MMAssist_II- A Lighthouse Project for Industrial Assistance

Assistance in Production in the Context of Human – Machine Cooperation

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***Abstract*—In this paper, we present MMAssist_II, a national Austrian flagship project for research, development and establishment of assistance systems, which could be used as a tool box for different applications. Besides a fundamental understanding of demands for such assistance units also a demonstration in industrial near production settings including an extensive evaluation is part of the project. Therefore, a mighty consortium of 9 scientific partners and 16 industrial partners join the consortium.**

Keywords - industrial assistance; collaborative robotics; reusable assistance systems.

I. INTRODUCTION

Initial situation: Austrian production companies manufacture goods of high quality and have a staff of well-trained employees. However, companies currently face technological and societal challenges to which they have to react to in order to continually provide competitive goods on an international level. These challenges include the demand of customers for individualized products, which leads to smaller lot sizes and faster production cycles. At the same time, production machines are more and more connected and equipped with sensors. This leads to an increased information density and more complexity for the workers, which induces a higher workload and stress. Furthermore, Austria is experiencing a demographic change. As Austrian citizens get older, they stay longer in employment. All of these trends, as well as the goal to keep up the high quality of produced goods, lead to an increased need of optimized assistance for the worker in the factory.

In Section II, this paper is presenting the general aspects of the project flowed by Section III describing the technical concept of MMAssist_II. In Section IV, the available basic technologies are presented. The paper ends with Section V were we present the first results after 6 months project duration.

II. THE PROJECT MMASSIST_II

A. General project description

The lighthouse project MMAssist_II [1] will form a national research network with an international scientific board in order to find recognition and acceptance within the Austrian economy.

Goals and innovation: The goal of the project partners in **MMAssist_II** is to research and implement modular, reusable assistance systems for employees in production companies. Therefore, the project partners will work on the exemplary uses cases *Maintenance and Service*, *Arming of Machines and Simultaneous Handling of Multiple Machines*, and *Assembly* to analyze the technical and socio-economic requirements for assistance systems in these areas. Based on a strongly context-oriented requirements analysis, the partners will implement so-called "Assistance Units", which are modular components for assistance systems. Assistance Units are defined in a way that they can be applied to different application contexts. The partners will implement a software framework to enable a dynamic configuration and interaction of Assistance Units, thus forming an assistance system for a given application. To configure an Assistance Unit, different input and output modalities, as well as modules for context generation are needed, which will also be developed in the project. In order to measure and evaluate the efficiency and feasibility of the project's approach, the partners will implement lab-based prototypes of defined Assistance Units and evaluate them in real production environments.

Expected results: The project partners expect to gain a profound empirical and socio-technical understanding of the demands and requirements for assistance systems in the production context. These systems will consist of reusable, scientifically grounded Assistance Units that are thoroughly evaluated. The implemented assistance systems will be evaluated, by workers of production companies, in real production environments. This will lead to findings about the acceptance and user experience of workers who use assistance systems and a measurable reduced workload of the workers.

B. Key facts

MMAssit_II was launched in May 2017 and will run until April 2020. The project involves 25 different partners from research and industry, which are key players for research and manufacturing in Austria [2]. The partners expertise covers the whole manufacturing value chain from basic research to industrial manufacturing of high tech

 ISBN: 978-1-61208-616-3

products and services. This consortium was set up to have all necessary competences without any overlap in research, and besides technical capacities there is also social-economic knowledge available. The industrial partners cover a wide range of different technical branches and provide real use cases to demonstrate the results in a production near environment. Key facts are shown in Figure 1.

