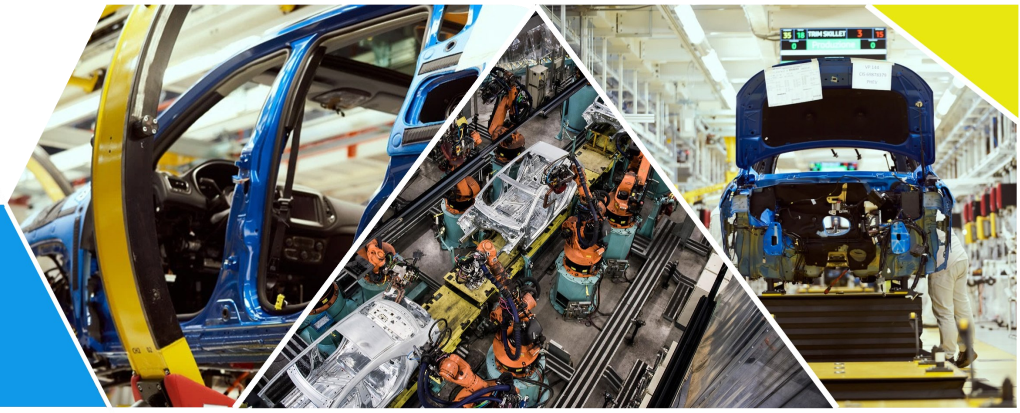
FELICE
NEWSLETTER Nb.7



Development updates | News | Publications & Press

Updates

Milestones

The FELICE project entered the consolidation phase (phase III)

Project representation at A&T fair (Turin) & LogiMAT (Stuttgart)

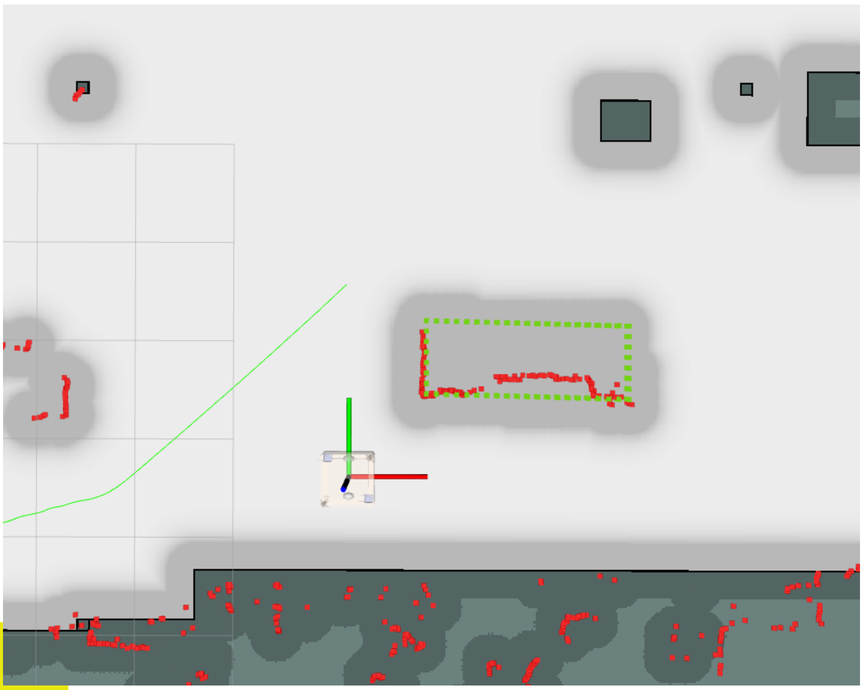
Development updates

Enhancements in Robot Software Components

In terms of software development, a number of changes have been introduced, mainly to improve navigation performance and the reliability of the robot so that it is able to respond to unforeseen situations. In order to improve the navigation accuracy of the platform, a goal achievement validation algorithm has been added to the navigation stack. If the navigation stack returns information about the theoretical achievement of the goal, it is necessary to additionally confirm that the position of the platform is within the assumed tolerance limits of the goal, excluding possible control and localization errors. In terms of navigation, the addition of workstations as potential obstacles has also been implemented. The position of the workstations is determined based on cameras placed in the work area and then sent to the robot so that it can plan the most optimal navigation path in advance. An algorithm has been added to respond to failures or temporary interruptions in the operation of the localization module. In the event of a momentary interruption in operation (e.g. loss of position), the robot will stop navigation and if the localization module does not return to correct operation, the platform will rotate to make it easier to find the current position, until a critical location error is reported.

