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Visual Assembling Guidance Using Augmented Reality

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Abstract

This paper describes a study of using the concept of augmented reality for supporting assembly line workers in carrying out their task optimally. By overlaying virtual information on real world objects – and thereby enhance the human's perception of reality – augmented reality makes it possible to improve the visual guidance to the workers. In the study, a prototype system is developed based on the Oculus Rift platform and evaluated using a simulated assembling task. The main aim is to investigate user acceptance and how this can possible be improved.

Keywords: visual guidance, augmented reality, assembling, oculus rift

1 Introduction

Within industry, assembly line operators commonly face complex products structures and complex assembling sequences. The complexity, in combination with the pressure of completing the assembling within a minimum time frame but with maximum quality, makes it hard for the operators to act optimally. To aid the operators and support them to carry out the assembling task in the most efficient way, enhanced visual guidance can be used. This paper describes a study of using the concept of augmented reality (AR) for this purpose. With AR, artificial information about the environment and its objects can be overlaid on the real world in order to enhance the operator's perception of reality. Formally, an AR system is defined as having the following features (Krevelen and Poelman, 2010):

(a) ability to combine real and virtual objects in a real environment,
(b) ability to register (align) real and virtual objects with each other, and
(c) ability to run interactively, in three dimensions, and in real time.

The technology enabling AR has advanced rapidly over the last years and there exist a number of real-world applications today, mainly within areas such as gaming, sports and tourism. Within the context of shop-floors, AR has been discussed for over 20 years, but there exist few practical

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demonstrators. Tiefenbacher et al. (2014) discuss that AR has so far only partly succeed when it comes to industrial applications, mainly because the industrial setting is highly challenging and complex. We believe that a key factor for the success of AR on the industrial shop floor is acceptance by the users, and in this study we focus on this aspect with the aim of identifying factors that has potential to increase acceptance. With increased acceptance, we believe that AR is one step closer to become part of everyday assembling at the industrial shop-floors. The following aspects are central of our study, which altogether distinguish it from previous studies:

- *Focus on acceptability rather than performance*
  A literature review reveals that the majority of the existing studies within the field focus on the improved effectiveness gained with AR (i.e. being quantitative), which is also noticed by for example Dünser et al. (2008).

- *Focus on non-experienced users*
  Our study focus on junior operators that have no previous experience from the specific assembling task they are to carry out. This focus is motivated by the fact that unexperienced operators are those who can benefit most from AR from a training perspective. To a great extent, assembling is a repetitive task that is memorized over time and an experienced operator might therefore benefit less by AR support. Also previous studies indicate that AR is most efficient when the assembly task is difficult for the operator (see for example Wiedenmaier et. al, 2003), which most assembly tasks normally are for new operators.

- *Fully replicable assembling task that can be reproduced for benchmarking purposes*
  The assembling task used in the study is a 3D puzzle that this fully replicable and possible to use for future benchmarking and evaluations of AR solutions.

- *Prototype based on cheap, off-the-shelf consumer hardware*
  In the study, we develop an AR prototype that is based on the Oculus Rift platform which is a cheap consumer product that is easy to work with. As far as we are aware of, this is the first study that uses Oculus Rift for industrial assembling.

The study is part of the research carried out at the University of Skövde in Sweden, which aims to technically improve the industrial shop-floor and provide industrial operators with better tools in order to support the operators in making the right decisions and work optimally. The authors are certain that AR is a key to fulfill this aim, and also that the technique will be a part of all modern, high-tech shop floors of the future.

The next section continues by describing the approach used in the study for implementing AR. In Section 3, the equipment developed in the study is presented, followed by a description of the experiment performed in Section 4. In Section 5, results from the experiment are discussed. Section 6, finally, outlines conclusions from the study and possible future work.

2 Related work

AR for assembly support is a research community that was established already over 20 years ago. A summary of some of the most relevant studies within the community follows below in chronological order.

Caudell and Mizell (1992) investigated the use of a heads-up display in the assembling of aircraft wire bundles and developed an early prototype of AR. Curtis et al. (1999) later on investigated the prototype developed by Caudell and Mizell (1992) and performed additional user tests which indicated practical problems as well as acceptance problem. Reiners et al. (1999) developed an AR prototype