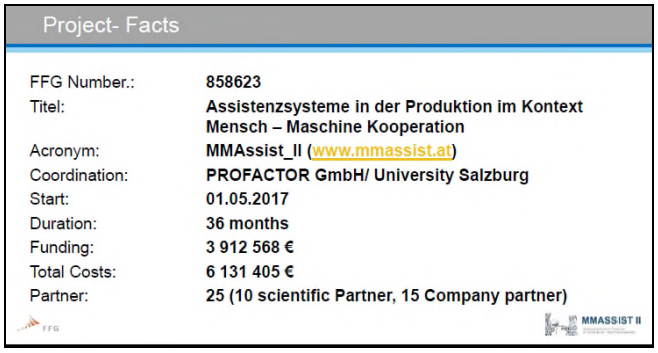

Figure 1. Key facts of the MMAssist_II project

C. *Objectives*

The goal of the project partners in MMAssist_II is to explore assistance systems for employees in production environments and to develop these systems. This is necessary to overcome future technical and socio-technical challenges for production, by setting new paradigms of industrial assistance. Figure 2 shows challenges for future.

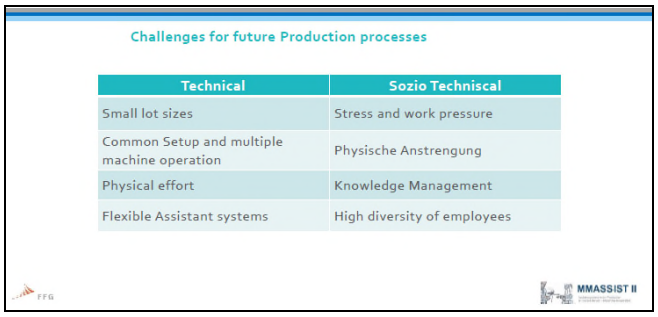

Figure 2. Challenges for Future production processes

These assistance systems should be tailored to the needs of employees for their special context. It is also the goal of the project partners, to develop more than only specialized solutions and assistance systems. Moreover, the assistance systems being developed are relevant for Austrian production companies in general. Therefore, the project partners have defined the following objectives.

OBJECTIVE 1: Exploration of modular, reusable assistance systems. The project partners will develop assistance systems that can be used not only for the specific individual cases, but are applicable in different contexts and for different applications. The purpose is to establish a general approach for implementing assistance systems for employees in manufacturing companies. This system should be open and able to motivate other companies to include there products and developments into the system later on.

OBJECTIVE 2: Context oriented detection of assistance needs. Methods are developed, to enable the identification of the assistance needs of people in the vicinity of the machines from machine point of view. The purpose is to explore intelligent assistance systems, which offer targeted assistance only if it is needed. An important point is the acceptance by the workers and therefore a neutralized information exchange has to be implemented.

OBJECTIVE 3: Improve the work and assistance experience. As a major goal, the project partners will implement assistance systems that increase positive factors of work and assistance experience while they are used, and reduce negative factors. Thus, it will be achieved that the systems are accepted by users and contribute to an improvement of their daily work.

OBJECTIVE 4: Applicability in real production environments. The project partner aims to use the implemented assistance systems application at the industrial partner's production facilities and to evaluate in terms of productivity, acceptance through the staff and ergonomics. This evaluation should prove that the assistance systems are also usable in real production environments and beyond the project. For this reason leading companies are included into the project development from the beginning to secure a real industrial relevance and industrial standards of the developed assistance systems.

III. PROJECT CONCEPT

The goal of MMAssist_II is to fundamentally research and characterize assistance in a production context. Based on this, optimized assistance systems for future working places focused on the human worker („Human-Centered Workplace") will be developed, implemented and evaluated in an industrial environment. Basis for the implementation are so called „Assistance Units" – which are modular components for assistance systems. Assistance Units are defined in a way that they can be applied to different application contexts. The partners will implement a software framework to enable a dynamic configuration and interaction of Assistance Units, thus forming an assistance system for a given application.

A. *Motivation*

The central motivation shown in Figure 3 is the development of Assistance Units (Unit 1…n) based on available and adapted basic technologies (for example mixed reality methods, Visualization of complex data, object recognition, scene interpretation and others). These Assistance units are implemented in a software framework and the best fitting Assistance Units for an application are composed to an assistance system that is tailored for the given production context. The Assistance Units and the assistance systems are implemented, tested and evaluated in different Use Cases, first in the labs of the partners and then in "semi" real production environment. Also some tests in real environment are planned.

