Redesign of a Human-machine Interface of a Micro-assembly Machine

The Fraunhofer Project Center (FPC) located at the university of Twente is a research centre that applies current research in the field of advanced manufacturing technologies – such as 3D printing and near net shape manufacturing – to industry. One of the projects currently running entails the development and testing of a modular micro-assembly machine. The machine is designed for moving, assembling, and detecting components on micro-scale. It is intended for low-volume production with large variability. (lot-size-1) It has a high precision, with an error of 1-2 microns over the whole operating range. The following figure displays the core of the machine:

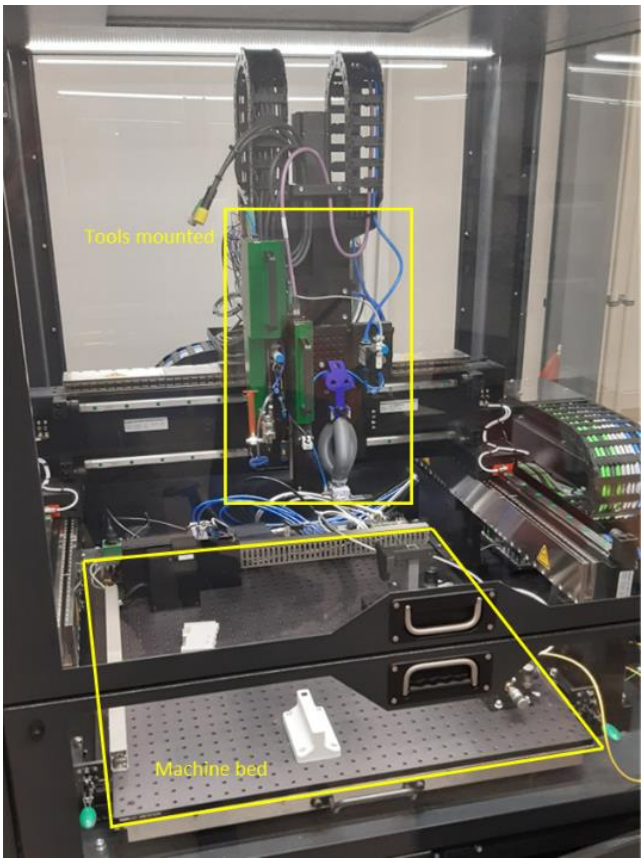

Figure 1: core of the micro assembly machine

The machine is modular since different tools and objects can be mounted in the outlined areas, allowing for multiple configurations. In the figure, the upper rectangle indicates where different tools can be mounted. The lower rectangle indicants the area of the machine bed, where different objects can be mounted dependent on the configuration.

The machine is controlled by a human-machine interface (HMI), which operated on a computer in this case. This software consists of a screen with buttons, text fields, and information. The HMI has several design and usability problems, which are especially apparent in the 'manual' function. This is an essential function that moves the machine

components in a user defined way. The problems mainly entail redundant sub-functions, and ineffective workflow and missing safety features. The aim of this assignment proposing an interactive prototype for a redesign of the 'manual' function to demonstrate how these problems can be mitigated. The prototype is independent of the machine, but contains feedback to show how it is supposed to work in conjunction with the machine.

The main screen of the HMI is displayed in the following figure:

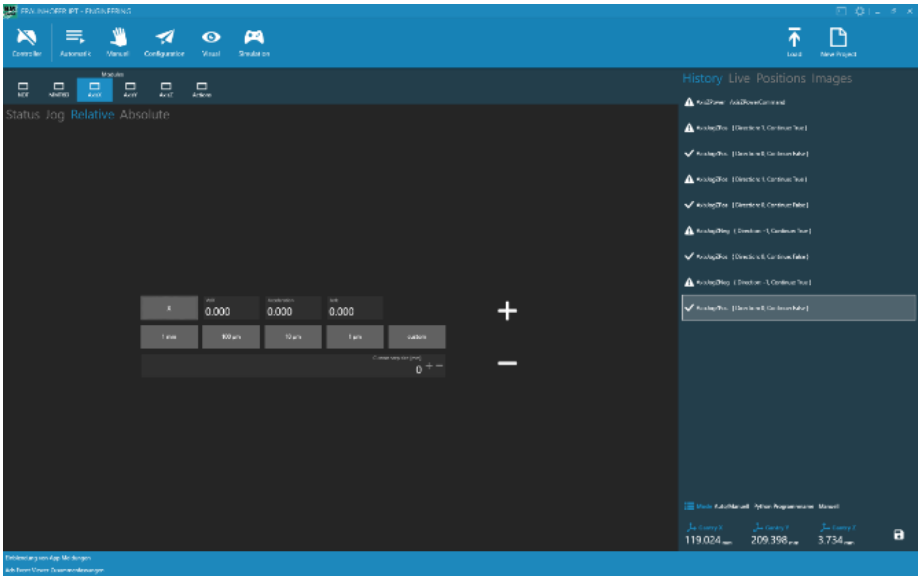

Figure 2: Current HMI

The assignment was executed by the following phases: research, development, testing, and evaluation. The research phase outline information about HMI design and guidelines, how the HMI works, and user research. It concludes with a list of requirements. The development phase includes idea forming, after which ideas are structured into a morphological diagram. 2 resulting concepts are described, which were tested in a short feedback session. This feedback resulted into 2 improved concepts and a third concept. A concept was selected by evaluating the advantages and disadvantages and analysing with common design guidelines like Nielsen's ten heuristics.

The main screen of the prototype is viewed in the figure below.

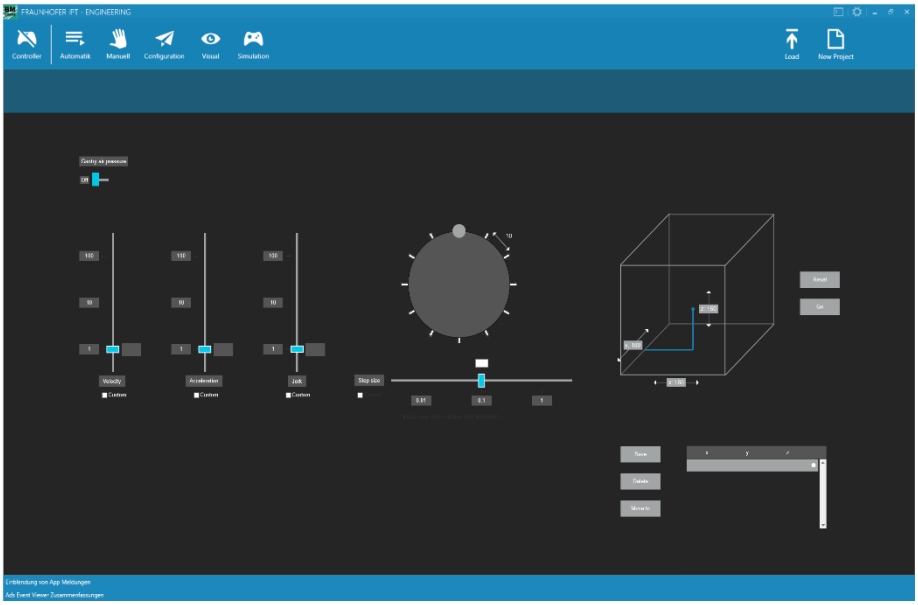

Figure 3: Prototype

The interactive model can be accessed via the following link: https://m3hrpa.axshare.com

This concept replaces all the functionalities of the original 'manual' function while adding 2 more:

1. A function to set, save, and select user defined reference points
2. A function to set limits to the axes travel for collision prevention

The second function in the list above was not implemented due to software limitations.

To validate the prototype and to compare with the original HMI, a testing session was held with 5 participants representative of the target group. From this session it could be concluded that the prototype can offer a better alternative to the original HMI function, but there are several opportunities for design improvements to make it more feasible.

In conclusion, the result of this assignment shows how the usability of this HMI can be improved by redesigning a part of it. With several changes to be made, it can be ready for implementation. It would contribute to mitigating the design and usability problems as mentioned before. More usability testing could help to revalidate the prototype and refine it. In a broader context, the working principles of this prototype could offer an alternative approach for the design of jogging functions in digital user interfaces for similar machines. This includes most machine that use a gantry system and have a digital user interface, which includes mills, CNC mills and lathes, 3D printers, and laser cutters.