SURV-AI-LLANCE

Surv-AI-llanc: personal safety in smart cities through advanced algorithms for human behavior recognition.

The imec.icon Surv-AI-llance project is our answer to a significant challenge: the overwhelming volume of video data produced by urban surveillance systems. Human monitoring can no longer cope with these extensive data streams, resulting in delayed incident detection and response.

The Surv-AI-llance project addresses this challenge by developing an advanced machine-learning approach that analyzes both camera and radar data to enable a swift detection and interpretation of incidents. This multimodal computer vision solution includes a skeleton-based anomaly detection algorithm and the use of Doppler radar-based observation to realize an accurate interpretation of human actions. Furthermore, the project introduces edge intelligence to process and analyze data locally, a crucial step in safeguarding individual privacy in public spaces.

The imec.icon Surv-AI-llance project is a valuable contribution to the smart cities initiative, improving safety monitoring and facilitating quicker responses to incidents.

FRAMING THE RESEARCH OBJECTIVE

The goal of the project was to create an accurate algorithm for anomaly detection based on human skeleton data, i.e. data about the position, orientation, velocity... of human joints detected in an image. That algorithm should be efficient enough to be able to run on edge devices. A second goal was to implement a Doppler radar solution to detect human skeletons under a variety of challenging environmental conditions, e.g., in dark, rainy, or foggy places. Both the algorithms as well as the edge computing approach focus on safeguarding the privacy of the observed people. In addition, the project included research into making the AI in the project explainable. Last, we also worked on federated learning to enable the training of algorithms on datasets distributed across devices.

THREE MAIN OUTCOMES

Looking back on the Surv-AI-llance project, these have been the major accomplishments:

- **Doppler radar detection:** Vision-based detection may lose its usefulness under harsh weather and extreme light conditions. Therefore, we made use of Doppler radars combined with a dedicated algorithm and imaging pipeline to generate high-resolution images of pedestrian scenes. These form the input for an innovative deep-learning model that generates human poses.
- **Unsupervised anomaly detection on video:** We designed a lightweight transformer encoder architecture for skeleton-based video anomaly detection. It is trained in an unsupervised fashion using future prediction, requiring only non-anomalous video samples. Additionally, we designed a transformer encoder-decoder for multitask learning, allowing the extrapolation of past or future skeleton trajectory segments and the interpolation of in-between segments.
- **Explainability of the anomaly detection:** We developed a Shapley-based method for skeleton sequence attribution with respect to the reconstructed skeletons. That way, we

can pinpoint the contribution of each skeleton from the input sequence on the prediction outputs.

- **Federated learning:** To overcome the disadvantages of model training in terms of privacy preservation and bandwidth use, we developed an efficient decentralized training framework that achieves detection comparable to centralized training. Our framework executes training directly on edge nodes, with only minimal partial updates (0.1%) to the server. The latter ensures that private data remain local.

The Surv-AI-llance technology as we have implemented it, has a number of aspects that set it apart from potentially competing technology:

- **Privacy awareness** was a key aspect of our approach and was built in by design. The project's main choice of using a skeleton representation as input for the anomaly detection is just one of these privacy-protective design choices we made.
- We incorporated **edge processing** as a default architectural approach. This ensures that local data are only used locally, another privacy preservation measure.
- **Federated learning** enables us to train the algorithms even when the datasets are distributed across independent systems. This way, data can be stored locally at the data owners' discretion.
- On top of this, we added a layer of **explainability** in terms of the relationship between the input, the derived skeletons and the algorithm output.
- The methods developed for anomaly detection achieve state-of-the-art results in **skeleton-based video anomaly detection**, the results of which have been quantified in several publications.

NEXT STEPS

The lessons learned on edge processing and the potential to optimize algorithms for edge computing are extremely valuable for products such as CityScenes or AICatcher (Atomic BITS and The Safe Group respectively). Also, the insights from the explainability tools are going to be essential for future production-ready algorithms. The European Data Act is expected to require such tools for verification before algorithms will be allowed on production systems. Further, the new algorithms and methods developed within this project are adding know-how and algorithmic substance to the tools that will be further exploited in our R&D. We count on valorizing the project's developments in other domains as well.

Commercial project partners:

Research partners:

Project funding:

The Surv-AI-llance project was co-funded by imec, with project support from Agentschap Innoveren & Ondernemen

FACTS

NAME	**SURV-AI-LLANCE**
OBJECTIVE	Privacy-aware anomaly detection on urban surveillance systems
TECHNOLOGIES USED	deep learning, vision transformers, Doppler radar, federated learning, TensorRT, CVAT framework for data annotation
TYPE	imec.icon project
DURATION	01/07/20201 – 31/12/2023
PROJECT LEAD	Peter Rigole, Atomic BITS
RESEARCH LEAD	Hichem Sahli, imec – ARF
BUDGET	1,159,206.67 euro
PROJECT PARTNERS	Atomic BITS, Autimatic, The Safe Group, Politiezone Eeklo – Kaprijke – Sint-Laureins, Stad Geel, Politiezone Geel – Laakdal – Meerhout
RESEARCH GROUPS	imec – ETRO – VUB, imec – ARF

WHAT IS AN

IMEC.ICON PROJECT?

The imec.icon research program equals demand-driven, cooperative research. The driving force behind imec.icon projects are multidisciplinary teams of imec researchers, industry partners and/or social-profit organizations. Together, they lay the foundation of digital solutions which find their way into the product portfolios of the participating partners.