WP9 – Dissemination, Exploitation and Communication

D9.9 - On-line training material

Due date: M48 - 31/10/2023

Version number: V1

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Summary

In order to ensure an effective knowledge transfer to wider audience working in the domain of flexible materials and their handing using collaborative robots, the MERGING project has designed different training materials to help in advancement of EU workforce. The training materials presented in this deliverable are categorised into three sections: control of robotic arms and grippers during manipulation of flexible materials, human tracking using computer vision, and orchestration and task scheduling while handling flexible materials. The training materials are freely accessible on the project's website in the form of presentations, manuals and videos, for easier understanding of the different technologies developed within the project.

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1. Context

MERGING aims at developing low cost and versatile solutions for the handling of flexible materials via intelligent and dexterous robots. An objective of the MERGING project is that it will contribute to high quality job creation in the robotics and manufacturing industry. For this purpose, an external training plan was developed with the technology providers for wider audience. These training materials are targeted towards the workforce to familiarize with the developed technologies within the Merging project. These training materials are also aimed at different audiences, such as software and hardware integrators, potential end-users and stakeholders, among wider application sectors (manufacturing, textile, agro-food, education, standardization bodies, certification entities, etc.).

The **Training Plan**, which is gave the perimeter and guide-lines of this deliverable, had the aim of organizing all these training activities, which are addressing the following different levels:

- Knowledge transfer from Merging project RTOs to integrators and industrial partners workforce, inside the consortium;
- Dissemination of the usable project results and created knowledge, to other relevant stakeholders and the public.

It integrates the elaboration of suitable materials for training and technology transfer, and introduces how training activities are to be organised within the project. The different levels and structure are described in the following sections.

2. Training materials classification and accessibility

2.1. Internal training materials

Owing to the confidentiality of several technologies, not all training sessions were made available to public. As previously explained in Deliverable 9.8 section 2, the internal training sessions are made available only to the consortium members to train the end users and validate the use cases. Depending on the building blocks, the training materials are either provided as a presentation or video instructions. All the internal training materials are uploaded the consortium website where the partners can freely access the materials for reference and training when necessary. Hands on training sessions were also carried out internally at different stages of the project to validate the different building blocks in the final use case implementation. The following are the list of internal training sessions that were planned in the deliverable 9.8:

- Gripper installation and usage conditions- OMNIGRASP
- Soft sensors- usage - EPFL
- Collaborative control – CEA
- Human tracking using computer vision- AIMEN
- Deformable material modelling and model based control -LMS
- Deformable object handling controller –LMS

2.2. Public training materials

Public training materials are accessible to wider audience which contain the overview of the building blocks along with the developed technologies. These materials are simplified to ensure easier understanding by the readers without great technical backgrounds. These training materials provide an idea of what building blocks can be employed for handling a flexible material and how can these be integrated in a human oriented collaborative environment. The following are the public training materials:

- Human tracking using computer vision
- Deformable material modelling and model based control
- Deformable Object Handling Controller

These training materials are provided in the format of video and/or presentation formats. These training sessions were also presented during the final workshop of the project.

2.3. Online training material format and accessibility

Depending on the building blocks, the training materials are either provided in the form of videos or presentations. All the training materials can be found on the website of the project (https://www.merging-project.eu/training-material/) (see Figure 1). The training materials are categorised by each building block. The training materials are either presented in the video format or PDF format for references. Video tutorials are self-explanatory and provide the overview of the technologies and how to use them. PDF files provide technical background and more in depth information about the module.