Fast Facts

- New algorithm in navigation stack
- Supervisor modul for more safety



The robot software consists of many interacting modules that should be monitored to ensure the reliable operation of the robot. For this purpose, a supervisor module has been implemented, which in case of problems with any of the modules will return an appropriate error and try to restore the correct operating mode.

In the FELICE project, Discrete Event Simulation (DES) provides an intuitive and flexible approach to represent complex systems. It is a simulation in which the state variables change at a discrete set of points in time. The essential feature of DES is that the model's state is only updated at event occurrences, leading to a series of instantaneous changes known as events. These events can be anything from a customer arriving at a service station, a machine breaking down, or a robot completing a task. DES uses timing estimations and probability distributions to model the occurrence of these events. Timing estimations are calculated based on historical data or theoretical calculations, giving an estimate of when a particular event is likely to occur.

Fast Facts

- Utilizes timing estimations & probability distributions for event modeling
- simulation-based optimization for efficient workflows

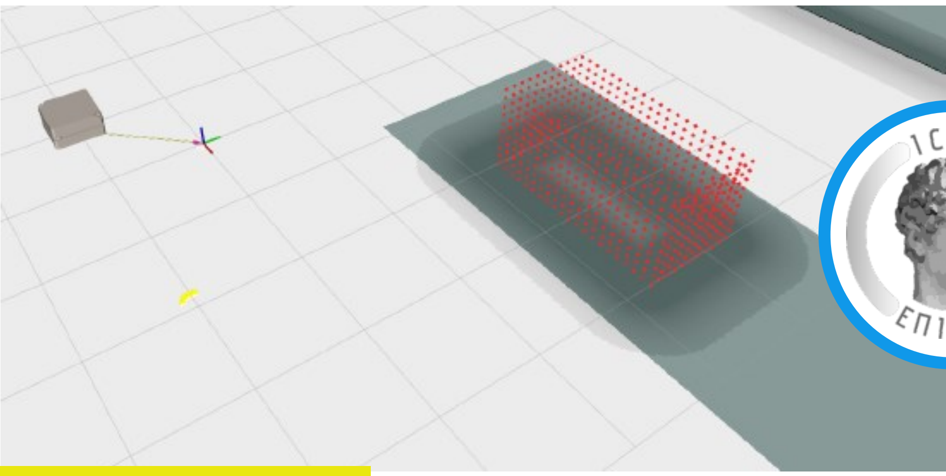
Probability distributions are used to model the inherent variability and randomness in real-world systems. For example, the time taken by a robot to perform a task might be modeled as a normal distribution with a certain mean and standard deviation. Simulation-based optimization is an application of DES that aims to find the best design parameters that optimize the performance of a system. In the context of a workflow involving a robot interacting with a human, DES can be used to model the system and simulate different scenarios.

Each scenario might involve different parameters such as the robot's speed, the sequence of tasks, or the timing of human-robot interaction. By simulating these scenarios, we can estimate key performance metrics such as the total time taken to complete the workflow, the average waiting time for the human, or the utilization of the robot. These metrics can then be used to form an objective function for optimization. For example, we might want to minimize the total time taken to complete the workflow, or maximize the utilization of the robot. The optimization process involves running the simulation multiple times with different parameters, and using an optimization algorithm to find the parameters that give the best performance. This approach allows us to optimize the workflow without having to physically test each scenario, saving both time and resources. In conclusion, discrete event simulation is a powerful tool for modeling and optimizing complex systems. By using timing estimations and probability distributions, it allows us to capture the inherent variability and randomness in real-world systems, and by using simulation-based optimization, it enables us to find the best design parameters to optimize workflows involving a robot interacting with a human.

The FELICE HBU system is capable of capturing and interpreting the behavior of a worker that performs assembly tasks in a workstation of the assembly line. The detection of the location of the 3D body pose of a worker across time, uses visual data acquired by two camera sensors installed at stationary positions on the shopfloor, in the proximity of the production line.

