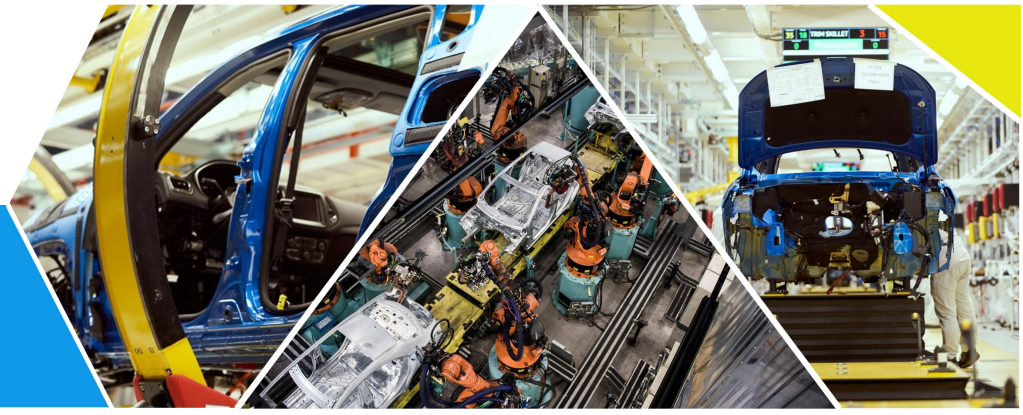
FELICE
NEWSLETTER Nb.6



Development updates | News | Publications & Press

Updates

Milestones

Implementation and demonstration of **Phase II prototypes** are progressing:

additional demonstrations and tests with the FELICE robot are underway in Melfi, Italy.

The FELICE team presented their progress on the Phase II technologies and demonstrations to the project's reviewers

Development updates

Assessing postures when using the FELICE Adaptive Workstation

The Institute of Ergonomics & Human Factors (IAD) at the Technical University Darmstadt is currently evaluating and further developing the adaptive workstation (AWS). The AWS is being evaluated with the Xsens Motion Capture system in order to assess and ultimately avoid harmful postures during the work process via the ergonomic positioning of large work objects. This motion capture system tracks body movements and generates a live avatar of the worker. Using 17 small sensors attached to the worker's body, Xsens captures movements and allows an analysis of the body angles during the assembly process. The analysis of shoulder flexion/extension is used to evaluate the potential improvement achieved by the height adjustment, while the wrist posture and the neck flexion/extension may be improved by the automatic inclination of the car door.

Fast Facts

- Using **motion catpture** to evalutate ergonomic postures during ssembly

Improvements in speech & gesture analysis

UNISA speech and gesture analysis is performed continuously on both the robot and adaptive workstation, but the two agents only respond to specific commands; in particular, the robot can receive both speech and gesture commands, while the adaptive workstation can only hear speech commands.

In the last months, the processing pipeline for speech recognition processing pipeline has been improved in two ways: 1) the neural network architecture for voice command recognition is no longer based on MatchBoxNet, but is now based on a newer Conformer; 2) the learning procedure is inspired to the Curriculum Learning (CL) paradigm, which allows to further improve the resilience of the approach to the noise due to the ego-motion of the robot and of the AWS and to the assembly line. The proposed solution has demonstrated its effectiveness, maintaining an accuracy of more than 90% (minimum limit imposed by KPI-O1-4) even in extremely noisy conditions, and a full achievement of TRL5 for both Italian and English speech command recognition. For gesture recognition, the solution implemented for Phase II, based on a single-stage neural network for hand detection and gesture recognition from RGB images, demonstrated an accuracy of over 90% on real data collected at a distance of less than 5m. TRL5 was achieved for this phase.

