Abstract: Omnidirectional Vision based Topological Navigation

Toon Goedemé[1], Marnix Nuttin[2], Tinne Tuytelaars[1], and Luc Van Gool[1,3]

[1]ESAT - PSI - VISICS
University of Leuven, Belgium

[2]PMA
University of Leuven, Belgium

[3]BIWI
ETH Zürich, Switzerland

Figure 1: *Left: the robotic wheel chair platform. Right: the omnidirectional camera, composed by a color camera and an hyperbolic mirror.*

This work presents a unique system for autonomous mobile robot navigation. It is developed for large unmodified environments, both indoor and outdoor. Our main application is an automatic robotic wheelchair. With this system, severely disabled patients gain back their mobility independence.

The system's main sensor is a omnidirectional vision sensor, which is composed by a color camera and an hyperbolic mirror. Only a set of ultrasound sensors is added for obstacle detection. This leads to a very cost-efficient and widely applicable system.

All algorithms of the system, i.e. automatical topological map building, localization, path planning and locomotion are based on state-of-the-art fast image computing methods. We make use of fast wide baseline matching techniques which are able to find natural correspondences between images even if viewpoint and illumination differ significantly. This enables quasi-real-time comparison of images and landmark detection on natural images, i.e. without the need for artificial markers.

Due to the automatical topological map building algorithm we developed, the system is very easy to train. During a human-guided training tour, the system is led through the environment while it takes images at a fixed rate. Later, these images are automatically ordered to form a topological map of the environment. The nodes of this map are distinct places such as rooms or crossroads, while the edges represent the paths between these places.

This map is very suited for localization. A new image taken at an unknown place is rapidly compared to all the images in the database using a two-stage illumination-invariant image comparison method. When available, a Bayesian framework takes in account previous localization results to decrease the localization error. Enabling very reliable sequential localization, this method also even solves easily the so-called *kidnapped robot problem.*

If the present location is known and the user indicates a target location, the topological map is used to find the shortest path to follow using Dijkstra's algorithm. This path is described as a series of training images where it passes through.

Execution of the path is implemented as a series of visual homing operations, consecutive visual guided runs from the place where one training image is taken to the next. We developed a highly accurate and robust visual homing algorithm for this, based on sparse local 3D maps and an occlusion-robust visual feature tracker. During the motion, a subsystem avoids obstacles that are detected by the ultrasound sensors. Because it is visually guided relatively to the training images, the locomotion system has the unique property that there is no drift or odometry error build-up.

This paper gives an overview of the different components of this autonomous mobile robot system, and describes the first real-life experiments we conducted with it.

Future work includes the development of a omnidirectional vision-based obstacle detection, to eliminate the need of additional sensors and reducing the cost.

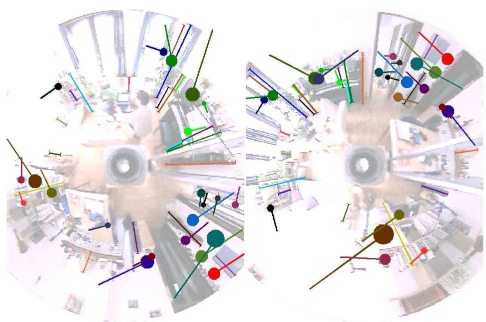

Figure 2: *Correspondences (color-coded) between two omnidirectional images found with a combination of two fast wide baseline matching techniques.*