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iMOCO4.E

KEY FACTS

Acronym: IMOCO4.E
Full name: Intelligent Motion Control under Industry4.E
Coordinating institution: Sioux Technologies B.V.
Project coordinator: Arend-Jan Beltman
GA No.: 101007311 - H2020-ECSEL-2020-2-RIA
Start date: 1st September 2021
Duration: 36 months
Consortium: 46 Partners from 13 countries

This issue provides a grasp of the main project developments.

IMOCO4.E BBs

With growing maturity and the economy of scale of the involved HW and SW, a trend has been initiated to connect more "information" to this infrastructure. The word "information" was chosen deliberately. Equipment can generate Gigabytes of data but can only 'interpret' a limited set in real-time. In I-MECH, we introduced a reference framework to deal with this challenge through a layered approach that we called "Master the behaviour of controlled interaction with physics". It helped to explain that tangible Building Blocks (BBs) often require 'components' at different layers. In IMOCO4.E 10 BBs has been identified and the current status of each of them presented below in details.

WHAT HAS BEEN DONE?

BB1

In BB1, IMOCO4.E partners have continued working during these months on the different platforms defined within the Building Block, achieving the technological developments of SoC and FPGA platforms for smart control and signal processing necessary for the project. In the middle of the year, BB1 delivered D3.4, where BB1 reported the status of all the platforms up to that moment. Most of them were in a high state of development, with the first tests and results being obtained and almost ready for integration with the rest of the project. In the following months, BB1 is focusing on finishing the HW platforms and we are starting with the integrations of the different Pilots/Use s/Demos for which they have been planned. In 2024, the partners expect to have all the platforms integrated, to finish the project with results and validations.

BB2

Regarding BB2 that is exploring high speed vision / visual serving, currently, Fraunhofer is having a problem with the ROS GEM model, which only provides pose data at a rate of 1 fps. EDI has improved the Sim2Real translation algorithm, developed

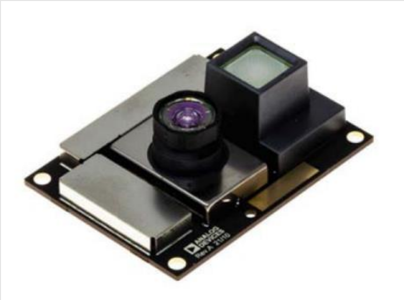
ToC

What has been done

pose estimation, and integrated Sim2Real with the object detector in order to pick and place bottles at least 10 minutes per minute. TNO is using a scalable architecture equipped with an optional GPU for massive acceleration of their 5KHz frame rate Vision-in-The-Loop system. Recently, TNO finalized their image acquisition and processing pipeline. The November meeting saw a convincing live demonstration of the closed loop motion control system. Ongoing improvements with tight integration of FPGAs are expected before the summer. TU/e is using a flexible DNN architecture to handle multi-size semiconductor dies and achieves an inference time of 11 ms while maintaining the required semiconductor packaging accuracy.

BB3

BB3 focuses on the development of novel low-power wireless sensors and is providing several hardware solutions, namely: a) vibration diagnostic sensor with energy optimization and long term operation; b) 9-DoF motion and vibration sensor with 3-axis linear acceleration, angular acceleration and magnetic field measurements up to 4.5kHz; c) overmoldable temperature and pressure sensing NFC tags with small form factor (6.2mm Ø × 1.5mm); d) low motion distortion 3D depth sensor with high accuracy and precision (+/-3mm with <15mm depth noise); e) radar sensor with 90° FoV, 3.75 cm distance resolution and 16° angular resolution; and f) dynamic vision sensor (DVS) with microsecond temporal resolution. These solutions are currently being deployed and validated in several IMOCO4.E use case and pilots.

