML model development and operations for regulatory compliance and governance
- OSS platform & reference architecture to provide a basis for MLOps operationalisation
- Model Cards Tooling for checking model card conformance to given specifications
- SAGED to detect and remove errors in tabular data using meta learning

Standardisation

- Participation in ETSI MTS AI
- Preparation of 3 documents at ETSI (DTR/MTS-103910, DTS/MTS-104008, DTR/MTS-20187318)

Patents

Patent applications filed:

- Automated Data Preparation Technique for ML
- Meta-learning for Error Detection in Structured Data
- Systems and Methods For Reinforced Learning Data Cleaning and Learning in ML Inclusive Computing Environments

ITEA is the Eureka RD&I Cluster on software innovation, enabling a large international community of large industry, SMEs, start-ups, academia and customer organisations, to collaborate in funded projects that turn innovative ideas into new businesses, jobs, economic growth and benefits for society. ITEA is part of the Eureka Clusters Programme (ECP).

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Partners

Finland

- Basware Oy
- Granlund Oy
- Reaktor Innovations
- Silo AI
- University of Helsinki

Germany

- Fraunhofer
- Siemens AG
- Software AG
- Spicetech GmbH

Hungary

- Budapest University of Technology and Economics
- University of Debrecen
- Vitarex Studio Ltd

Project start

May 2021

Project end

September 2024

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Project website

https://itea4.org/project/iml4e.html

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