Fast Facts

- Continuous speech & gesture analysis on robot & AWS
- Phase II achieved accuracy above 90% on real data

Designing useable interfaces (IfADo)

If humans and robots are to work together, successful communication is an important factor. A key component of such communication is the design of user interfaces. As part of the FELICE project, researchers at IfADo are taking steps to design interfaces that are both highly usable and reliable. Designing comprehensible human-robot communication for human-robot collaboration requires a careful interface design. This process consists of several different steps, such as a thorough analysis of the task, in which scope the communication takes place, the creation of a conceptual interaction design, and the definition of task-relevant information. As part of the process, IfADo researchers conducted, task analyses, interviews and surveys on the concerns of workers when collaborating with a robot. In addition, information from small-scale evaluation tests at FHOOE was considered to investigate the requirements of the collaborative interface.

Fast Facts

- **Small-scale** evaluation tests to investigate the **requirements**
- Supports flexiility in interface use & redundancy for specific tasks

Reliability and Usability

The key to interface design for human-robot communication is to provide the basis for mutual, reliable understanding. To achieve this, the human must be provided with adequate means to communicate with the robot, but also to retrieve information from the robot. One way to achieve reliability in system interactions is to support flexibility in the use of interfaces and redundancy of interfaces in specific tasks. This means to not only using visual interface design, but also considering physical and auditory based interaction, such as voice commands. This allows the human to respond in a meaningful and preferably natural way. In addition, voice commands have the advantage of providing a safe space around the worker and allowing the worker to continue with the assembly task. Another advantage of providing redundant communication options is that the workflow is not disrupted in the event of a failure. Taking these aspects into account, IfADo supports the FELICE partners in ensuring reliability and usability in their multimodal interface design. Doing so contributes to the goal of enabling the FELICE robot to support human workers in the best way possible.

The benefits of workflow optimization in a manufacturing environment are significant. By systematically improving and fine-tuning the sequence of tasks and processes involved in manufacturing or service delivery, organizations can reap several key benefits, such as improved efficiency through significant increases in operational effectiveness.

Fast Facts

- **Leaner & faster** production processes
- **Cost savings** by minimising ineffeciencies
- Essential practice for **staying competetive**

This involves identifying and removing bottlenecks, reducing downtime, and eliminating redundant or non-value-added tasks. As a result, production processes become leaner and faster, resulting in higher output rates and shorter lead times.

Another obvious benefit is cost savings: by identifying and minimizing inefficiencies, waste, and underutilization of resources, companies can substantially reduce operating costs. This in turn leads to improved profitability and cost competitiveness in the market. Product quality can be also improved as workflow optimization ensures consistent adherence to quality standards at every stage of production. It minimizes defects and errors by enforcing standardized processes and quality checks, ultimately resulting in higher-quality products or services.

Efficient allocation of resources, including labor, materials, and machinery, is a hallmark of workflow optimization. It maximizes the use of resources, reducing idle time and waste while increasing productivity. Streamlining operations reduces employee frustration caused by inefficiencies, making work more enjoyable.

This improved job satisfaction can lead to higher employee retention rates and a more motivated workforce. In conclusion, workflow optimization in production environments is invaluable for organizations striving to succeed in today's dynamic business environment. Its ability to increase efficiency, reduce costs, improve quality, and support strategic decision-making makes it an essential practice for staying competitive and ensuring long-term growth.

In our continuing effort to refine and advance our robotic technologies, we have recently made several significant enhancements. These upgrades focus on improving the overall performance and reliability of the Felice robotic platform.

Enhancements in Mechanical Components

Improved sound quality with a new microphone housing: To ensure clearer audio communication, we've replaced the microphone housing to reduce sound attenuation. This is critical in environments that require clear audio inputs.

The improved motorized wheel "M1": We've replaced the previous motorized wheel with a new one, improving the robot's mobility and operational efficiency.

Advanced Castors for smoother rides: We've switched to advanced castor wheels to counteract high vibration during movement. These new wheels absorb shocks better, ensuring a more stable and smoother navigation.

