Assistive Augmentation at the Manual Assembly Workplace using In-Situ Projection

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Abstract
In this paper, we argue for using in-situ projection and optical motion recognition to augment a user's working experience. By recognizing motion and objects on a workplace, our system is able to detect the current step within a work flow. Based on the information about position and orientation of the work-piece specific feedback can be given - even on top of the work-piece. So far, our work indicates that this technology is accepted by the industry. Currently, we are investigating the use of gamification elements on the error rate of the working process. Additionally, we introduce a model for the conception of context aware assistive systems. We believe especially for impaired workers, using in-situ projection at the manual assembly workplace will facilitate the assembly task and enable assembling more complex products.

Author Keywords
In-situ Projection; Augmented Reality; Motion Recognition; Gamification; Workplace of the Future; Context-Sensitive Assistance; Assistive Augmentation

ACM Classification Keywords
H.5.2 [Information interfaces and presentation (e.g., HCI)]: User Interfaces; H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous.

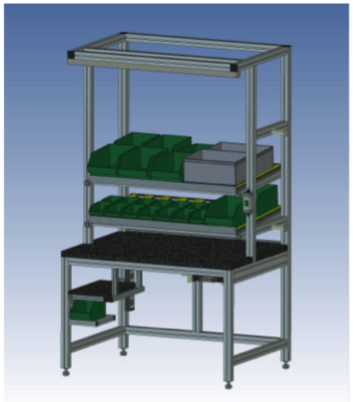

Figure 1: Assembly table as currently used in industrial production.

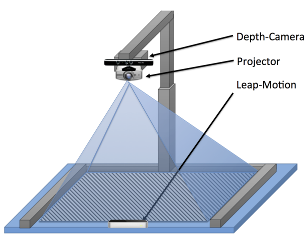

Figure 2: An overview about the used technology in our assistive system for the workplace.

Motivation

In the industry there are many workplaces where manual assembly work is done. Such an assembly workplace is usually a table with top-mounted tools that can be pulled into the workplace area when they are needed. The parts needed for the assembly task are placed behind in small boxes at the background of the table (see Figure 1). A worker needs to grab the right parts and use the right tool to complete a working step. An impaired worker usually either works with reduced complexity (i.e. simple products, few work steps) or needs a supervisor to handle the complexity of more demanding workflows (i.e. complex products with many steps). This scenario can be augmented with a depth-camera and a projector [6] to be aware of the current step and to display appropriate help according to the current situation. Using assistive systems for the workplace, cognitive and physically impaired workers can handle complex tasks on their own and do not need supervision anymore. Our previous work shows the need for adaptivity and introduces gamification [4, 5, 1] as a possibility to motivate impaired workers.

Context-aware Assistive Systems

We describe context aware assistive systems (CAAS) in production environments, which analyze the workers movements and provide context specific instructions according to the current step: Which part is next? Where does the worker need to fasten it? Has an error occurred? Has the part been processed in time? All these questions can be answered by a context aware assistive system.

A general model for CAAS is provided (see Figure 3). Since the system needs to adapt to the users needs, the model shows how sensory data are assessed and how adaptation occurs on several layers.

Projection and adaptation of instructions

We describe how CAAS in production environments can augment workplaces and support impaired workers by projecting context sensitive help into the workplace. In our prototypical setup, a top-mounted Kinect can detect touch with the surface, a bottom-mounted Leap Motion captures motion that occurs over the surface, a top-mounted web-camera identifies currently used tools and components, and a top-mounted projector displays information into the workers field of view (see Figure 2 - also see [2]). This setup allows to identify and survey the working steps performed on the surface with a granularity that is accurate to the millimeter. Thus, the system can detect movement trajectories and compare them to a reference-trajectory. If the trajectory includes errors, e.g. picking the wrong piece, mixing up the order of the working steps, or using the wrong tool, the system detects that the worker is not focused or needs help with the working step. Consequently, the system can change the modality and frequency of displayed information or provide help according to the current step.

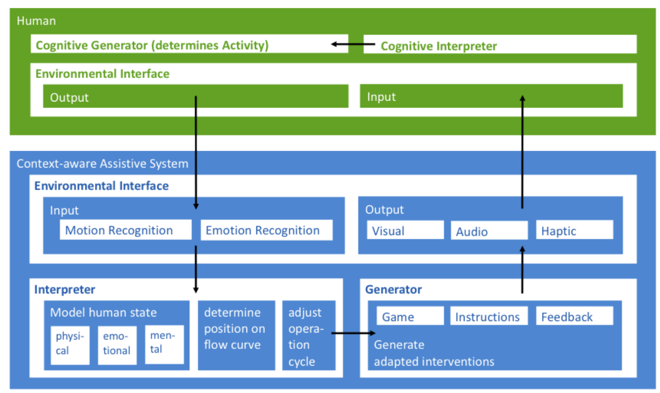

Figure 3: Model for context-aware assistive systems.

How adaptivity is realized (example)

As the cognitive condition of impaired persons can vary from day to day, an adaptive system is necessary for giving ideal feedback. The CAAS implements several levels of adaptation. In the first level, only the basic instructions are displayed e.g. an arrow pointing towards the position of the current piece. In other levels, a more detailed explanation can be displayed. This includes displaying an animation of how pieces are assembled, displaying information according to the success of the working step or displaying interactive manuals for training-on-the job.

How work motivation can be increased using gamification

The adaptivity and the context-awareness of the system allow new techniques to motivate workers during their work: the inclusion of gamification elements into the working process. State of the art techniques mount a traffic light on top of the working place, which displays the workers performance. In the CAAS in production environments, these elements are directly displayed into the working place to give immediate feedback to the worker. The displayed elements refer directly to the current task that the worker needs to do. Furthermore, achievements can highlight exceptional work like frequent high quality or work speed above the personal average.

Assistive systems as an extensible platform

As the setup of our CAAS is non-intrusive, we can envision more applications to extend a worker's capabilities and working experience. Our setup can e.g. enable user-defined tangibles [2] to control digital functions using everyday objects. The worker could e.g. bind his water bottle to control the brightness of the light at the table. Another interesting extension could be projecting a video showing assembly information onto a distinct video object. Whenever assistance is needed the video object just has to be put on the table. If the worker understood the assembly task, the video object can easily be removed.

Related Work

Augmented Reality at the workplace has previously been investigated. We divide the related work in two categories: augmenting an office desk and augmenting a manual assembly workplace.

Many systems have been proposed for using Augmented Reality in an office desk environment. The LuminAR system [8] is a camera projector system that is integrated into an incandescent bulb. By adding robotic capabilities to the lamp, the system is able to move according to the worker's needs. Another office-prototype is the interactive desk by Hardy [3], in which a projector is used to display additional information directly on the desk.

The other major scenario for Augmented Reality at the workplace is the manual assembly workplace. The ASED experimental table [7] uses a top-mounted Kinect and a projector to guide the worker to take spare parts out of the correct box. This setup is also used to survey stationary assembly tasks. However, special appliances have to be used that the Kinect can detect a work step solely based on depth data.

Conclusion and Future Work

In this position paper, we presented an assistive system for the workplace which uses in-situ projection and optical motion recognition to assist a worker with the current task. We belive that those systems will find their way into the industry as they are lightweight and rather cheap. At the current stage of our work, using gamification elements has not proven to have a positive effect on the error rate.

But this needs to be further investigated. As for impaired workers, we believe that our system can increase the workers capabilities. Guiding an impaired worker using in-situ projection might enable them to assemble more complex pieces. As currently our scenario envolved mostly impaired workers, we want to extent the scope of our system to non-impaired workers, too.

Acknowledgments

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