Image frames from the cameras are used to estimate a 3D skeleton-based representation of the human body for each frame. The computed information of the fine-grained body motion in 3D space will subsequently be used to assess posture deviations in terms of ergonomics and to recognize the ongoing assembly actions performed by the worker in real-time. Advanced ergonomic estimation aid in detecting postures which indicate fatigue. The estimation of the human pose exploits two state of the art methods to estimate the 2D and subsequently the 3D body configuration based on a known O-penPose [1] tree-based skeletal model.

Additionally as a person moves around the potential car, it is important to detect and segment the car door area from camera streams on the shop floor in order to include it as a dynamic moving obstacle in the updated environment map. For this purpose, a Mask R-CNN deep Machine learning model [2] was exploited for instance segmentation as part of the Detectron2[2] framework. The training of the model utilized sample images (attachment 1) utilized annotation masks of the car door area, selected from a series of videos acquired using static cameras along the assembly line. This model has been trained using the images of the COCO dataset, resulting in 80 classes describing daily objects.



An indicative result of the transformation of a detected car door as an environmental object is shown in attachment 2. This result aid the robot's navigation and to derive dynamic location estimates for points of interest in the case of a moving cart.

FELICE at A&T Fair (Turin)

FELICE was represented by coordinator Prof. Maria Pateraki at the A&T— Automation & Testing fair in Turin. Visitors could see the robot in operation from the 14-16th of February. Sky Video Italy and Torinoggio featured the FELICE robot in their reports.

To watch the video featuring the FELICE robot click here!

To read the articel featuring the FELICE project click here!

Fast Facts

- More than 67.000 visitors on LogiMAT
- FELICE represented by IML

Felice at LogiMAT 2024 (Stuttgart)

Fraunhofer IML hosted a booth at LogiMAT 2024 trade fair March 11 - 13 and represented the FELICE project. LogiMAT is the largest annual trade fair on logistics in Europe. This year LogiMAT welcomed more than 67.000 visitors — a quarter coming from abroad to Stuttgart. IML provided flyers and attendees could get insights on the projects.

New Flyer available

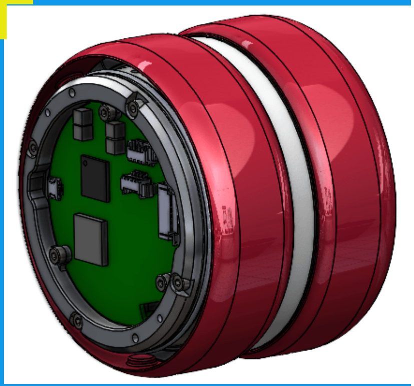
The FELICE flyer was recently updated by TU Darmstadt and includes the current state of the project as well as an image of the collaborative robot.
To check out the new flyer click: Dissemination Material - FELICE (felice-project.eu)

FELICE NEWS

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

Development Update by ACC: RIM Module –

Empowering Felice robotic arm with precision and intuitive control



The core of the RIM module lies in its integration of a 6 DoF force/torque sensor with sophisticated control electronics.The RIM module is more than just a technological advancement; it's a practical solution to enhance the efficiency of robotic systems. By allowing the robotic arm to sense the weight of tools and parts, RIM ensures a safer and more collaborative work environment. Human workers can confidently entrust delicate assembly tasks to the robotic arm, knowing that the RIM module will handle them with precision and care.

Update: Object Detection and Localization

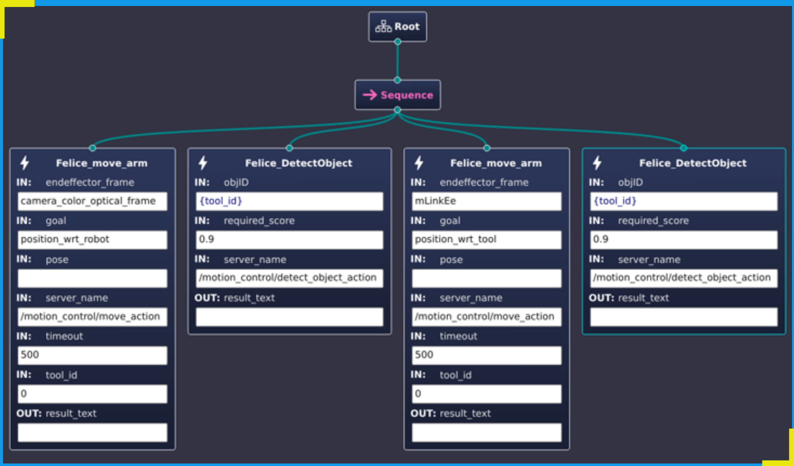
IfADo drafted first Wireframe/Mock-Up Display designs of workstations in FELICE. The displays are designed to meet the following requirements:

