Connecting tangible and virtual objects in a Synthetic Prototyping Environment

An assignment for the Virtual Reality and Smart Industry Lab

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This Bachelor Assignment has been executed for the Virtual Reality and Smart Industry Lab (VRSI Lab) at the University of Twente, in consultation with Roy Damgrave and Eric Lutters. In the VRSI Lab, the interaction between tangible and virtual objects is used to help with decision making. In this assignment, the focus lies on the moving virtual objects in a 3D application (Unity3D), based on the movement of tangible objects in the real world. This is all combined in a Synthetic Prototyping Environment (SPE). This SPE is already placed in the VRSI Lab, and allows the movement of tangible objects based on data from the 3D application. During this assignment, steps have been taken to add functions to the existing prototype and make a connection from the real world to the virtual world. As the current world situation made it impossible to work in the VRSI Lab, the assignment is mainly theoretical and not (yet) functionally incorporated in the SPE.

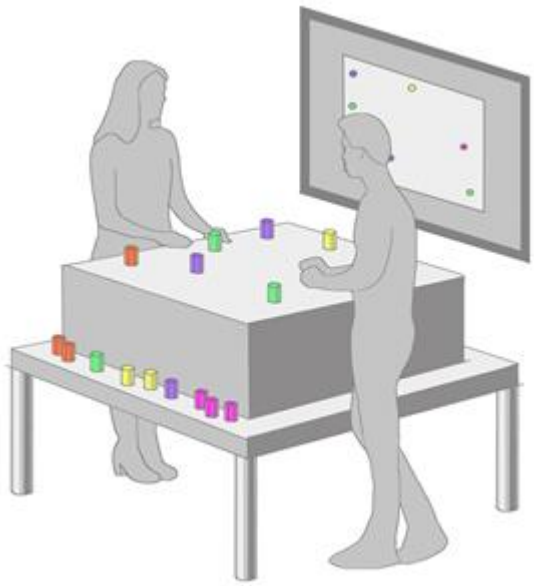

Figure 1: An example of the SPE in use; users are moving tangible objects on a table, while a screen shows a virtual representation.

This assignment consists of two main parts: research on the available and required technology, and writing of functional code. First, some smaller steps had to be taken to define the outline of the assignment. An analysis was performed on the current status of the SPE. Also, stakeholder discussions and scenarios helped set up functional requirements for the SPE, now and in the future. Some outlines were set for the physical design of the SPE in the future of this project.

The research executed was focussed on two fields: research on different ways of tracking tangible objects, and research on different software programs. To track the tangible objects, the use of camera systems and (radio) wave systems were discussed. According to the research, a

camera tracking system would be best suitable for the current version of the SPE. The technology would be able to track objects without interfering with the currently applied technologies. Therefore the choice was made to use a camera system for this version of the SPE. To build the connection between the tangible and virtual objects, a software system is needed. The use of OpenCV (and Python as a programming language) was compared to the use of Vuforia. OpenCV is a library that works well with cameras and detection in images or video. Vuforia is aimed at augmented reality, and has two systems to track objects. As OpenCV offered more freedom where Vuforia was limited, the choice was made to work with OpenCV.

Following the research, software for detecting tangible objects had to be created. First, the camera that is used will take a picture and store this image. Then, the image will be analysed. *Figure 2* shows an example of an image. This example is not a picture of the SPE but a digital image created for testing purposes. During the analysis, the code looks for markers to find the tangible objects in the image. Once objects are recognised, their information is stored in a digital file. This file can be accessed by other software to create a virtual representation of the real world situation. To recognise the objects, many steps have to be taken. Most steps are necessary to prevent errors or incorrect results of the analysis. An example of a virtual representation (based on *figure 2)* is shown in *figure 3*. In this example the results are colors, in practice the virtual representation will look very different, with 3D models of the objects that need to be represented.

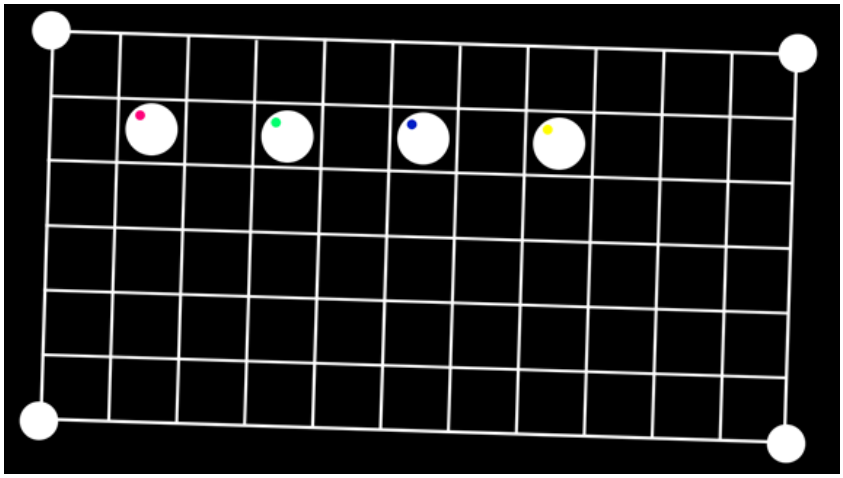

Figure 2: An example of the top view of the SPE

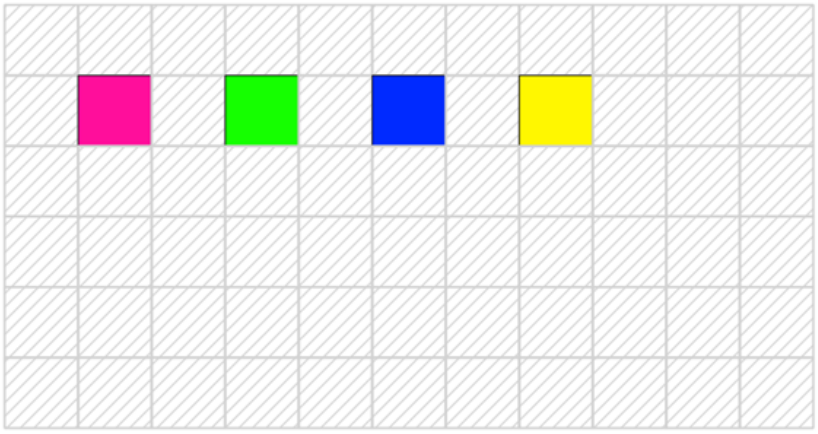

Figure 3: An example of a virtual representation

For further developments it is recommended that the tracking system is researched again. For the current SPE the use of camera tracking was the best option, but this technology has certain limitations. The accuracy of detection should be improved in the future, and making use of other tracking systems may enable stacking of objects. It could also eliminate the requirement for a line of sight between the objects and the tracking system. The software written for this project should also be revised and improved by professional computer programmers. The next step in the process of developing a SPE is visualizing the data with 3D software, in this case most likely Unity3D. Only when the data is visualised, the connection between tangible and virtual objects will be complete.