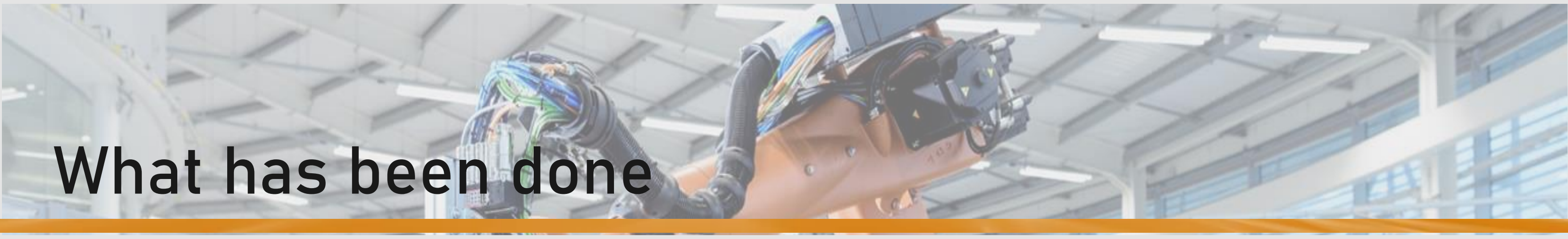


BB4

The BB4 partners have continued their efforts to develop their solutions regarding the Real-Time Smart-Control Platform, and in the middle of the year, released D4.6. TUE-EE has developed a framework for XIL testing, analysis and validation vision-in-the-loop systems targeting predictable and composable virtualized multi-core platform (i.e., CompSOC platform). Evidence has designed a Multi OS solution based on the Huawei's Atlas 500 Pro device. Unimore has proposed the virtual TSN (VTSN), which enables platforms with limited ethernet ports to have virtual machines (VMs) run by static hypervisors access the TSN. Sioux received the hardware board and has programmed the MCU with test software for the Demo on the 8th of November 2023. SoC-e is developing a modular platform with cutting-edge (real-time) communications and processing capabilities, with sensor acquisition capabilities as well, supporting highly customizable functionalities in all those aspects. These solutions are undergoing testing and integration into the various planned Pilots and Demos.

BB5

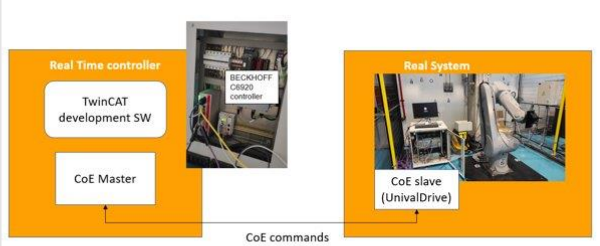
BB5 is about Smart Control Algorithms. Different control functionalities are available to improve mechatronic system performance, covering centralized and de-centralized, as well as model and data-based approaches. Repetitive Control using gaussian process for disturbance estimation, Offset-free model predictive Control, machine learning based feedforward for industrial robots, Iterative Learning Control (ILC) with Linear Position Varying functionalities, etc. are an example of the developed functionalities. At this stage, they are being successfully implemented and validated in several IMOCO4.E use case and pilots, improving their performance. Proof of the relevance of the proposed approaches is that several research works have been already published and more are to come.



What has been done

BB6

BB6 specializes in condition monitoring, self-commissioning, and predictive maintenance of motion control systems.The technologies find applications from high-speed elevators to CNC, robot control, and advanced and intuitive robot control and programming.The use of digital twins and hardware-in-the-loop is fundamental for the design phase, the training, and the deployment of the technologies. The designed technologies have been successfully implemented and validated in several IMOCO4.E use cases and pilots, improving their performance. Published Research works highlight the improvements with respect to the state-of-the-art.