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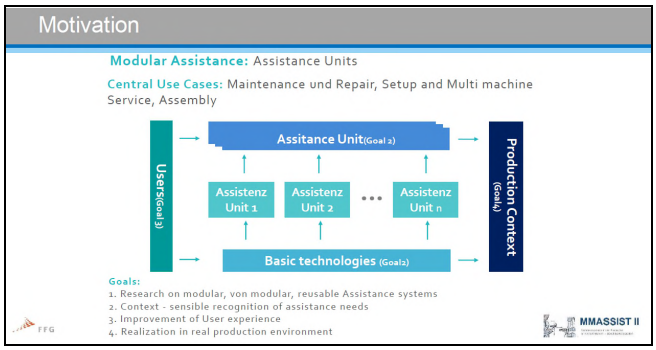


Figure 3. MMAsist_II Motivation

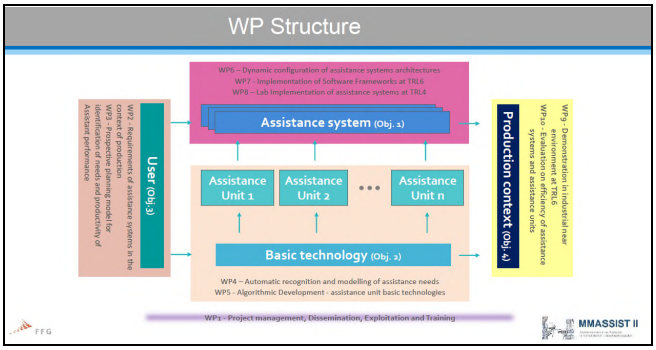
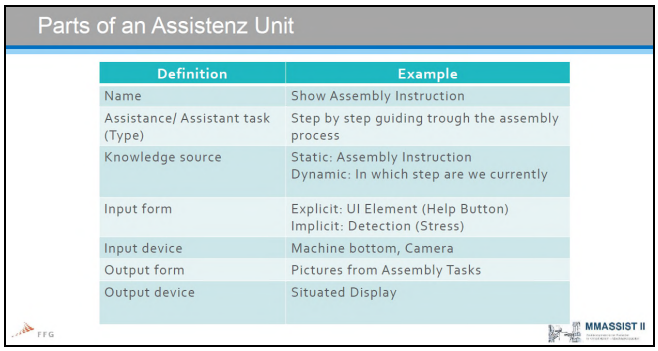


Figure 5. Work package structure

B. *Assistance Units*

A generalized description of an **Assistance Unit** is shown in Figure 4 considering the example of an Assistance Unit for assembly. Any assistance has, in addition to a clear title and a short description of the unit, primarily a definition which knowledge source is needed by the Assistance Unit to work correctly. These sources of knowledge can be for example information about the condition of the employee that is available on the machine, or process data, such as installation instructions. Among the needed data also the information, when the Assistance Unit must be activated, based on the context information of the employee and the process, is required. A second central element of an Assistance Unit is a description of "how and by which equipment" the employee can make submissions to the Assistance Unit, and also the output form, in which way the information of the machine is given to employees. So, the main components of an Assistance Unit are name, Assistance/Assistant task (Type), Knowledge source, Input form, Input device, Output form and Output device.



Definition	Example
Name	Show Assembly Instruction
Assistance/ Assistant task (Type)	Step by step guiding trough the assembly process
Knowledge source	Static: Assembly Instruction Dynamic: In which step are we currently
Input form	Explicit: UI Element (Help Button) Implicit: Detection (Stress)
Input device	Machine bottom, Camera
Output form	Pictures from Assembly Tasks
Output device	Situated Display

Figure 4. Assitance Unit description

C. *Workpackage structure*

The work package structure for MMAssist_II in context with the aim of the project is shown in Figure 5. 10 different Work packages including the project management and leaded by experienced project managers are the key for a successful project implementation. Workpackages are on different TRLs (Technology readiness level) and are well connected to each other. The detailed structure of the Workpackages is shown in Figure 5.

