Detection of Objects and Obstacles Using Sparse 3D Information for a Smart Walker

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The aim is to develop a small and autonomous device for rollators to help elderly people, especially those with some degree of visual impairment. We propose a method for the detection of obstacles in real-time using sparse 3D information. In our approach, 3D data are extracted from a stereo-rig of two icycams [1] and processed to perform a classification. We also present a deformable 3D object detector for which the 3D points are combined in several different ways and result in a set of pose estimates enabling a more robust classification.

The need for mobility aids is becoming more and more important in view of the increasing proportion of senior citizens and their wish to enjoy a high degree of autonomy for as much time as possible. The EyeWalker project aims to develop a low-cost, ultra-light computer vision-based device for users with mobility problems. It is meant to be an independent accessory that can easily be fixed on a standard rollator and will help to detect the position of specific objects in various environments and under widely varying illumination conditions.

We developed a novel strategy for the effective detection of obstacles and objects by boosting classification on sparse 3D information. Extracting a few stereo data points with our low power and high-dynamic range cameras enables the obstacle detector to run in real-time under any illumination conditions and for a long period of time.

The obstacle detector employs three families of features to describe the cloud of points (Figure 1). It uses a mixture of 3D sparse information and 2D pictorial information.

![Figure 1: Visualization of the obstacle detector features: (top left) a 3D box in which we count the number of points; (top right) a pair of areas for the computation of difference of luminance; (bottom) Haar filter with the third shape described in the sketch on the right.](image)

With pose indexing detection method [2], we aim at detecting planar objects in a 2D image by combining the 3D points in several different ways, resulting in a set of poses. A feature family is defined in the model space: the pose estimate allows the features defined on the model to deform themselves. For example, the pose estimate describes that a square door will appear as a trapeze in the image. The features will be deformed to stick to the trapeze (Figure 3). Three families of features were defined including the Haar-like filters shown in Figure 2.

![Figure 2: Haar like feature for the detection of the cabinet door.](image)

The performance of the obstacle binary classifier was evaluated on a test set with 732 pairs of frames. Our system is trained to detect obstacles and trigger an alarm as soon as one obstacle is at a distance of less than two meters from the rollator. Compared to a baseline detector that counts the number of points into a warning area, an improvement from 68% to 75% true-positive at 10% of false alarm was achieved.

![Figure 3: Square model correspondence to a trapezoidal representation of a door, with a deformable Haar-like feature, the model being a front facing square.](image)

Cabinet doors were chosen for the evaluation as examples of planar objects. The preliminary experiments were performed on a data set of stereo pictures taken in kitchens (Figure 4).

![Figure 4: Samples of the data set of cabinet doors (left-camera).](image)

The localization of the doors improved for open doors as compared to closed ones: the rate went from 85.4% to 96.1% and the true-positive rate from 66.5% to 83% at 10% false-positive rate. It highlights several limitations of the selected pose estimator and the ambiguity brought by closed doors.

The generic obstacle detector shows promising results. The deformable 3D object detector remains an interesting strategy, but still needs to be further improved in order to be put into practice.

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