Fast Facts

- Switched to **advanced castor wheels**
- Added a quick connector for gripper for **easier maintenance & operation**

Enhancements in Electrical Components

We have successfully identified and resolved a problem with the HALL motor in the platform drive, ensuring smoother operation. The USB cable for the tablet has been replaced to improve connectivity. In a significant upgrade, we moved the tablet's data transmission to a WIFI card, improving wireless connectivity. Our software development team modified the Roboteq software by adding a script that activates a digital output for error signaling. This output circuit is now connected to the DSC-M1 programmable relay, improving control and diagnostics. The DSC-M1 relay program has also been updated for improved functionality. On the hardware side, we have added capacitors and resistors to the drive motor circuits for noise suppression. We have repaired the EtherCAT connection with slave number 7 of the arm to ensure stable control. For the gripper, a quick connector has been added to the electrical connection, making it easier to maintain and operate.

We also upgraded the external power supplies for the PC box, increasing their output power to support more demanding tasks. The batteries in UPS1 (NUC) were replaced to ensure uninterrupted power supply. Necessary repairs and enhancements were also made to the UNIDEV to improve its performance.

FELICE NEWS

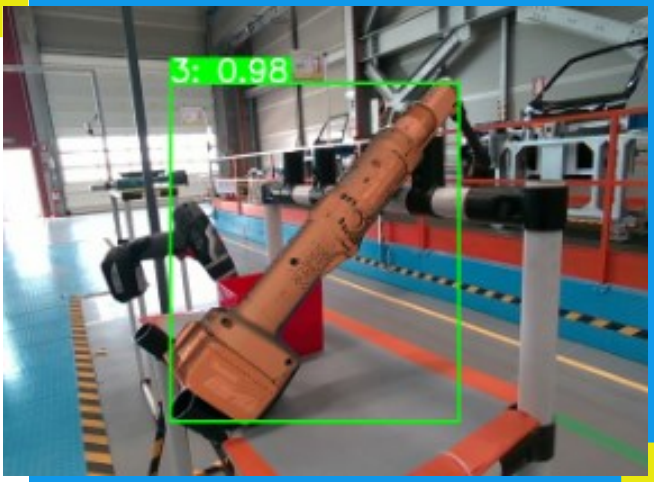
For more FELICE News & Blogposts click here: [News - FELICE (felice-project.eu)]

Research Update by ICCS

The FELICE Cobot (Cooperating Robot) is not a typical desktop workstation with mammoth GPU (300W) capabilities. The FELICE cobot requires mobility and energy efficiency, so it hosts edge-like (not a cloud-size) components (~40W) that use embedded processors to locally process vision-oriented data. Cobot Edge computing leverages the power of AI directly through an NVIDIA AGX platform, processing the captured data at its source in a decentralized manner—rather than in the cloud or data center. This accelerates the AI pipeline to power real-time decision-making and isolated software-defined environments.

Update: Object Detection and Localization

The FELICE edge technology uses *Docker technologies* to bundle "tons" of software into a *container (i.e. isolated software components)* required for ODL (Object Detection and localization) and make it GPU aware. This is not an easy task, however, as all the major software stacks (OpenCV, TensorFlow etc.) need to be recompiled and tweaked. Squeezing out the last bit of performance comes from optimizing the learned model during the inference phase with hardware-specific tricks such as TensorRT to be able to process industrial resolution video feeds to detect different types of screwdrivers in real-time.



Human-Robot Interaction: UNISA's Latest Advancements

In the innovative landscape of the FELICE project, UNISA is proceeding with its advanced speech and gesture analysis. The robot and adaptive workstation respond adeptly to specific commands: the robot processes both speech and gesture inputs, while the workstation responds to speech commands only. Recent enhancements include the adoption of a conformer-based neural network architecture capable of achieving better performance in speech command recognition with the adoption of the curriculum learning for improved noise resilience. These advancements allowed us to achieve over 90% accuracy, surpassing KPI-O1-4 standards, and reaching TRL5 for both Italian and English speech recognition. Similarly, gesture recognition, utilizing an advanced single-stage neural network, has also attained TRL5 with a remarkable accuracy rate above 90% in real-world scenarios.

Why limit ourselves to just CI/CD?

