Reflections on augmented reality for Heavy machinery- practical usage and challenges.

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2017 Workshop on Augmented Reality for Intelligent Vehicles
September 24, 2017, Oldenburg, Germany

Abstract
As industrial systems, for example, vehicle systems, get increasingly autonomous and information intense, the information exchanged with the user, i.e. the operator, are increasingly becoming a designed interaction. Augmented reality is one interesting approach to mediate the increasing information available through the machine systems. This reflection statement discusses some of the possible use of augmented reality in industry vehicles. It also touches on hypothesizes for interaction with these systems and related challenges for an increase in adaptation.

Author Keywords
Augmented reality, Heavy Vehicles, Interaction Design

CCS Concepts
Human-centered computing → Ubiquitous and mobile computing → Ubiquitous and mobile computing design and evaluation methods

Introduction
Vehicles used in industrial applications, such as in agriculture, construction, and forestry, are increasingly powered by digital information in their production.

These new information based systems aid the operator's task fulfillment, improve productivity and enhance safety etc. Moreover, as machines get connected, even more information is exchanged with the machine and external information systems, as well as between machines [11]. With higher levels of autonomy, it is also likely that the activities and purpose of the operator will transform more towards managerial activities than operational. The operator might, for example, control not only one but a number of machines. This evolution has many benefits but there might also be negative side effects. Operation of industrial vehicles can be related with cognitive challenges and high mental load. For example, already today the working situation of a forestry harvester operator has been compared to that of a fighter pilot [10]. Further increasing the information load can potentially increase the risk of failure and human safety [2,7].

One approach to mitigate the negative effects of the increasing information being presented is the use of augmented reality and see-through interfaces.

Potential use of augmented reality in industrial vehicle settings

Using augmented reality interaction, thus blending system information with the real world, have potential to enhance situational awareness. Following is a short imaginative scenario to illustrate this:

The operator of an excavator prepares a ground on a building site. Visible in front of the operator is the different leveling areas and their needed adjustment, based on the blueprints and scanning of the surrounding. The system also presents and alerts about pipes and electrical lines in the soil. The operator can hence focus attention on the area of operation, instead diverting attention on to display based precision systems. Meanwhile, a supporting autonomous dump truck is approaching the excavator. It's carrying additional gravel to fill an area. Upon arrival the excavator system displays an alert in the visual range of the operator, indicating close range movement. The planned passage and unloading place for the dump truck also is presented and the operator can acknowledge the passage. This example can be extended with more information, for example, pedestrian information, sensory data, full 3D visualization of the property construction etc.

Augmented reality can be done both using information presented inline of sight of the operator. But it can also be used with traditional displays mounted in the cabin. This would provide a more near term solution as modern advanced industrial machines are now commonly equipped with graphical displays and cameras that present information from the surrounding area or from the production process. Using augmented reality in the cabin displays would let the operator be in touch with the surrounding while at the same time get benefits from the information available via the vehicle information systems. Although, to use the whole cabin windows to present information would open up for more possibilities. This way the user doesn't have to look away from the operation area to acquire system information, and it would also provide a larger screen area for information presentation.

Challenges and hypothesizes

Realizing augmented reality solutions for the heavy vehicle industry is related both to technical challenges and usage challenges.

There are at least three basic technological solutions to visualize augmented reality in industrial vehicle settings. Each with its pros and cons [14]. One alternative is to use head-worn mixed reality displays [4]. Together with digital models, this technology is maturing to replace blueprints while building properties [8]. But these devices still have limited battery time and the operator have to take extra steps by putting on equipment before being able to operate or move in and out of the vehicle. Mobile devices (smart phones) can also be used in augmented solutions, for example, in mobile mixed reality interfaces where information is overlaid on the display of the device [5,12]. But these solutions limits operation, when the users hands are occupied holding the device. Still, it can be a good complement when the operator is outside of the vehicle, or for people that aren't actively working hands-on.

Finally there is Head up displays. Although Head up displays visualization has become more available there are still limitations. They currently lack a big enough display area for the large windscreen of heavy vehicles. Also, many vehicles lack dashboards, and would thus require another type of mechanical and optical solution. Alternative technologies, such as OLED, does not sustain the environment. Examples exists of bigger displays even for industrial settings, but pricing makes them unavailable for mainstream introduction. Many advanced machines are also produced in fairly low volumes, thus they cannot take the cost to make the fundamental technology development needed. There is a need for research of a visualization technology with an affordable cost that can fit the application and the environment of heavy vehicles.

Although technology offers possibilities for enhanced efficiency, usefulness and experiences, the use of technology itself does not warrant these benefits. Many interesting technologies have failed or taken time to reach a market break through due to insufficient maturity, lack of a usefulness or subpar usability. Additionally, the way to mediate information in information intense and increasingly autonomous vehicles is an area of research. In comparison, again with road vehicles, there is a different need of information in industrial applications than with road vehicles. The information need is not only about transportation but also about the production process performed by the vehicles. In farming, Sørensen et.al mention that acquisition and analysis of information still prove a demanding task [13]. Furthermore, the availability of data does not warrant the understanding or usefulness of the data to the user [1]. In my studies of vehicle operators, I have used eye-tracking equipment to register where the operator put their attention, and the display usage was surprisingly low. The sample set was too low for a firm quantitative result, but for this case, the majority of the users (four out of five vehicles) spent less than 1 percent looking at the display during the production cycle. There were also cases when information on displays was missed, as it was presented outside of the operators visual area. However, the vehicle information system was quickly accessed when something wasn't behaving as expected or when doing specific tasks where the data was

crucial. During more information intensive tasks the usage raised up to 7 percent.

Also, examples of studies that have evaluated see-through interfaces in the heavy machinery have mainly focused on taking production information currently visualized on displays, and replicating this in the field of view of the operator [6,9]. Thus focusing less on renewed ways to present production information, as well as mediation of additional information. Finally, there is also the challenge of over utilizing AR, with the subsequent risk that the operator will be flooded with information.

Final remarks

Successful application of AR will require a well-founded understanding of the practical application, this in addition to visualization technology, incorporation of sensory data, vehicle data and external data sources. I also believe that it is about designing the interaction between the user, the machine, and the surrounding environment. In our work, we have thus initially focused on exploring a minimalistic approach of presentation, including a cross system language of interaction. This language could be a uniform symbol language that can be used in many types of applications in several industrial machinery contexts and handle diverse levels of criticality.

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