WP (Workpackage) 1 summarizes the tasks of the project related to the management of the project and the dissemination of project results. AP2 parses the requests of Assistance Units and assistance systems in the context of production from the point of view of the users and from a technical perspective. A planning model for the identification of assistance needs will be developed in WP3. Moreover, a model for structured preparation of work content and an employee model will be designed. Based on the theoretical results of WP2 and WP3, Assistance Units are explored in WP4. With these units assistance can be detected automatically. WP5 develops basic algorithms for Assistance Units. In WP6, partners develop approaches for the dynamic configuration of Assistant Units for specified use cases. A software framework is developed to implement the dynamically configured assistance systems in AP7. This framework is basis for WP8, in which assistance is prototypically implemented in laboratory environments. The assistance systems in real environment are implemented in WP9 at the facilities of the industry partners. Finally, the implemented assistance systems are evaluated in WP10.

D. *System architecture*

Core unit of the technical system architecture shown in Figure 6 are the single "Assistance Units" which are integrated to an overall assistance system via the Software Framework. The assistance system has interfaces to sensors that allow, together with a direct user input, a context recognition for the identification of assistance needs. Derived cognitive or physical assistance is provided via the respective Assistance Units. The overall system also has interfaces to external legacy systems (especially ERP & MES), which can retrieve, for example, job information and machine structural analysis.

Task management module manages the orders that can be adopted or entered directly via the administration interface from external systems, and informs the users about a specific job and corresponding support performance. The user management module enables central management of user master data and roles of all Assistance Units and interacts with a skill database that stores relevant skills of employees for the respective tasks. In the asset database, resources or appropriate references are stored, which can be consumed by the assistance units. The content management system has the purpose to take care of digital resources that need to be

 ISBN: 978-1-61208-616-3

imported in an appropriate form, edited, saved, updated, illustrated and re-exported.

A knowledge data base provides process knowledge from and also knowledge about the relevance and quality of certain assets. Here, employees can assess for a specific resource, which was offered by the assistance system in one specific step, how helpful it was, or correct a proposed sequence by the system.

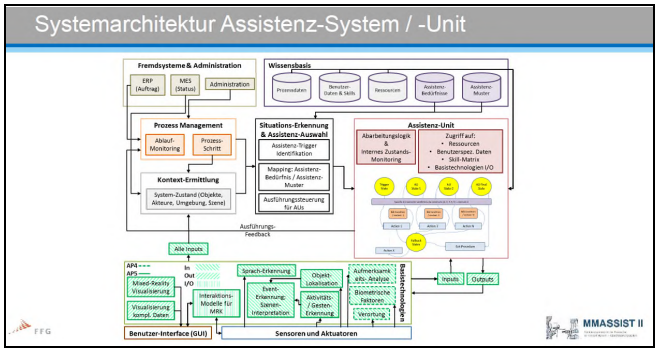


Figure 6. System architecture

IV. BASIC TECHNOLOGIES

In the MMAssist_II project, 9 scientific partners from Austria provide different basic technologies shown in Figure 7 for various Assistance Units. Either these technologies are ready for implementation or they were developed ready for use. The most challenging problem is the interfaces between this basic technologies and the software framework. Main basic technologies are:

Object recognition, Event recognition and scene Interpretation by Technical University Vienna [3]: A system to generate hypotheses on the current state and events happening in Human Robot Collaborative scenarios (HRC) is being developed. The software modules will be based on existing approaches and software libraries for object modelling and object pose recognition, concepts to describe events in HRC scenes, and fusion of data streams including action recognition, robot states and object recognition.

Mixed Reality methods by Evolaris [4]: Focus of this work is to develop methods to augment visual information using Head Mounted Displays (HMDs) and modes for the user to interaction with the HMD (data input). A major challenge is given through the requirement of selecting appropriate information given the current context and individual needs of the user.

Visualization of complex data by Fraunhofer Austria [5]: The main focus is developing approaches to enable real-time visualization of large amount of data, e.g., complex CAD models, on thin clients (data glasses). Moreover, a model-based tracking approach based on CAD data is developed, to facilitate position-stable augmentation of data in industrial environments.