At FELICE, we're taking it up a notch with Grafana for Continuous Monitoring. Even on weekends, someone is working hard in the background. Grafana (https://grafana.com/) is an open-source analytics and visualization suite, widely used for IT infrastructure monitoring. It integrates with various databases to display real-time metrics such as CPU usage, memory, storage, and network usage. Customizable dashboards make it easier to spot patterns, trends, or anomalies, thereby portraying system health effectively. Contrastingly, Continuous Monitoring and Continuous Integration/Continuous Deployment (CI/CD) – two aspects of DevOps – complement each other. Continuous monitoring enables early problem detection, enhanced system security, regulatory compliance, and increased productivity. On the other hand, CI/CD focuses on smooth integration and deployment, accelerating time to market, reducing risks, improving code quality, and boosting team productivity. The integration of these processes heightens system reliability, optimizes operations, and improves system performance.

Development Update: PC Box Addition to the Mobile Platform of the robot

We are thrilled to announce a significant enhancement to our mobile platform: the addition of the PC Box, an integral component designed to streamline and elevate the functionality of the FELICE collaborative robot.

An Integral Part of the Mobile Platform

The PC Box, now seamlessly integrated into our mobile platform, serves as a hub for critical computing functions. Its primary role is to provide easier access to the PC interfaces, making it a cornerstone for both the operation and maintenance.

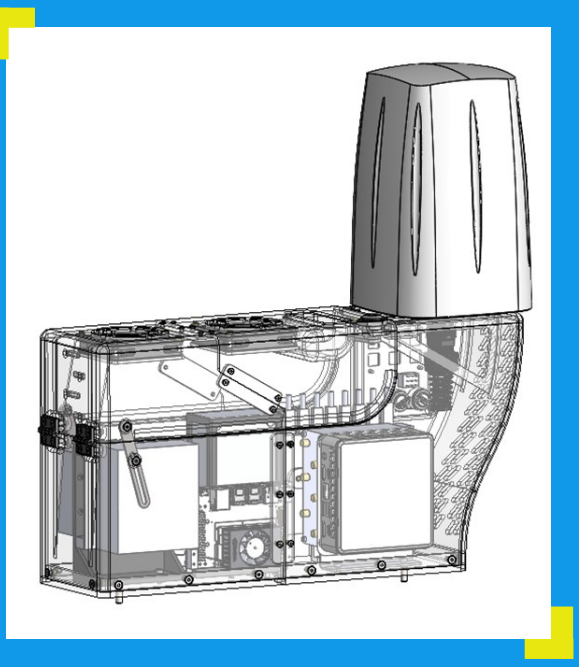
New Components for Enhanced Performance

The new PC Box is more than just an enclosure; it's a powerhouse of technology. It incorporates a KVM (Keyboard, Video, Mouse) system, allowing for remote control and monitoring of the PC functions. This is especially beneficial for tasks that require real-time interaction and troubleshooting.

In addition, the PC box includes an extra Wi-Fi antenna, which enhances the robot's connectivity and data transmission capabilities, ensuring a robust and stable network connection, which is essential for tasks requiring real-time data exchange.

Simplifying the Software Development Process

One of the most significant benefits of the PC Box is its impact on the software development process. By providing direct and easy access to the PC interfaces, developers can work more efficiently, implementing and testing new software with greater ease and speed. This not only speeds up the development cycle but also improves the quality of the software, resulting in more advanced and reliable robot functions.



Publications & Press

Book chapters

Akkaladevi, S. C., Propst, M., Hofmann, M., Hiesmair, L., Ikeda, M., Chitturi, N. C., & Pichler, A. (2021). Programming-Free Approaches for Human–Robot Collaboration in Assembly Tasks. In Advanced Human-Robot Collaboration in Manufacturing (pp. 283–317). Springer International Publishing.
DOI: https://doi.org/10.1007/978-3-030-69178-3_12
Link: https://link.springer.com/chapter/10.1007%2F978-3-030-69178-3_12

