

Industrial Augmented Reality: Requirements for an Augmented Reality Maintenance Worker Support System

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ABSTRACT

Supporting maintenance workers with Augmented Reality (AR) applications has always been one key use case to demonstrate the advantages of AR. However, such AR applications are still not widely used in industry, which may lay at the complex industrial requirements. We present the user, technical, environmental and regulative requirements for an AR maintenance worker support system, which were gathered by analyzing three diverse production sites.

Keywords: Augmented Reality, Requirements, Maintenance, Service.

Index Terms: [Human-centered computing]: Mixed / augmented reality; [Computer systems organization]: Embedded and cyber-physical systems

1 INTRODUCTION

Augmented Reality (AR) applications supporting workers in complex service or maintenance tasks belong to the most desired industrial AR applications since the early days of AR research [1–3]. Unfortunately, up to date we fail to see the brought use of AR applications for maintenance worker support in industry, despite the extensive efforts in research considering divers approaches from hand-held [4] and glass [5] approaches [6] via assistive robots [7] to the automated creation of instructions [8]. The reason for this may lay in the complex user, technical, environmental, regulative and economical requirements that AR maintenance support applications need to meet. So far, especially projector-based AR-systems could make an impact in industrial applications especially for assembly tasks but less for maintenance applications [9–11].

In the Horizon2020 project PreCoM (Predictive Cognitive Maintenance Decision Support System) we aim at developing an AR maintenance worker support application meeting the complex industrial requirements. We use three different industrial test beds for this development: a paper tissue machine (see Figure 1), large-scale milling machine for wind power plant hubs, grinding machines for high precision gears. In 2017 we published our first step in this feat explaining how we want to extend the functionality of a numerical machine control connected AR system to

achieve an AR maintenance worker support system [12]. Now, we have completed the requirements gathering for this system. Because, of the diversity of our researched industrial use cases our gathered requirements are likely applicable for many other companies. Also, developers of industrial AR application might find our results helpful for their developments.

2 REQUIREMENTS GATHERING METHODS

We choose a combination of methods to gather all relevant requirements of the different domains. In on-site workshops the production environment, the working conditions, the current maintenance process and the maintained machines were observed. Structured interviews with maintenance managers and maintenance workers clarified their expectations at the AR maintenance support system concerning its functionalities, interactions and the relevant information needed for the maintenance support.

3 INDUSTRIAL SITES

The production environment of the paper tissue producer in Pre-CoM is characterized by high humidity and tissues particles that are swirling through the air. The production site of the wind power plant hub producer contains dust from the casted raw pieces, metal chips from the milling process and traces of various lubricants. At both production sites, workers need to wear security glasses, hard helmet, noise protection and gloves. In the high precision gear factory, traces of various lubricants and metal chips are present. Here, workers need to wear security glasses, noise protection and gloves.



Figure 1: Paper tissue production machine.

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4 REQUIREMENTS

4.1 User Requirements

Using the described methods in section 2, we could identify the following requirements for an AR maintenance worker support system covering all three industrial use cases:

- Portable access to all relevant documentation (e.g. manual, video, photo)
- Overview about required tools, materials and spare parts for a specific maintenance task
- Assisted orientation with AR projected 3D objects (especially for larger machines)
- Workflow guidance with the help of 3D animations
- Adding to the existing documentation during the task by taking notes or pictures etc.
- Accessing live telemetry data of specific machine parts while being present at this part
- Cross referencing maintenance cases to reuse solutions established in a similar case
- Recording statistical data for future planning of similar tasks
- The option to open a video conference to an expert to get additional information about the case at hand
- A feature for the expert and the maintenance worker, to share documents (text, picture, video) and augment the shared live feed with arrows, circles, etc., to highlight points of interest
- Offline mode to operate in areas without Wi-Fi connection
- Hands free operation

4.2 Technical Requirements

To support the maintenance workers with AR several technical conditions need to be met:

- Data connection (preferred wireless) at all locations of use
- Connectivity to a central data storage system, to store general task data and documentations
- Connectivity to a system that aggregates the live telemetry data of all involved machines
- Connectivity to additional systems e.g. for spare part ordering
- Operation time of at least 4 h
- Minimum of 8Mbit/s internet connection for sharing files or a video conference at production site

4.3 Environmental and Regulative Requirements

Any AR hardware used in the industrial environment will be exposed to dirt, liquids (also corrosive), mechanical hazards and electromagnetic interference. Further, the AR hardware must be usable with any required safety gear used by the worker. In this context an AR device need to meet the following environmental and regulative requirements:

- Usable with hard hat, safety glasses and/or noise protection (alongside or integrated in the equipment)
- usable with safety gloves (compensation for impaired gesture recognition and touch input)
- The device must be able to sustain a fall from a height of at least 1.2 meters
- The device must be resistant to water, airborne dust, corrosive materials, scratching and/or electromagnetic interference (can also be achieved with a replaceable cover)
- The protective measures should not impede the functionality of the device (e.g. wireless connectivity)

5 IMPLICATIONS FOR THE AR MAINTENANCE SUPPORT SYSTEM

The listed requirements demonstrate that from the sole worker support point of view a complex data integration task has to be solved. Step-by-Step guidelines for maintenance with the according supporting material have to be generated from existing manuals and CAD-data, but also new supporting materials like pictures need to be produced. Further, Live-machine-data and production-planning information must be accessible by the worker with the AR maintenance support system. What emerged clearly from the interviews with the workers is that the 3D objects, which are being displayed by the AR maintenance support system, do not in any way need to be photo realistic. CAD-system like visualizations are sufficient. More important is the easy creation of AR instructions and the easy use of the AR maintenance support system.

After seeing the complexity of the maintenance tasks, which need to be performed and supported, we decided that an authoring system operated by the workers might be the best way to generate the AR instructions. The workers are the actual experts and know best what information they need for each maintenance tasks. In our opinion, it is also the best way to ensure the AR maintenance support system will be used sustainably and not just for a few demonstration use cases.

The biggest challenge for the development is to select AR hardware that can survive the harsh environmental production condition, complies with work safety regulations and allows comfortable hands-free interaction. This rules out any head mounted displays (HMDs), as high-end devices like the HoloLens or Meta are not robust enough and cannot be worn with all needed safety gear. Also, safety gear integrated data glasses are ruled out due to the small display size which makes it impossible to read large graphics, e.g. electrical plans. Rugged projectors could have provided a good solution, however they cannot be installed everywhere at the machines due to spatial reasons, require considerable setup time and an additional device to operate it. The AR maintenance worker support system must be very flexible and easy to carry around. Using a projector system would be cumbersome to carry around and may reduce the benefits of the AR maintenance support system due to the longer setup and installation time compared to a tablet.

The only AR hardware that is currently applicable are rugged tablet computers. Although they do not comply with the hands-freeness requirement, we will rely on them in the absence of alternatives. Further, by using suction or magnetic stands the rugged tablets can be attached at the machines so that the worker can see the display and is still able to work with both hands.

6 CONCLUSION

Developing an AR maintenance worker support system that will be sustainably used in industry is a challenging feat. In PreCoM we analyzed the requirements of three industrial partners from different areas. We found a complex set of user, technical, environmental and regulative requirements an AR maintenance worker support system needs to fulfill. We identified the rough production environment and the worn safety gear as the biggest hurdles ruling out any currently available HMD AR hardware.

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