ITEA 4

Project Results

FAMILIAR

Privacy-preserving solutions for federated machine learning

To increase the uptake of federated machine learning (FedML) in industry, the ITEA project FAMILAR (Holistic Federated AI Development for Mixed-Reality Applications in Europe) developed an application-agnostic system and various extended reality (XR) applications that utilise head-mounted displays (HMDs).

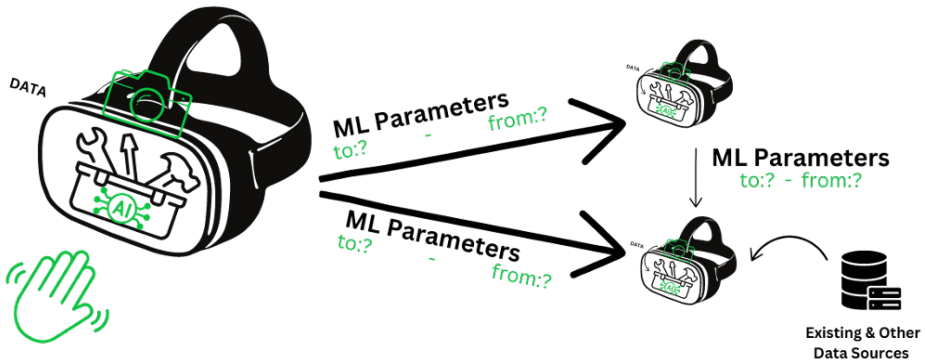
FedML trains algorithms across multiple decentralised edge devices or servers, allowing companies to benefit from collective intelligence while retaining control over proprietary datasets. However, this demands a high level of trust; individual corporations are unwilling to share critical, sensitive or secret data with their competitors. FedML is therefore rarely seen in industry due to a shortage of the relevant, high-quality data needed to train valuable machine learning (ML) models, as well as the difficulty in labelling the data that is acquired.

In 2021/2022, when the ideas behind FAMILIAR were formed, the state of the art showed that ML and XR were becoming increasingly relevant to industrial applications, yet rarely integrated – and not in a federated learning architecture, which itself remained dependant on a central coordinator. The project therefore sought to address this by creating privacy-preserving FedML solutions using HMDs. In doing so, FAMILIAR aimed to improve accessibility to FedML and XR while offering both economic and sustainability benefits, such as increased productivity in simulation set-ups and lower carbon footprints due to a reduced number of physical prototypes. Crucial gaps that hinder industrialisation were also identified as a springboard to further research.

Technology applied

Alongside the XR itself, FedML-based XR applications require ML algorithms that can be trained within a federated architecture. FAMILIAR developed three main solutions to achieve this. Firstly, an application-agnostic XR environment creation pipeline was created, including HMD-agnostic input handling, a shared setting framework, localisation, and a communication layer with additional back-ends. Secondly, an application-agnostic model creation pipeline was developed that involves the integration and combination of sensor data with simulated and physical datasets to automate parameter estimation, thereby enabling a closed feedback loop where simulation-informed, AI-optimised outputs directly adjust production settings. Finally, a novel gossip-based federated learning approach facilitates peer-to-peer communications and maintains privacy without central dependencies.

While the integration of those innovations allows for application-agnostic federated learning for XR applications, industrial applications also require subject-specific knowledge and potentially additional sensor systems. The consortium therefore aimed to develop this application-agnostic system on highly exploitable industrial applications, demonstrating it across four diverse use cases: (1) automatic interior window masking for XR driving simulation, (2) set-up assistance for 3D printing industrial robots, (3) extended failure prediction in parts production and refinement, and |(4) increasing traffic safety by leveraging vehicle-to-everything (V2X).



Holistic federated AI development for mixed-reality applications in Europe

Making the difference

The benefits of these use cases range from efficiency to sustainability to human safety, with major successes already demonstrated. In UC1, FAMILIAR's ML model and corresponding dataset reduced development times for the masking process from days or even weeks to just minutes. Another aspect of efficiency is the capacity for untrained personnel to use machinery effectively, which the project enabled in UC2 via a clamp position proposal XR application and ML model, data stream and sensor-based visual and acoustic data collection

system. For sustainability, meanwhile, UC3 resulted in a spray paint XR application, defect detection ML model, data stream and digital twin framework for composite material parts, through which the current scrap rate in parts production was reduced by 10%. As for safety, UC4 developed an XR application, data stream and sensor-based V2X communication and visual data collection system to visualise occluded vulnerable road users, thereby increasing the visibility of vulnerable road users by approximately four times the average reaction time.

Exploitation, too, has begun strongly, with commercialisation already underway. NXRT, for instance, used the project's ML-driven masking and scalable XR integration to rapidly prototype an improved product for mixed reality vehicle visualisation. This has so far attracted 114 customers with 160 systems deployed, resulting in a revenue of around a million euros for NXRT. On the academic side, FAMILIAR led to one PhD and four master's theses and identified domain-relevant research gaps, such as the difficulty of harmonising ML model complexity with XR compute capabilities. In turn, this will lead to opportunities for the consortium: Fraunhofer IAPT has already exploited FAMILIAR's scientific results to acquire two industry projects worth around 60,000 and 70,000 euros respectively.

Future outlook

The figures are only the start. For just the automotive partners, for example, the total serviceable obtainable market is roughly EUR 450 million, mainly in the virtual testing and production process optimisation of bus and truck components. However, expansion in such markets is not just about the consortium; FAMILIAR anticipates major benefits for wider society. In combination, full uptake of UC1-3 is expected to result in annual savings of 5,000 tonnes of CO_2 thanks to fewer physical prototypes and out-of-quality parts produced, while UC4 would improve collision risk inception for vulnerable road users in specific traffic scenarios by 75%. These ambitions are part of a future in which all production sites feature numerous processes run with HMDs and where ML algorithms are trained together in networks to make process production processes more efficient – a future that FAMILIAR hopes to enable.

Major project outcomes

Dissemination

- 4 scientific artefacts (1 publication)
- 5 presentations at conferences/fairs

Exploitation (so far)

New products:

- **HeroShow: virtual showroom for car dealerships, events & customer visits, augmenting cars for virtual showcasing of products that aren't physically present**
- **Visualizer: traffic infrastructure integrated XR-application for de-occlusion of vulnerable road-users.**

New systems:

xFPSS.1 - ML-model for extended failure prediction in FEM simulation software in bumper part production plastics extrusion process

- xFPSS.2 - XR-application for extended failure prediction in bumper part production spray paint process
- SA3D - Digital clamp positioning assistance system – XR-application for Setup assistance for 3D printing industrial robots
- application-agnostic XR-environment creation pipeline
- application-agnostic ML-model creation pipeline
- application- and model-agnostic FedML-library for novel network learning approach

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FAMILIAR

AI2021-112

Partners

Austria

- Nekonata XR Technologies GmbH

Germany

- consider it GmbH
- Fraunhofer IAPT
- Pumacy Technologies AG

Türkiye

- Mercedes-Benz Türk A.Ş
- PLASKAR PLASTİK ENJ. OTO. YED. PARÇA TİC. VE SAN. A.Ş.
- Vimansys Arge Teknolojileri LTD.ŞTİ

Project start - end

January 2022 - September 2025

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