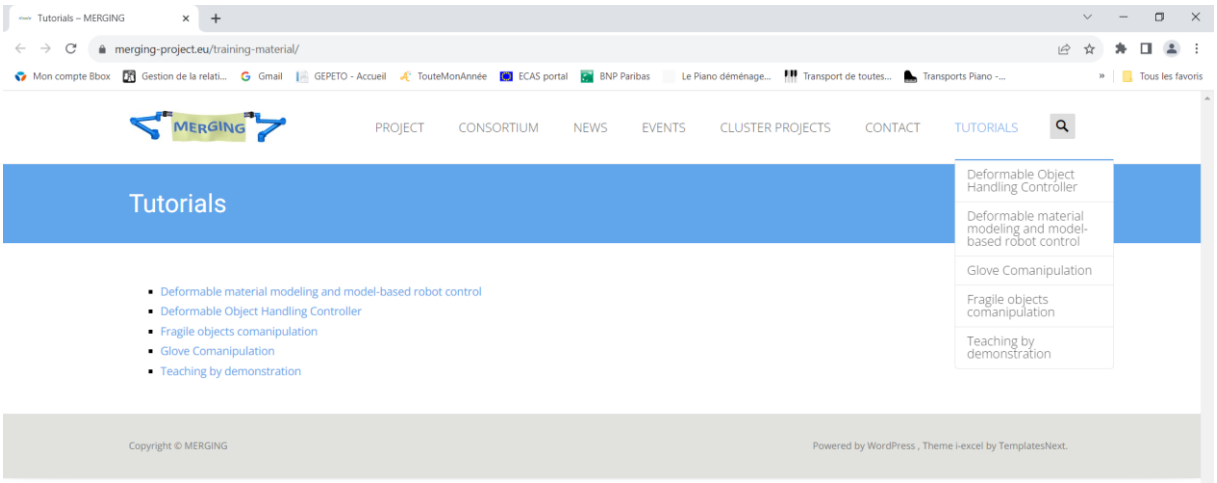

Figure 1: Tutorials tab in the project website main toolbar (www.merging-project.eu)

3. Implementation

3.1. Human tracking using computer vision

The main objective of this training session is to provide a global overview of the human tracking in an environment with collaborative robots developed by AIMEN (see Figure 2). The details of the human tracking using computer vision can be found at this ***link.*** The presentation explains the different methodologies of human tracking using computer vision and difficulties can arise during such implementation. The presentation provides a general background on the existing techniques of human tracking and its importance. The training is carried out in the context of two different test cases: textiles and plastic pouches. The readers are requested to refer the public deliverable 5.3 for the technical details of these modules and the workshop session which is available here.

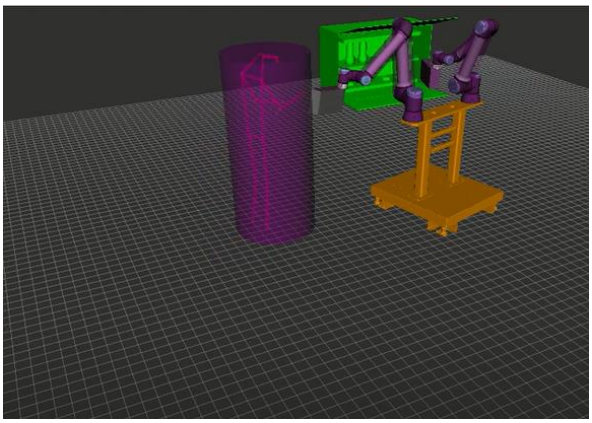

Figure 2: An extract from the video tutorial for human tracking using computer vision developed by AIMEN

3.2. Deformable material modelling and Model-Based Robot Control

This training session aims on providing information on how a digital representation of a flexible materials such as fabrics can be achieved and how that representation can be used for planning the handling actions of cooperating robot agents. The digital reconstruction of such flexible materials is not simple because of their stochastic deformation and non-uniformity. These deformations are dependent on the geometry of the materials and also the materials properties. While handling such materials, accurate representation of the material deformation in real time is necessary. Hence, LMS has developed a deformable material model and model based robot control within the framework of the project Merging (see Figure 3). The details of these models can be found here on the website of the project Merging, which includes a training manual in a PDF format and an explanation video on how to use this module.

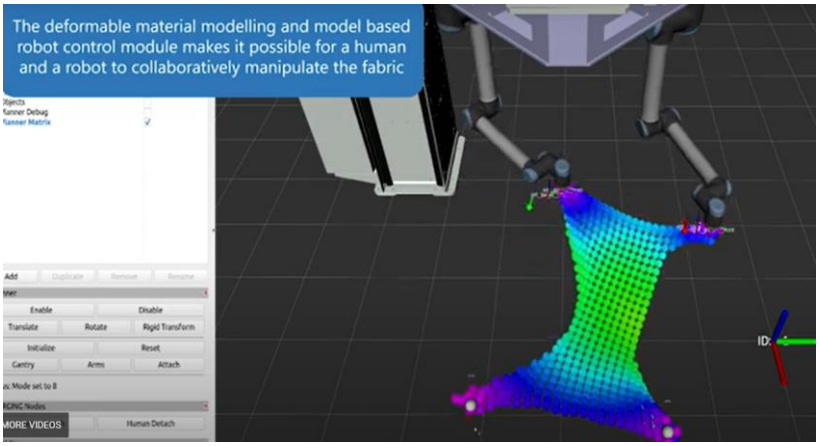

Figure 3: An extract from the deformable material modelling tutorial video developed by LMS

