Detection of Environmental Obstacles for People with Walking Disabilities

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Introduction: Advances in machine learning have paved the way for numerous applications. These include real-time object detection to help individuals with physical impairments navigate their environments. At the MedTech Lab at OST, an advanced exoskeleton was developed to support people with walking disabilities. To leverage the potential of this exoskeleton, reliable real-time detection of environmental obstacles like stairs is crucial, notifying their pilots of approaching barriers or enabling the exoskeletons to adapt dynamically to changing environments. This project aims to integrate a real-time stair detection system, tailored for use in an exoskeleton, on an edge device.

Approach: A literature review was conducted to explore existing approaches to staircase recognition and identify suitable datasets and algorithms from available resources. Initial efforts included the selection of appropriate edge hardware, leading to the choice of a Raspberry Pi 5 paired with the given Espros Time-of-Flight (ToF) and RealSense D455 cameras. Using the setup shown in Fig. 1, a diverse dataset was gathered which features various camera mounting positions. Depth images from both cameras, and RGB images from the RealSense camera, were collected for different environments and scenes with stairs (Fig. 2). In further work steps, the selected algorithms were analyzed and aligned with the dataset, including processing and labeling the data, understanding the algorithmic requirements, and evaluating the algorithms' performance. After selecting the most promising algorithm, the final step was to adapt and extend it, deploy it on the Raspberry Pi and integrate it in a cohesive real-time system which coordinated camera data acquisition, algorithm processing and output presentation.

Conclusion: This project resulted in a versatile dataset, a performance analysis of the two selected stair recognition algorithms and a final framework that allows to detect both ascending as well as descending stairs in real-time (Fig. 3). Since the chosen model not only detects stairs but also provides information about their geometry, future efforts may focus on measuring the step dimensions as valuable and feasible enhancement, providing the exoskeleton or its user with even more detailed information.

Fig. 1. Wearable hardware setup used to capture the dataset with Raspberry Pi 5, RealSense D455 and Espros ToF cameras.
Own presentment

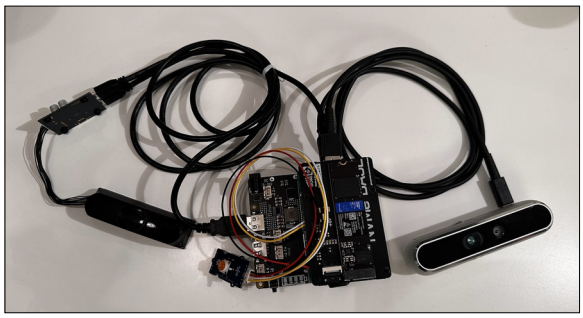
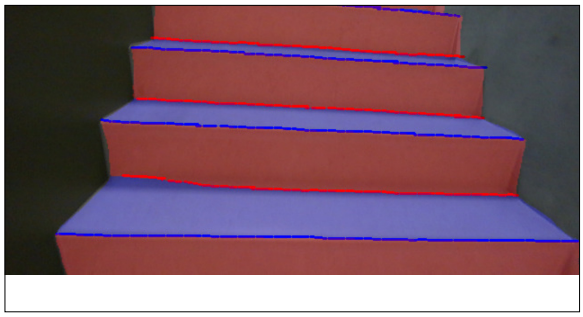


Fig. 2. A selection of various scenes featured in the collected dataset.
Own presentment

Fig. 3. Visualized output from the chosen model, StairNet [1], a deep convolutional neural network (CNN).
[1] https://github.com/MrChenWang/StairNet-DepthIn



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