TRAIL Summer Workshop' 25
Project Proposal (25/08 - 05/09)

Full Name of Team Leader	Xavier Lessage, Ir, PhD
Project Title	Multimodal Federated Learning for BioMed: From Cloud to Embedded Inference.
Profile of the Team Leader(s)	Xavier is an expert research engineer in CETIC's Data Science department. His work focuses mainly on artificial intelligence, cloud computing and distributed data processing. He is particularly interested in the synergies between AI and cybersecurity, notably through advanced approaches such as federated learning and homomorphic encryption. He actively collaborates with several universities and research centers, contributing to both academic research and applied innovation in distributed and secure AI systems. Several publications about the Federated learning are available in collaboration with universities and researchers. Xavier has shown his ability to supervise projects in the 4 past TRAIL Summer Workshops. Xavier federated a very efficient approach to foster the teams of researchers involved in publishing scientific publications and technical reports as well as producing results release in the TRAIL Factory. Furthermore, results from these past workshops raised the interest of Walloon businesses and various industry-driven use cases in Health and Industry domains are explored in on-going collaborative projects (eg. dAIEdge – a Horizon Europe project, and Flaracc – a Mecatech collaborative project).
Abstract	This project aims to develop a federated, multimodal AI model for real-time anomaly detection in healthcare. During the London workshop, teams will build and integrate unimodal models trained on clinical text, medical images, and physiological signals. The final multimodal model will be trained via federated learning and optimized for deployment on embedded devices such as Raspberry Pi and other microcontroller technologies. Using public datasets like MIMIC and CheXpert, the project emphasizes privacy-preserving, edge-ready medical AI. A specific focus will be given to Personalized Federated Learning (PFL), allowing each local model to be fine-tuned based on its data modality and distribution. This will improve model generalization and adaptation across heterogeneous clients. Post-workshop efforts will focus on further optimization and remote validation.
Project Objectives	During the summer workshop, we will be implementing a federated learning (FL) pipeline on a server infrastructure, aimed at training models for the detection and prediction of anomalies in healthcare. The ultimate goal is to transition these models to real-time execution on embedded devices such as Raspberry Pi or other microcontroller technologies. Current status: We currently do not have a multimodal model in place. Our focus will be on constructing this multimodal model during the workshop in London, which will integrate various types of healthcare data. Once developed, we will federate this model for distributed training across multiple devices. Personalized Federated Learning

	strategies such as local fine-tuning and meta-learning will also be explored to ensure better adaptation to the local distribution of each participating node. Expected outcomes by the end of the workshop: • Construction of a multimodal model for the detection and prediction of health anomalies using several models already trained on a single modality. • Optimization of model architectures suitable for deployment on embedded devices. • Implementation of a Federated Learning framework to train the model across distributed nodes. • Evaluation of Personalized Federated Learning (PFL) strategies to improve performance on non-IID medical data. • Extension of existing TRAIL factory automation tools to support continuous training / testing / deployment pipeline in a federated setting on edge devices. • Demonstration of the full pipeline, from constructing the multimodal model to federating it for training and real-time execution at the edge. Beyond the workshop: The challenge will continue remotely after London, with ongoing efforts to optimize the federated learning framework and improve real-time deployment on embedded devices. Researchers: • Sarah Pinon (UNAMUR), Giuseppe Patarino (ULB), Lise Pirenne (ULIEGE), Mathis Delehouzee (UMONS), Pauline Delmotte (UMONS), Maxime GLOESENER (UMONS), Rahi (UMONS) • CETIC : Raphaël Michel, Gérard Florence, Arnaud Palgen, Pierre De Handschutter, Xavier Lessage
Project Dataset	We plan to use several publicly available multimodal healthcare datasets to develop and train our models for anomaly detection and prediction. These datasets include structured clinical data, medical images, physiological signals, and free-text reports : • Adni-data (Alzheimer) : https://adni.loni.usc.edu/data-samples/adni-data/ • BiDAlab/mEBAL : https://github.com/BiDAlab/mEBAL • MIMIC-CXR / MIMIC-IV : https://physionet.org • CheXpert : https://stanfordmlgroup.github.io/competitions/chexpert/ • EchoNet-Dynamic : https://echonet.github.io/dynamic/ • BioVid Heat Pain Database : https://www.biosignalsplux.com/research-database/biovid-heat-pain-database/ • RadGraph + MIMIC-CXR-JPG : https://physionet.org/content/radgraph/1.0.0/ • OpenNeuro : https://openneuro.org/ • EyePACS : https://www.kaggle.com/c/diabetic-retinopathy-detection

	• Messidor : http://www.adcis.net/en/third-party/messidor/ • BCI-IV : https://www.bbci.de/competition/iv/ • MoVi Dataset : https://movi.cs.toronto.edu/ • PhysioNet Databases (général) : https://physionet.org/about/database/
Background Information	This project aims to develop federated, multimodal artificial intelligence models for real-time anomaly detection in healthcare. By enabling decentralized learning across institutions without the exchange of raw data, it promotes a privacy-preserving approach to medical AI. The models will be designed for deployment on edge devices such as Raspberry Pi and other microcontroller technologies, building on prior advancements in federated learning and embedded systems. Leveraging publicly available clinical datasets, including MIMIC, CheXpert, and BioVid, this work contributes to the development of ethical and secure AI solutions tailored to clinical environments. Personalized Federated Learning (PFL) will allow each site to adapt the global model to its own local context, ensuring both performance and fairness across heterogeneous healthcare data distributions.
Bibliographic References	
Detailed Work Plan	As Xavier applied in the 4 previous ARIAC Summer Workshops, this year's project will be organized into structured phases, with responsibilities distributed across team members working in dedicated pairs of researchers, to ensure focus and efficient collaboration. Preparatory phases, including dataset acquisition, cleaning, and standardization, will be completed prior to departure for London. This ensures that all teams begin model development with well-prepared data and clearly defined objectives. Each pair will be responsible for one specific modality—such as medical imaging, physiological signals, or clinical text—and will develop dedicated AI models accordingly. Once unimodal models are trained and validated, the teams will collaboratively integrate them into a federated, multimodal architecture designed for real-time anomaly detection in clinical scenarios. The personalized aspect of the federated learning process will be implemented at this stage through local adaptation and performance optimization methods tailored to each modality and client profile. AI implementation on embedded platforms makes more sense in an IoT context. With this in mind, Gérard and Arnaud will work on integrating AI models into DMWay, the data flow management middleware for IoT architectures developed at CETIC. This work will lead to implementation on one or more edge microcontroller platforms, as well as automated model deployment, and will also incorporate aspects of federated learning. Prior to London, the project setup will also verify that remote access to the embedded platforms considered will be available. In this way, deployment of AI models on remote devices as targeted in real life application will also be tested.
Other Remarks	

Optional: Add any relevant figure for the project