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Overview: Multimodal Smart Sensor Networks for Plant Monitoring and Improved Energy Efficiency

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Summary:
The project MIMOSE-A is a combined work of industry and academia to improve the monitoring of chemical industry parks. The monitoring should detect and locate leakages, especially of energy sources incl. hydrogen, and anomalies (e.g. fire) to save energy and therefore money for the operator of the industry park. Mimose-A tries to realise this surveillance with small sensor nodes, equipped with a variety of sensors like microphones and metal oxide gas sensors. Together with advanced data evaluation and machine learning algorithms the sensor system is tested to detect anomalies.

Keywords: Multimodal IoT Sensors, Industrial Facility Monitoring, Leakage Detection, MOS Gas Sensors, Machine Learning

Motivation

Humans are able to recognize the state of their environment very quickly by taking in information via various sensory channels and processing it with each other [1]. Today, a large number of inexpensive sensors are available for technical systems, some of which are far more powerful than the human sensory [2]. Nevertheless, a similarly comprehensive assessment of the environment is not yet possible because the individual sensor data is not sufficiently fused and interpreted [3].

In plant monitoring, not only in the chemical industry, dedicated sensor systems, i.e. systems designed for precisely one specific application, are common today, usually associated with high costs, partly due to the low quantities, which do not allow an economy of scale. These limited technical systems are supplemented by humans, who can only selectively detect unusual conditions and potentially hazardous situations with their ‘sensors’.

The availability of sufficient computing power to interpret the resulting flood of data enables a paradigm shift in the sensory monitoring of systems, which is to be addressed for the first time in this project. The aim is to record multimodal plant data over a large area and thus significantly improve the assessment options, e.g. for the early detection of leaks in energy sources (compressed air, water vapour, gas and, increasingly in future, hydrogen). Suitable visualisation of spatially and temporally high-resolution measurement data allows the current situation to be recorded quickly and accurately, even if the data quality of individual measurement points is poor. The stationary sensor nodes are supplemented by mobile, autonomous sensor systems that can react to unknown situations in particular in order to offer significant added value with a lower use of resources. Wireless networking of the nodes and higher-level evaluation based on extracted features using distributed AI methods in the sense of edge or fog computing can further increase the sensitivity, selectivity and robustness of system monitoring thanks to the redundancy this provides.

Approach

The sensor nodes are designed and integrated by the two project partners GTE Industrieelektronik, Viersen, and 3S Technologies, Saarbrücken. They combine metal oxide semiconductor (MOS) gas sensors, operated in temperature cycled operation (TCO) with microphones and other miniaturized sensors in order to have transducers for all kind of possible signals. As MOS sensor the ENS170 sensor (ScioSense Germany GmbH, Germany) is used. The ENS170 is a multipixel sensor, using different sensitive materials in four layers in

order to boost the sensitivity and selectivity. One possible sensor node is depicted in Fig. 1. Communication between all sensor nodes is a challenge, which can be addressed by low-power communication protocols like LPWAN and is part of one work package.

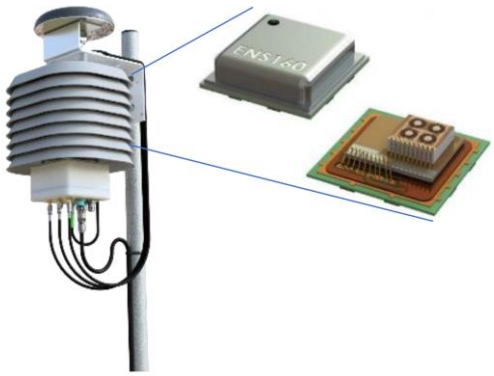

Fig. 1 Multimodal sensor node (3S GmbH, Germany) with the digital MOS-multisensor ENS160 (Sciosense Germany GmbH).

Evaluation is done by multiple project partners, which try to use a various amount of Machine Learning Algorithms in order to detect the previously described anomalies. Especially Transfer Learning can be useful in order to solve inherent problems like sensor drift or domain shifts. The complete timeline of the project, structured in the designated work-packages, is displayed in Fig. 2.

Supplementary to the sensor nodes, mobile drones are deployed in case an anomaly is detected by the stationary nodes. These drones try to verify or falsify anomalies to allow for human actions only in real alarm cases. Otherwise, people's alarm tolerance is reduced.

Summary

Mimose-A is a project aiming to detect energy source leakages with a fine-meshed grid of sensor nodes in order to increase energy efficiency while also monitoring other anomalies. The overall goal is to save energy and thus money.

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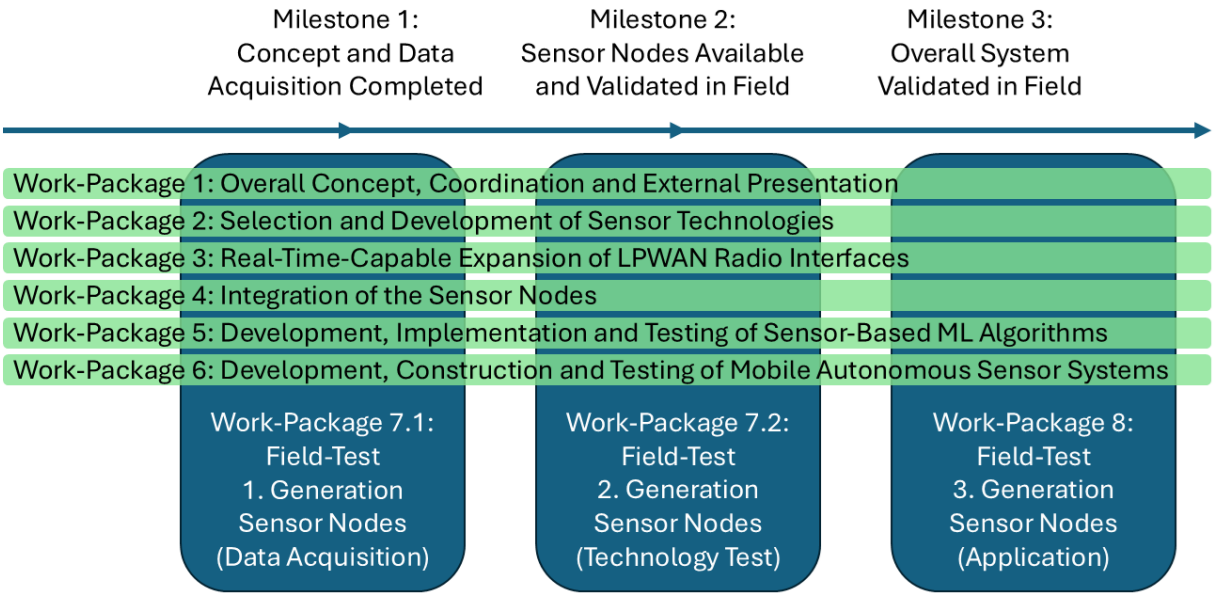

Fig. 2 Suggested solution with all scheduled work packages in the MIMOSE-A project.