3.3. Deformable Object Handling Controller

While orchestrating complex tasks such as handling flexible materials, task execution and task flow are of utmost importance. Deformable Object Handling Controller (DOHC) is a tool that provides the ability for high level orchestration of the shopfloor resources and monitoring the executions' process which is developed by LMS. The provided software has been tested using ROS noetic on ubuntu 20.04. DOHC follows a hierarchical approach for constructing the execution process based on 5 levels of activities: Orders, Jobs, Tasks, Operations and Actions. The highest level is the Order, which is a superset of activities that take place in a certain period in a shop floor. To execute actions, only the details regarding the actions' execution are required. The more complex information needed for executing activities that consist of a sequence of steps (Operations, Tasks, Jobs and Orders) is represented by

diagrams. The training materials for DOHC can be found here on the website of Merging project in the video and pdf format.

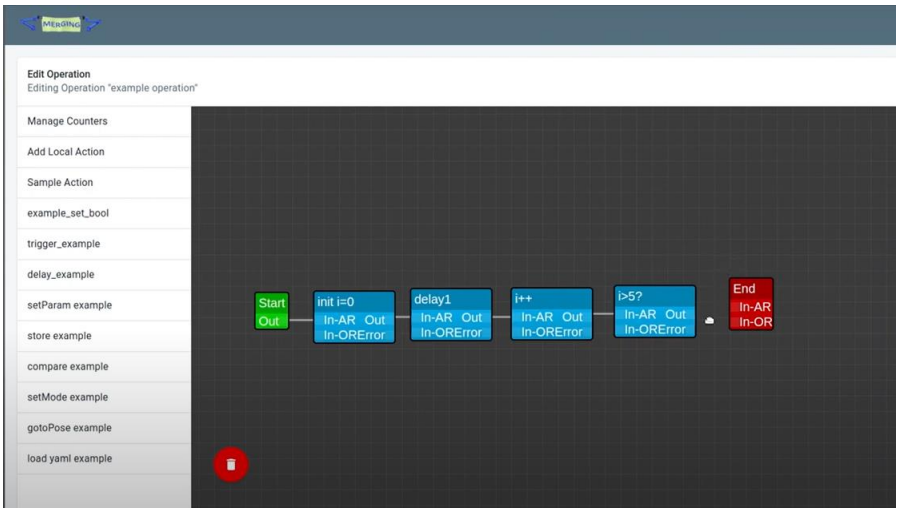

Figure 4: Extract for training video for DOHC

4. Workshop training materials

This section provides access to different training sessions that were carried out during the final workshop of Merging project. A total of five training sessions on the different technologies developed within the project were presented. The tutorials are presented in the video format and be accessed via the hyperlink. Owing to the confidentiality of some materials, the presentations of the training sessions are restricted.

- How to install and drive Electro-adhesion grippers for flexible objects (OMNIGRASP)
  This tutorial presents information about the installation of the flexible grippers on the universal robots for manipulation of flexible materials.
- Lessons Learned from Computer Vision Implementations in Merging Work Cells (AIMEN)
  This tutorial describes the various scenarios of implementation of computer vision for human tracking, quality monitoring and fault detection.
- Deformable Object Handling Controller: an intuitive package for scheduling, execution control, and monitoring (LMS)
  This tutorial describes the different ways to schedule the tasks using the DOHC for orchestrate complex tasks. This tutorial is similar to the one presented in section 3.3
- Robot easy programming - tutorial 1 : How instrumented gloves can facilitate human-robot collaboration for large flexible pieces transportation (CEA)
  This tutorial is a hands on experience on human robot collaboration for manipulating large flexible materials using haptic gloves.
- Robot easy programming - tutorial 2 : How to teach a robot through intuitive teleoperation (CEA)
  This tutorial is a hands on session and it provides information on the different ways of teaching a robot through teleoperations.

5. Conclusion

The Training materials aim at the knowledge transfer of selected building blocks developed within Merging project. The different training forms presented offer a great overview of the training material, which can be freely accessible through the website of the merging project. These activities will enable the knowledge transfer of MERGING project results from RTOs to industrial partners. It also ensures that the users can be confident while implementing or using MERGING technologies during and after the project. In addition, these training materials can be facilitate and enhance the European work force and pave path to the next generation workers who are well versed with different technologies linked to handling flexible materials using collaborative robots.