HUBCAP
Digital Innovation HUBs and Collaborative Platform for Cyber-Physical Systems

Newsletter 8 November 2022

More SME Success Stories

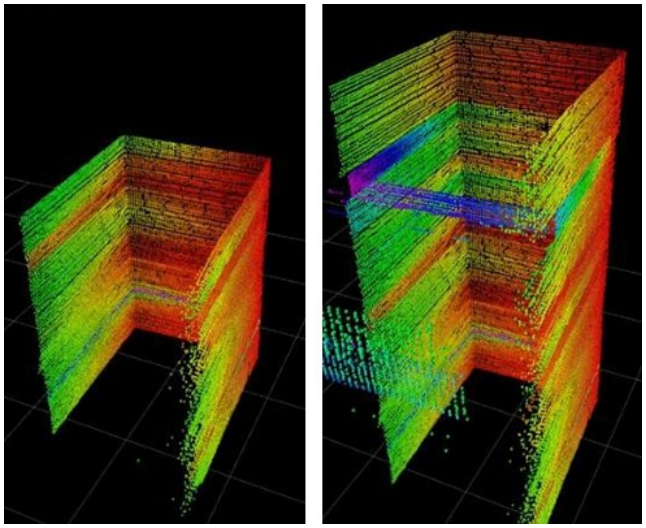
HUBCAP brings together Digital Innovation Hubs to support SMEs embracing digital innovation. Our focus is on **model-based** technologies and solutions to develop **cyber-physical systems** (CPSs), for which HUBCAP has developed an open, cloud-based **collaboration platform**. This innovation portal enables businesses to contribute and access digital assets needed to undertake **model-based design** (MBD) for building cyber-physical system solutions on the scale required for SMEs. Assets include both models and services, and they are made available to allow businesses to manage their investment in MBD technology and to promote experimentation.

HUBCAP has funded three calls: the first attracted and engaged with individual SMEs to join and to integrate existing CPS and MBD tools in the HUBCAP platform to enlarge the HUBCAP ecosystem. The second encouraged SMEs to adopt or improve CPS products and services by applying assets from the HUBCAP platform in a two-SME consortium. The final call funded the deployment of new products and demonstrations of highly innovative collaborations using the HUBCAP platform. In this newsletter, we summarise the achievements of six more SME projects.

Autonomous Robotic UAV platform for the 'as-built' modeling of building assets (CPS4asBuild)

Unmanned aerial vehicles (UAVs) are widely used and their application domains are diverse. This motivates a systematic approach for engineering UAVs. However, existing development processes and tools are inherited from the aerospace industry and typically produce inefficient solutions.

The aim of this project was to develop an MBD method for engineering a UAV that is tailored to meet specific requirements and is optimal in design. Specifically, a UAV for making precise measurements of lift shafts in high-rise buildings whilst navigating through tightly confined spaces.



The key components of a UAV: propellers, motors, battery systems, sensors, actuators, and controller boards were modelled mathematically, as well as the body dynamics of the UAV. A Component Placement Algorithm was developed that used these models to design the configuration of the UAV, either automatically or by assisting the designer, to meet requirements on the overall mass, maximum thrust, flight time, and cost targets. The models were integrated to create a digital twin that was used to simulate inspection missions and to predict (using machine learning) the expected failure of components for timely maintenance. A test bed was built to validate the model of the motor/propeller combination, which showed <5% error. Other test beds are being built to validate models involving the batteries and the body dynamics of the UAV.

A web-based UAV design tool has been produced. Also, a prototype UAV with tilted rotor mechanism, using the Pixracer Pro board running ArduPilot and the Robot Operating System. The UAV has 2D Lidar, 3D Lidar Up & Down, and a stereo camera.