- Provide (multimodal) feedback for user actions
- Keep consistency of color schemes, shapes and positions across designs and actions to guide attention
- Hide unnecessary information to reduce errors
- Provide preview information to allow for preparation and system transparency to foster acceptance
- Use icons and short text to save cognitive resources (memory)
- Use shapes and colors that efficiently represent actions and processes

Successful integration took place in Week 26.02.-01.03. at Melfi CRF smart manufacturing environment.

Research Update by PRO & ICCS

The FELICE proposed framework intricately orchestrates the dynamic interplay between the perception and acting/reacting layers in the context of human-robot collaboration, with a specific emphasis on the role of Behavior Trees (BTs) in both task execution and deviation handling.



Behavior Trees (BTs) are increasingly favored for human-robot collaborative assembly tasks in industrial settings due to their hierarchical, modular structure [1]. BTs excel in managing complex assembly scenarios by breaking tasks into manageable sub-tasks, promoting fault tolerance, and ensuring real-time adaptability. Their organized architecture facilitates skill mapping and organization, enhancing efficiency in skill-based robot task execution. The use of sub-trees and fallback sub-trees in BT design promotes modularity. This structured approach allows task de-composition and modularity, catering to collaborative assembly intricacies and enabling real-time adaptability. Fig. 1 demonstrates a BT structure for a pickup skill.

In FELICE the Behavior Tree-based Task Execution (BTE) is seamlessly integrated into the acting/reacting layer, collaborating synergistically with the perception layer, which includes robot proprioception and object localization modules.

This integration facilitates the efficient detection and handling of deviations, particularly those arising from failures during robotic manipulation (grasping), ensuring real-time responsiveness to dynamic changes in collaborative assembly tasks. A dynamic change could be either a failure of robot localization or a poor object detection result. Failures, in terms of BTs, are implemented as a Dynamic Behavior Tree Execution Engine (DBTE) which loads a BT as a two-stage approach.

In a real case scenario on the shopfloor, initially, the robot arm moves to a scan pose relative to itself, allowing scanning from the side of the tool/object. Subsequently, the arm moves to a scanning pose relative to the tool/object, enabling scanning from the top. At each iteration of moving to a scanning position and performing a scan, there is an interaction between the RAE and the ODL module.

[1] 11. M. Iovino, E. Scukins, J. Styrud, P. Oegren, and C. Smith, "Asurvey of behavior trees in robotics and ai," Robotics and Autonomous Systems, 2022, Vol. 154, pp. 104096

New poster by FELICE partner

@EunomiaServices participated in the ETSI #AIconference in Sophia Antipolis with a poster entitled "Ethics-by-Design in AI-Driven Human-Robot Collaborative Manufacturing: Navigating Regulatory and Ethical Challenges", focusing on challenges within the EU AI regulatory framework.

Ethics-by-Design in AI-Driven Human-Robot Collaborative Manufacturing: Navigating Regulatory and Ethical Challenges

Nanou C. (1), Koulierakis N. (1), Crociani M. (1), Danilatou V. (2)
1. Eunomia Limited, 2. European University of Cyprus

Background

Innovative progress in the integration of AI and collaborative robotics (CR) promise to radically transform manufacturing efficiency. Aligning such advancements with societal values introduces intricate challenges, underlined by the need to harmonize innovation with ethical underpinnings, as enshrined within the rationales of the EU's AI Act proposal and of previous official EU resolutions and guidelines.

Research Update by EUNL

Innovative progress in the integration of AI and collaborative robotics (CR) promises to radically transform manufacturing efficiency. Aligning such advancements with societal values introduces intricate challenges, underlined by the need to harmonize innovation with ethical underpinnings, as enshrined within the rationales of the EU's AI Act proposal and of previous official EU resolutions and guidelines. In face of these challenges, adopting an Ethics-by-design methodology is crucial for the advancement of relevant technology. This approach emphasizes a holistic view, covering a broad spectrum of ethical considerations throughout all stages of development and use while urging for ethical alignment with harmonized ethical guidelines that guide conduct beyond legal requirements.

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

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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FELICE H2020 Project

https://www.felice-project.eu/

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

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