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# Mobile Augmented Reality based Monitoring of Assembly Lines

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**Abstract**

Showing process-relevant information of assembly lines is an important task in production, e.g. for diagnostic purposes. Accessing the relevant manufacturing values during production requires extensive knowledge of the used machines and their control systems (e.g. PLC, CNC) and could cause a delay of the production process. Therefore, this paper presents an Augmented Reality (AR) based application for mobile devices realizing a user-friendly and problem-oriented visualization of relevant information directly on-site. The AR application uses a uniform graphical user interface. Due to this the user does not need to handle different human machine interfaces.


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## 1. Introduction

Augmented Reality (AR) applications are already used in various areas in production engineering. Examples are assistance systems for assembly processes, assembly design and planning and the maintenance of machine tools [1], [2]. However, the usage of such mobile applications for monitoring in production processes was not in focus yet.

The scenario in this article is based on an assembly line which consists of several process steps. Without a mobile application, the user has to query all required data, e.g. the current process values, directly from the machine tool control unit. Therefore, knowledge about the handling and structure of the special control unit is required. In addition the manufacturing plant could be managed by a central control computer to get the information from one device. There, the disadvantage is that the process data is not directly available at the machine tool for the user.

For both scenarios, Augmented Reality can be a solution. With the presented AR based monitoring application for mobile devices the user can get all process-relevant information directly on-site. Thus the interruption of the production process can be kept as short as possible.

An important point is the development of a uniform and user-friendly graphical user interface for mobile devices (e.g. tablet PCs). This interface should show the current and important process values and also malfunctions so that the user can influence the process if necessary. The visualization is done with suitable graphical elements that are superimposed over the current camera video. The developed software solution is applied to a specific scenario of an assembly line.

## 2. State of the Art

In the last few years, several approaches were researched for using AR technology in production engineering. Assembly and maintenance scenarios are typical fields of application for it. AR approaches were introduced which support workers with dissolved virtual instructions for assembling or repairing a machine tool. Such systems show animations and graphical hints (e.g. virtual arrows). Users of the system can see where


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a part has to be applied and which tools are needed. Another benefit is that all instructions are shown in the right order. Therefore, workers can also maintain machine tools which are unfamiliar. No time consuming teaching is necessary because the required knowledge is stored in databases. [1]

For more difficult damages, predefined repairing instructions may not be sufficient due to the fact that the cause of the damage is not clear. In this case expert knowledge is necessary. A remote support system can solve this issue. [3] describes an application tool which addresses this field of research. The authors suggest an approach how a maintenance expert sitting in his office accomplishes technical support to a maintenance operator on-site. The expert has a graphical interface with several elements for creating AR based instructions (e.g. highlighting components or marking dangerous zones).

In contrast to the maintenance scenario, [4] present an approach for assembling only with AR components instead of real objects. This *"AR aided interactive manual assembly design"* enables to simulate a whole assembly process without the need of auxiliary CAD information.

AR assistance systems are another field of application for planning and extending assembly lines [5], [6], [7].

Beside the scenario, the technique behind is also worth investigating. Different AR frameworks were introduced to support the development of AR applications. *Distributed Wearable Augmented Reality Framework (DWARF)* (see [8]) is a very well-engineered and well-developed framework. It is built on a service oriented, distributed architecture and relies on the *Common Object Request Broker Architecture (CORBA)* [9]. This leads to a high modularity of *DWARF*. However, the initial training effort is very high. Performance may also be an issue for mobile devices with moderate hardware equipment.

Another approach is *Augmented Presentation and Interaction Language (APRIL)*, an authoring language to describe AR content [10]. The advantage of such a platform is also the disadvantage. The easy usable scripting language (in contrast to a programming language) is restricted to the possibilities of the authoring language.

Summarizing, the presented approaches concentrate on assembly scenarios and assembly line planning. Monitoring process values with AR support was not in focus of work, yet. Available frameworks are not easy to use or limited in their possibilities.

## 3. Augmented Reality Framework

Programming AR applications presumes a deep knowledge of the technology behind. However, the scenario and the content are much more important for application developers than understanding the detailed concepts of AR programming. A solution for this fact is the introduction of an AR framework which defines clear interfaces and hides the complexity of AR technology (see Fig. 1). Therefore, the goal of such a framework is to simplify and to speed up the development of AR applications.

With regard to the required components of an AR application, it was proven as an advantage to separate the AR framework into three areas:

- picture taking
- tracking
- graphic

An AR application needs a camera picture of the real world where virtual objects dissolve. This is the area of picture taking. After this, a tracking must be performed to recognize objects (e.g. markers) and to calculate the position and orientation of the virtual camera. Both parts are isolated from the user scenario and represent the basis of the AR framework.

In contrast, the graphic part is dependent from the scenario to visualize the received data. It has to be in full charge of the application programmer. Therefore, the graphic has to be mounted from outside through an interface. The strict separation in the presented three areas leads to a high cohesion resulting in a high usability and maintainability of the software design.

Based on this concept, an application was realized (called *ARViewer*) which implements the introduced interfaces. Picture taking and tracking takes place within *ARViewer* itself, handled by manager classes. Therefore, the application is capable of showing pictures and tracking, without any scenario.

Now, the application developer is in charge to provide the graphic which should be displayed on top of the camera picture. Therefore, a plugin concept was implemented for visualizing scenario dependent content. Plugins have to contain an AR container which provides the specific data management, the AR graphic and an optional 2D graphical user interface (GUI) for the *ARViewer*. To adapt the visualization with respect to the tracking information the recognized tracking IDs are transmitted to the graphic object.

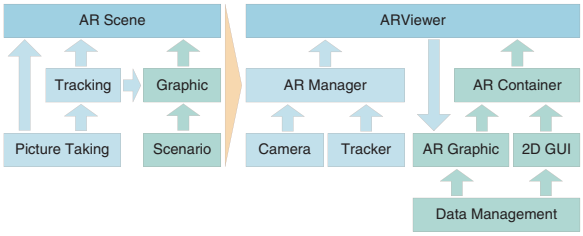


Fig. 1. Structure of the Augmented Reality Framework.

Summarizing, the presented framework enables the development of AR applications with focus on the scenario data and their graphical representation. Camera management and tracking are part of the *ARViewer* and therefore, no further programming work in this fields is necessary for the application developer.