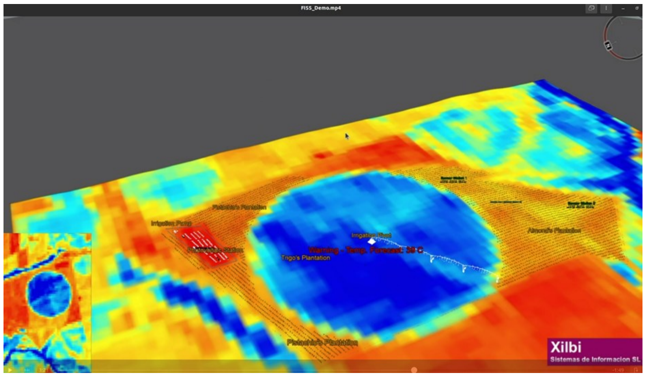
Contact
Prof. Peter Gorm Larsen
Aarhus University
pgl@eng.au.dk

"The use of Model-Based Design techniques promoted by HUBCAP assisted VERTLINER in the evaluation of the current UAV performance in the given conditions, helped us to understand the critical parameters that affect the system within its environment and mission profiles, and enabled us to design a dedicated UAV optimized for specific tasks, prior to committing to a next generation physical prototype. GIVE as a provider will be able to offer their customers a holistic solution when it comes to engineering and operating UAVs, leading to a mutually beneficial collaboration."
- Michael Striligkas, CEO VERTLINER

Farming Intelligence System of Systems (FISS)

This project aimed to help medium-/large-scale farmers in southern Europe (in particular almond and pistachio producers) to optimize their irrigation procedures, fertilizer and pesticide application, and photovoltaic electricity generation, by using their resources (water, fertilizer, and energy) more efficiently, and consequently reduce their costs and environmental impact.

A simulation environment was developed on the HUBCAP platform, based on a digital twin of almond plantation fields. Input data from IoT sensors (measuring, for example, temperature and humidity), from satellite (Copernicus, providing atmospheric data), meteorological data, and data from drones, robotic and non-robotic field machinery was integrated in the digital twin. The data was analysed



using an AI algorithm (a combination of supervised machine learning and deep learning techniques) in order to run simulations, which were used to make recommendations on irrigation planning and forecast weather and photovoltaic generation of electricity. The output was displayed on desktops, smartphones, and augmented reality glasses. Thus, FISS provides an AI-based decision support system for farmers. The system was validated using the irrigation recommendation and weather forecast models.

The project progressed the FISS prototype from TRL5 to TRL7 (system prototype demonstration in operational environment).

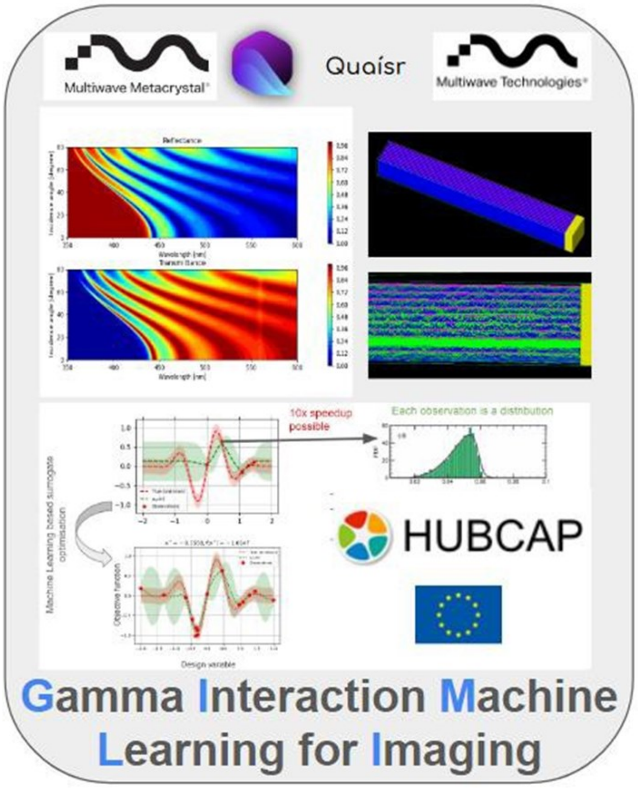
"The HUBCAP funding allowed our team to further develop the FISS prototype and to successfully demonstrate it within an operational environment, to promote to product towards relevant potential clients and to enable the future commercialisation of the FISS line of products and services." - The FISS Team

