ITEA 4

Project Results

MIRAI

A pioneer in AI and IoT at the edge

The ITEA project MIRAI (Machine intelligence techniques for smart and sustainable planning and operation of IoT and Edge computing applications) developed a distributed artificial intelligence (AI) approach for edge devices. This enables Internet of Things (IoT) applications to be planned and operated efficiently and securely.

Distributed IoT applications face a number of challenges, including hard real-time constraints for critical applications and high demands on storage, computational and communication power. Resource-heavy AI usage is also increasing on end-devices while poor security/privacy standards create questions regarding service resilience and trustworthiness. Through these factors combined, just 1% of data generated by end-nodes and available at the edges of modern networks is being utilised. The current approach of leveraging cloud infrastructures to address constraints is no longer viable.

An alternative lies in MIRAI's distributed AI approach for edge devices, which uses edge computing methods that scale vertically to the cloud and horizontally to other devices. RD&I on distributed data mining, machine learning models and private, secure data-sharing policies has resulted in the design and validation of security assessment for distributed edge analytics and a secure, distributed AI edge framework. As a decentralised intelligence framework, this will ultimately enable the optimal distribution of AI computing tasks and workloads across existing computing nodes, serving as a scalable edge computing software toolkit for IoT and edge applications.

Technology applied

MIRAI's technical innovations span four main pillars. Crucially, all partners have collaborated to implement a framework that distributes edge AI jobs and limits resources on the device; this enables AI algorithm distribution and execution on edge devices with limited communication and computational power. Secondly, algorithms have been optimised using adaptive approaches that improve bandwidth and energy through remote monitoring and control, thereby managing device energy usage during AI jobs. For secure data sharing between edge/end-nodes, lightweight approaches have been developed in Python to run AI at the edge with limited computing, memory and battery power. Finally, the consortium considered several standards and selected Node-RED as a workflow manager to coordinate existing application services. This open-source framework is well-known in the IoT sector and has been adapted to trigger AI pipelines.

The broad applicability of MIRAI's approach has been demonstrated in five use-cases. For energy management, edge AI was implemented in solar devices to optimise energy use and distribute edge AI algorithms, offering smart monitoring and management. In the textile domain, MIRAI targeted continuous auto-configuration of industrial controllers at the edge, enabling control of dyeing machine hardware (such as micro-controllers) to optimise chain performance. In traffic management, the focus was on pedestrian safety via next-generation cameras that integrate edge AI to predict dangerous situations, transmitting only processed results and not images with personal data. For secure internet, MIRAI implemented algorithms in routers to read network traffic at customer premises, detect abnormal traffic and take mitigation actions. Finally, water management created anomaly detection algorithms for leaks in buildings while extending battery life.

MIRAI facilitates edge computing approaches that scale vertically to the cloud and horizontally to other devices.

Making the difference

As one of the very first edge AI projects, MIRAI pioneered the concept of scalable, low-latency distributed ecosystems for AI-enabled computing. This will increase robustness by enabling new failover approaches and decreased criticality of network problems while increasing security and privacy by executing

computations near the data source. For secure internet, for example, the project targeted an attack detection speed of under five seconds and a false negative rate of under 5% but achieved an average of 600 milliseconds and ~0.04% respectively. In the textile use-case, network utilisation reached around ~85 Kbps versus a target of <100 Kbps – a better-than-expected result demonstrating the importance of a horizontal framework to distribute tasks in edge AI.

These technical achievements will translate into benefits for end-users. For instance, the water management use-case, currently at TRL 7, has proven that edge AI can optimise energy and consumption flows by increasing device lifetime to 120-125% of its starting point. As for energy management, MIRAI's Python compression code has made data flows 288 times smaller, thereby increasing speed and lowering infrastructure needs. With this foundation, the consortium can push forward products and services in the emerging market of edge AI software, expected to be worth at least USD 3.8 billion by 2028 at a CAGR of 27.8%. With business cases centred around lower operational costs, improved security analytics, device optimisation and greater customisation, they can stake out strong shares in a rapidly-evolving field.

The market has also changed substantially during the project's course and has aligned well with its societal objectives. The European Green Deal has highlighted the need to limit the resource impact of AI and MIRAI has demonstrated how this can be achieved with its energy optimisation. The European Chips Act also plans to spend EUR 11 billion on ECS and will open up previously unforeseen business models for MIRAI, such as AI on chips. Finally, MIRAI is dedicated to improving the future of this field and will publish a whitepaper concerning the best practices and lessons learned on AI at the edge. Through this, they hope to have an outsized impact on the ITEA Community and beyond for years to come.

Major project outcomes

Dissemination

- More than 10 publications and 2 scientific workshops (e.g. DARE and DE-AI)
- Presence in several fairs (e.g. EFECS 2022, ITMA exhibition, EDIH Network Summit)

Exploitation (so far)

New services:

- Starter Kits on data compression and predictive control (Sirris): illustrate how AI and ML methods could be used / combined to tackle a wide variety of industrial problems.
- Security Assessment Model (Sirris): supports evaluation of current / design of new security and privacy architectures for end/edge nodes supporting distributed AI.
- Smart Model Development (NOS): cloud-based architecture to train models from third-parties without sharing datasets, respecting intellectual property and privacy.

New libraries:

- Node-RED running embedded on the QCAM camera (Macq).
- Event-to-action framework (Macq): a MQTT interface to python scripts that allows custom code in the camera.
- Adaptive PID parameter (Eliar): tunes PID parameters to adaptatively change process dynamics, improving the process control quality and decreasing excess consumption.
- Central Monitoring Application and Controller Integration (Eliar): for distributing centrally calculated data among the textile dyeing machines in real-time.

New product:

- Container Based Distributed Simulation leveraging Docker containers (Enforma): accelerates control algorithm development, enabling simultaneous operation, interaction, & seamless communication among multiple machines.

Patents

- Cloud-based data processing system based on a serverless execution environment - EP 119023 (NOS)

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MIRAI

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Partners

Belgium

- 3E
- Macq
- Shayp
- SIRRIS

Portugal

- Instituto Superior de Engenharia do Porto (ISEP)
- NOS Inovação
- University of Porto

Sweden

- Blekinge Institute of Technology

Türkiye

- Eliar
- Enforma

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Project end

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Project leader

Joana Sousa, NOS Inovação

Project email

joana.sousa@nos.pt

Project website

https://project-mirai.eu/

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