Creating Effective Interfaces in Autonomous Machines

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Topic: Guiding the Design of Human-Autonomous Machine Interfaces

Background

Benchmark Electronics is a large electronics development and manufacturing company with its headquarters in Tempe, Arizona. Benchmark Netherlands in Almelo is specialised in research and development services for mainly industrial controls, aerospace, test & instrumentation and medical markets. The design engineering group within Benchmark Netherlands executes complex and innovative projects from initial concept phase through development, NPI, manufacturing, fulfilment and aftermarket support.

Autonomous machines play an increasingly prominent role in daily life and in industrial settings specifically. The interface of an autonomous machine is of great influence of the successful application of the autonomous machine, especially in industrial settings. Therefore Benchmark Electronics issued an assignment focussed on the development of guidelines to aid the design of human-autonomous machine interfaces. These guidelines were then applied in a design case with the YuMi, a collaborative robot developed by ABB Robotics Ltd. This design case focussed on the assembly of small parts and aimed for optimisation of the interface between operator and YuMi, whilst guiding the assembly process.

Approach

Extensive literature research was used to create the guidelines. These guidelines were applied in the analysis phase of the design case with the YuMi, along with other analysis methods such as a PACT analysis and an interview. The analysis phase provided requirements that were used in the interface design. In the ideation phase four participants who have experience working with the YuMi were invited to take part in a generative session. During this session issues in programming and working with the YuMi were addressed and ideas to solve these issues were generated. The session provided input for a morphologic overview, which led to three concepts. The final concept was a synthesis of the three concepts. A prototype was created to validate the final concept. Finally, the application and effectiveness of the guidelines was reviewed.

Results

In the end the developed guidelines can be divided in two distinct sets: one set of guidelines determines how to analyse the level of autonomy of the autonomous machine and the impact it has on the human-autonomous machine interaction. The other set of guidelines sets out to support the design of effective interfaces for autonomous machines.

The set of guidelines to analyse the level of autonomy of an autonomous machine was explicitly applied in the design case with the YuMi as part of the analysis. The second set of design guidelines was implicitly applied in the design of the interface for the YuMi. The final concept in the design case comprised of a mixed reality interface for a headset to be used when the operator is collaborating with the YuMi, either during the assembly process or whilst doing visual inspections. The final prototype was a simple click through interface prototype for the HoloLens.

Conclusion

The guidelines proved a powerful tool in process of analysing and designing the interface for the YuMi. Though the guidelines were only applied in the analysis phase of the design process, the guidelines can be applied throughout the entire design process, as means of generating information or reviewing a design and analysing the use in the real world. The guidelines need to be tailored to the context they are used in to be most effective, making a distinction between industrial and consumer contexts.

Using mixed reality to support assembly and visual inspection tasks is a good match with the YuMi. The interface provides more natural means of interaction and enough flexibility for the operator to enjoy their work. The concept is still in a very early design stage and will need further development.