Gamma Interaction Machine Learning for Imaging (GIMLI)

Positron emission tomography (PET) is a technique widely used in the diagnosis of cancer and evaluation of its treatment. A PET scanner contains scintillating crystals used to detect gamma rays emitted by cells (that contain radionuclides) during their metabolism, and cancer cells emit more gamma rays than normal cells due to their higher metabolism. PET detectors are typically designed using Monte Carlo (MC)-based simulations. However, these simulations can require considerable processing power and memory, and they do not adequately capture the physics involved.

GIMLI aimed to use machine learning to reduce the resource requirements of MC-based simulations and to improve the quality of their output.

A synthetic data generator was developed, containing a GEANT4-based GATE MC simulator with a Python



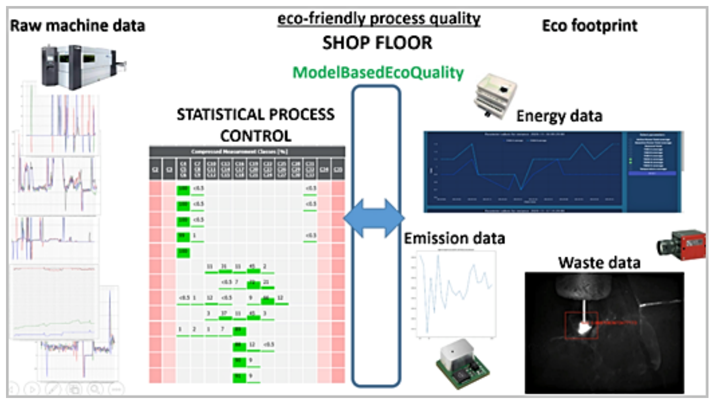
wrapper to facilitate control of inputs and outputs. The simulator is easily configured to test a detector design using different dimensions, materials, gamma efficiencies, gamma ray energy, and photon detection efficiency. Simulations were performed using supervised machine learning and uncertainty quantification algorithms to explore the trade-off between computation time and accuracy.

GIMLI produced software that reduces PET detector design time by 90%, a web front-end hosted on the HUBCAP platform, and designed a cheaper, high quality, new material combination for a detector.

> *"With this project we break through the most difficult aspect of time-optimized radiation detector design, simulating particle tracks and detector dimensions till we find an optimized solution, reducing the cost of new detector development 10-fold timewise."*
> *- The GIMLI Team*

CPS-based and data-driven modeling, monitoring and improvement of the eco-friendly quality (ModelBasedEcoQuality)

The purpose of the project was to provide a CPS-based infrastructure that enables comprehensive monitoring, analysis, and improvement of both the product quality and the environmental aspects of a manufacturing process.

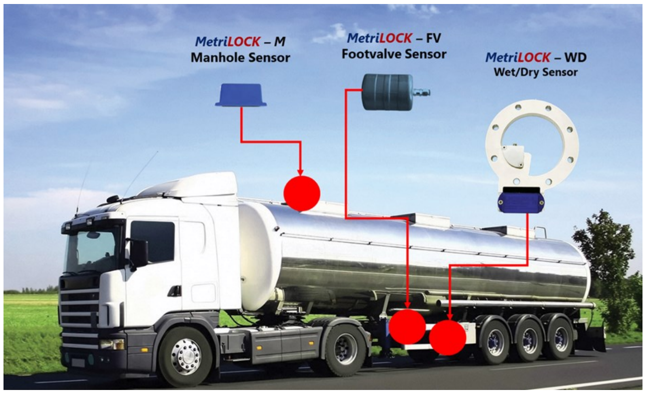


The project developed a data-driven digital twin of the manufacturing process, as the process was too complex for an analytical model, and focused on energy consumption, emission (air quality), and waste (anomalies) as key factors that have an environmental impact. These factors were measured using non-invasive sensors and cameras attached to machines; this approach can also be used with older manufacturing systems. Analysis of the correlations between working modes and the environmental factors was performed using the HUBCAP asset D3Scan (Deep Data Diagnostics through Cognitive Scanning). The analysis results in combination with monitoring were used to detect anomalies in the manufacturing process in real-time. This was tested in the manufacturing facility of **EMDIP** (one of the SMEs).