Conference publications in Phase II

Pratheepkumar, A., Hofmann, M., Ikeda, M., & Pichler, A. (2022). Domain Adaptation With Evolved Target Objects for AI Driven Grasping. In 2022 IEEE 27th International Conference on Emerging Technologies and Factory Automation (ETFA). IEEE. (25.10)
DOI: https://doi.org/10.1109/etfa52439.2022.9921470

Dimolianis, M., Kalogeras, D. K., Kostopoulos, N., & Maglaris, V. (2022). DDoS Attack Detection via Privacy-aware Federated Learning and Collaborative Mitigation in Multi-domain Cyber Infrastructures. In 2022 IEEE 11th International Conference on Cloud Networking (CloudNet). IEEE. (11.22)
DOI: https://doi.org/10.1109/cloudnet55617.2022.9978815

Pateraki, M., Sapoutzoglou, P., Lourakis, M. (2023) Crane Spreader Pose Estimation from a Single View. In 18th International Conference on Computer Vision Theory and Applications - VISAPP 2023
DOI: https://doi.org/10.5220/0011788800003417

Holzinger, F., Beham, A. (2023) Multi-criteria optimization of workflow-based assembly tasks in manufacturing. In Lecture Notes in Computer Science
DOI: https://doi.org/10.1007/978-3-031-25312-6_5

Pätzold, M. (2023) Adaptive positioning of large work objects to reduce physical load in industrial assembly -Adaptive Positionierung großer Arbeitsobjekte in der industriellen Montage zur Reduktion von physischen Belastungen. In 69th GfA spring conference
DOI: 10.26083/tuprints-00023640

Papadopoulos, G., Maniadakis, M. (2023) Human-robot interaction: Assessing the ergonomics of tool handover. In Ergonomics & Human Factores 2023
DOI: https://publications.ergonomics.org.uk/publications/human-robot-interaction-assessing-the-ergonomics-of-tool-handover.html

Hoose, S., Würtz, F., Kirks, T., Jost, J. (2023) An Evaluation of Open Source Trajectory Planners for Robotic Manipulators with Focus on Human-Robot Collaboration. In 2023 IEEE 19th International Conference on Automation Science and Engineering DOI: 10.1109/CASE56687.2023.10260597

Tüzün, A., Hackenberg, G. (2023). Quality Assurance of Digital Twins: An Experience Report in the Automotive Industry. In: Fernandes, J.M., Travassos, G.H., Lenarduzzi, V., Li, X. (eds) Quality of Information and Communications Technology. QUATIC 2023. Communications in Computer and Information Science, vol 1871. Springer, Cham. DOI: https://doi.org/10.1007/978-3-031-43703-8_2

FELICE press articles in Phase II

FELICE was featured in issue 22 of the Discover Logistics magazine by Fraunhofer IML (German language)

FELICE was featured twice in January 2023 issue 123 of ERCIM news

Journal Publications in Phase II

Papadaki, A., Pateraki, M. (2023) 6D object localization in car-assembly industrial environment. In Journal of Imaging 2023
DOI: https://doi.org/10.3390/jimaging9030072

S. Bini, G. Percannella, A. Saggese, M. Vento, (2023). A multi-task network for speaker and command recognition in industrial environments, in: Pattern Recognition Letters (Volume 176, pp. 62-68, 0167-8655).
DOI: https://doi.org/10.1016/j.patrec.2023.10.022

Kostopoulos, N., Kalogeras, D., Pantazatos, D., Grammatikou, M., Maglaris, V. (2023) SHAP Interpretations of Tree and Neural Network DNS Classifiers for Analyzing DGA Family Characteristics. In IEEE
DOI: https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=10151849

Metzler, Y., Renker, J., Zickerick, B., Dreger, F., Karthaus, M., Rinkenauer, G. (2023) AI-coordinated collaboration between Humans and Robots. Implications for Work Design and Introduction in Organizations. In Zeitschrift für wirtschaftlichen Fabrikbetrieb
DOI: https://doi.org/10.1515/zwf-2023-1127

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https://zenodo.org/communities/felice-h2020/

This project has received funding from the European Union's Horizon 2020 Research and Innovation program under grant agreement No 101017151.