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Subject Area	Digital Image Processing
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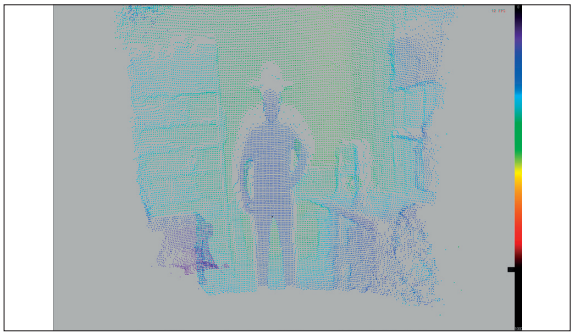
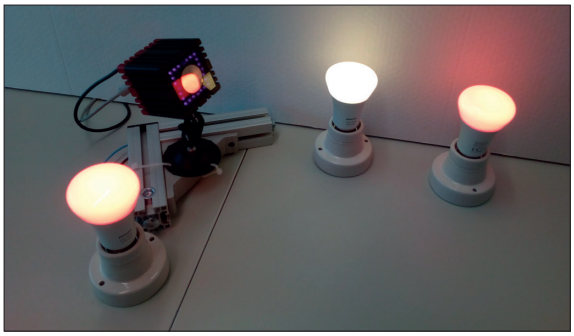
Smart Lighting

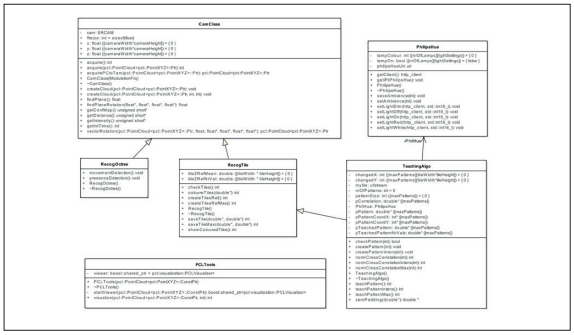
Design and implementation of a smart lighting solution using a Time of Flight (ToF) camera



An illustration of a Point Cloud with a person standing in front of a wall. The colour indicates the distance



An example of a setup where the Swiss Ranger 4000 camera works together with Philips Hue light bulbs, building a smart lighting system



The class diagram provides an overview of the C++ implementation

Task: The central goal is to develop an algorithm that provides the possibility to detect objects and living things in a defined area and to extract their positions and activities. The smart lighting system then uses the information to adjust its parameters to the given circumstances. Philips Hue is used as the lighting option, while the ToF data from the SR4k camera is visualized and processed by the Point Cloud Library. As the latter is written in C++, the solution is based on this programming language. In addition, as Heptagon is currently working on a new camera which is called TARO, the algorithm has to be optimized for its different specifications compared to the former SR4k camera. The goal is a demonstration of the smart lighting application and a characterization of several implemented algorithms.

Objective: In a first step, the differences between the two cameras are discussed. As the TARO camera features a slightly worse resolution and a different ratio, the SR4k's image has to be adjusted. Another difficult task is the setup of scenarios. The camera is therefore attached to a stand. It points towards the ground, recording in the bird's eye view. With a RANSAC-based algorithm, the system is able to find the ground plane and its angular position to this plane. A vector rotation then corrects the orientation of the plane. While the physical setup is done, the issue of connecting all the different libraries in C++ is dealt with simultaneously. A difficult task is the relationship between the Mesa Imaging library, which communicates with the camera, and the Point Cloud Library.

Result: It was possible to downsample the image to the resolution of the TARO camera. More importantly, it was possible to track a person from above. The camera's field of view was therefore split into tiles which consist of several neighbouring pixels, building a squared pattern. Those tiles were observed over time and compared with reference values. By implementing a normalized cross-correlation computing the data series, an object or person can be tracked in the observed area. Considering that the aspect of rotation is not included, a principal component analysis could be an approach to detect rotated patterns. As a result, a smart lighting system was implemented controlling the Philips Hue light bulbs, using the computed information. A ROC analysis concludes the thesis, illustrating the performance in various test situations.