Interaction for robot-based Assembly processes by PROFACTOR [6]: Within this technology package, concepts to enable intuitive interaction in HRC scenarios will be developed. Major challenges include the implementation of flexible models to enable fast adaptation of process knowledge and adaptation of the human-robot interaction (user specific needs), avoiding explicit programming.

Acoustic Interaction by Joanneum research [7]: The main goal is to develop speech-interfaces to enable intuitive interaction with assistance systems in an industrial setting. In order to maximize user friendliness, the interfaces are not restricted to a collection of commands and can cope with different dialects and languages. Acoustic feedback is used to inform the user about the states of the assistance system.

Iterative Interaction Design by AIT [8] and PLUS [9]: The goal is to implement a Research through Design (RtD) based process, where prototypes for current and present interaction models/modes are developed by potential end-users. This generated, valuable feedback serves as input to an iterative development process for assistance system interaction design.

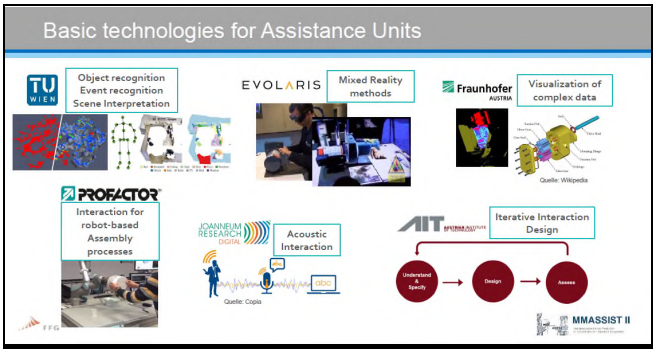


Figure 7. Basic technologies avialable for MMAssist_II Assitance Units

V. FIRST RESULTS

As the project has started in May 2017, the work performed in the first 6 months was focused on requirements and finding a set of basic technologies as described in chapter IV. Also a more detailed definition of the use cases and the Assistance Units, which will be implemented, was done. This led to 3 different Use Cases with 7 Assistance Units in total.

- **Service and maintenance (Use CASE 1)**
  - Notification of maintenance protocols (Assistance Unit 1)
  - Communication with Experts (Assistance Unit 2)
- **Setup and multi machine service (Use CASE 2)**
  - Guiding through setup process (Assistance Unit 3)
  - Multi machine service (Assistance Unit 4)
- **Assembly (Use CASE 3)**
  - Notification of Assembly instructions (Assistance Unit 5)
  - Part delivery (Assistance Unit 6)
  - Assembly instructions review (Assistance Unit 7)

A requirement Analyses based on the needs of Users of the assistance systems in the context of production was done. The goal was to capture the requirements from a technical and a socio- economic view. First steps were done so far:

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- Determine the requirements for assistance units: data collection is almost completed; current data will be analyzed and interpreted.
- Conceptual design and modeling of Assistance Units to the subsequent implementation: an adequate conceptual base model for the taxonomy of Assistance Units and situation patterns was identified and is now further developed for the project problems.
- Investigation of job satisfaction and acceptance by the use of Assistance Units: an existing framework for the project was adapted. A data collection tool to raise job satisfaction was developed.
- Analysis of relevant safety and security factors within the use of Assistant Units: Data collection was carried out and a knowledge base was developed.

VI. CONCLUSION

The main expected results is a software framework which connects all main basic technologies to Assistance units which could be used to create a Use Case sensitive Assistance system adapted to the needs of the workers. This is an open system which could be enlarged by contributing (and other interested) companies.

The main challenge is to find a software solution and architecture which is able to handle the interface problematic between the single sub systems.

Besides first promising results, it is a challenge to manage a research project with 24 partners and to find a common solution for a lot of different companies.

ACKNOWLEDGMENT

This work has been supported by the Austrian Research Promotion Agency [10] in the program “Production of the Future” funded project MMAssist II (FFG No.: 858623) and the Austrian Ministry for Transport, Innovation and Technology (bmvit) [11].

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