> *"Easy to deploy and affordable (software-hardware) solution for understanding the factors which impact the waste (energy, emission) based on a novel, AI-based analysis of past data." - Nenad Stojanovic, Nissatech*

Optimised Management of Fuel Tank Trucks (SimTank)

Up to 90% of fuel management in tank trucks in the oil industry is sub-optimal, and optimized management can increase the operational time of these trucks by up to 45%, which provides the motivation for this project.

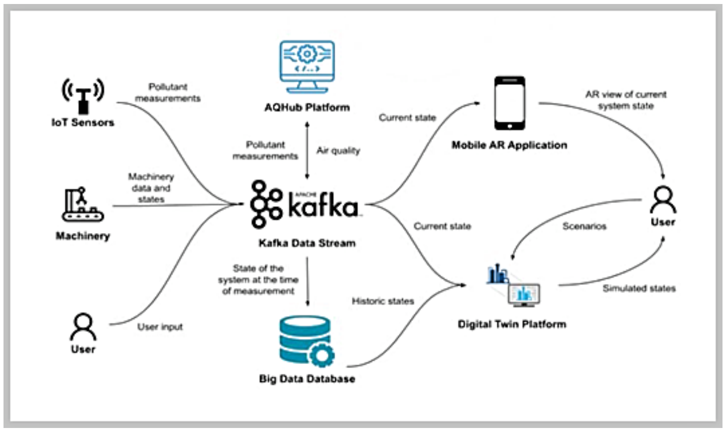


The project built energy models for complex tank truck sensors of different types (for placement on the manhole covers, on the air tube controlling the foot valve, and on the fuel discharge pipe) and their combinations. The models were used to develop a simulator to calculate the energy consumed by different configurations of the sensors and by the overall system. Also, optimization services to configure tasks monitoring the sensors and to determine their order of execution. Specifically, a greedy algorithm was developed to produce near-optimal solutions in polynomial time, and a linear programming algorithm was used to recommend exact configurations in exponential time. Model validation with user-supplied data showed <5% error in the energy model. The simulator and models are assets on the HUBCAP platform.

> *"Thanks to the HUBCAP INNOVATE funding tool, our company was able to build novel energy models for commercial hardware used by the oil industries and validate a set of optimisation services that can further be exploited commercially as a product."*
> *- Vassilis Papataxiarhis,*
> *Coordinator of the SimTank project*

Monitoring Environmental Conditions in Industrial Operations with IoT, Digital Twin and Augmented Reality Techniques (MENIoR)

The purpose of this project was to enable industrial operators to understand and improve the environmental conditions inside their factories, and also to raise the awareness of the factory workers of these conditions that impact on their health and well-being.



The project developed a low-cost environmental monitoring network that was installed in two factories in Spain. The network collected air quality measurements in real-time, as well as data on other environmental parameters (e.g. temperature, humidity, and concentrations of CO_2). The data was analyzed on the cloud and visualized on a web-based digital twin platform that was provided to the factory administrators to assess scenarios for environmental improvement inside the factories. The factory workers were able to visualize the data using an app on their smartphones. Both user groups had the opportunity to test the system and provided useful feedback.

> *"HUBCAP gave the consortium companies the opportunity to combine their expertise in environmental intelligence, IoT sensing, and occupational health to develop a solution that raises the awareness of industrial employees about the impact of environmental conditions in their work environment and helps them protect their wellbeing." - The MENIoR Team*