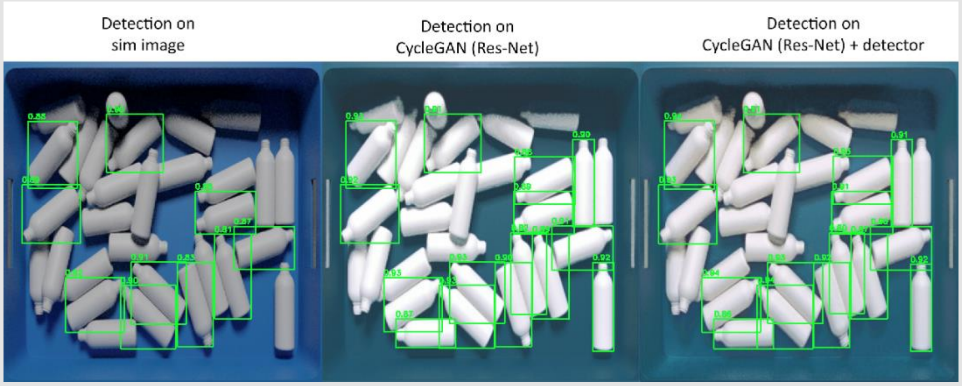


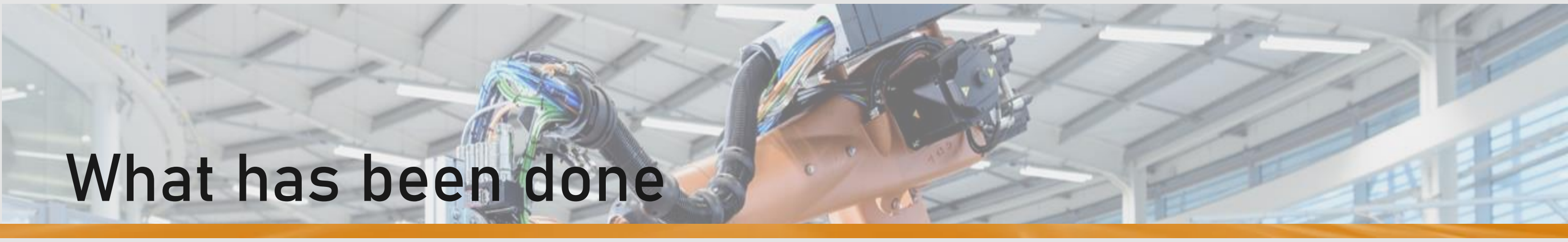
BB7

BB7 specializes in high-performance servo drives, engaging in tasks that span from researching optimal servo drives for high-throughput machines in semiconductor manufacturing to developing custom-built miniature servo drives capable of independently executing user-defined algorithms. Our meticulously designed servo drive is versatile, finding applications in robotics and beyond. It features compact dimensions, high-performance communication through the EtherCAT bus, a flexible set of I/O connectivity, and the implementation of smart control algorithms. These algorithms are fine-tuned for optimal actuator control, emphasizing vibration reduction and motion control optimization. Our servo drive has been utilized and validated in various IMOCO4.E use cases.

BB8

Partners are collaborating on various AI-based components under BB8, used in several pilots, use-cases, and demonstrations within the project. BB8 components can function independently, similar to other building blocks, but they can also integrated as sub-components within other building block components. Example BB8 AI developments include components for aligning wafer dies, image-based anomaly detection, and predictive maintenance in semiconductor manufacturing. Additionally, BB8 includes tools for predicting performance and detecting anomalies in high-speed packaging, streamlining the model development process in healthcare robotics, and generating synthetic data. For industrial drives in smart mechatronics, efforts focus on sensor prediction and anomaly detection. In tactile robot teleoperation, wrist tracking and object recognition are key areas. IMOCO4.E partners are also working on synthetic data generation, object detection, and pose estimation for automated intra-logic transportation, and leveraging reinforcement learning and synthetic data in vision-based pick-and-place robotics. Currently, while some components are under development, others are already being validated in their intended applications.





What has been done

BB9

In recent months, for BB9 that is focusing on cyber-security tools and trustworthy data management, the involved partners worked towards revising the BB9 internal architecture and specifications. This actions intended to address requirement adjustments that emerged from the development process of BB9 components and the application of BB9 in selected Pilots and Use Cases. These updates were documented in D5.3. In addition, a video and a poster were produced that aim at communicating the features, operation and added value of BB9 to a broad audience. More recently, BB9 participated in the Pilot 3 Integration Workshop in Modena, where it was integrated with other BBs and successfully tested. In addition, a first round of BB9 integration tests have been successfully carried out in Pilot 1. BB9 components were also further developed and integrated for the needs of Pilot 4 and Use Case 1. All recent BB9 test results have been reported in WP6 and WP7 deliverables.

BB10

After extensive preparatory work, the BB10 modules that are dealing with motion / path planning, collision avoidance and navigation algorithms, are now in the implementation phase. All partners involved have started to integrate the customised modules into their physical systems (use case, pilot or demonstrator). STILL has started the validation tests of the localisation and path planning modules on its own iGo neo platform. Visual servoing approaches based on powerful pose estimation are now being used, especially for the precise positioning to load carriers to pick them up. Together with partners, Philips Medical Systems is exploring the application of path planning with collision avoidance to its image guided therapy robot systems in a complex healthcare environment. Initial integration and testing of BB10 components such as sensors, novel mapping technologies and safe testing of new path planning algorithms in virtual reality are underway. VTT has continued the development and testing of collision-free path planning algorithms mainly in the HIL environment, but first tests with the real boom have also been successfully performed in VTT's laboratory. Fraunhofer IML has further developed and started to integrate the implementation of its fleet management system with the iGo Neo of Demonstrator 3. Based on the collaboration with Reden on Demonstrator 4, a Kalman filter application was developed by Siemens. This Kalman filter application estimates the position and velocity of the analysed system based on noisy position measurements received from a virtual sensor with time-varying noise characteristics. In close cooperation with Still and Philips Medical, IMST successfully applied its 77 GHz radar technology used for obstacle avoidance to Demo3 and Pilot4. Work on a sensor node for radar and camera is progressing well.

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