

1. Type of Presentation

- The type of presentation:
Demonstration with poster and video.

2. Introduction

Autonomous mobile robots are being seen more often in various real-world applications, such as transportation, cleaning or surveillance tasks. The navigation task contains two problems.

The first problem deals with the question "*Where am I?*", and is called the localization problem. Because of wheel slippage, the odometry becomes an inaccurate position estimate. One way to solve this problem is to use *exterospecific* sensors, which look at the environment, and estimate the position of the vehicle based on the sensor values or recognition of landmarks.

The second problem deals with the question "*How do I avoid collisions?*". Although indoor environments can usually be modeled accurately, there will be unexpected objects. The solution to this problem is also to use the *exterospecific* sensors, but now in a *reactive* control mode: the sensor data are used directly to control the vehicle. However, ultrasonic sensors which are often used for this do not provide accurate information for the localization and recognition task.

We decided to use a vision system to solve both problems simultaneously. An image provides a rich description of the environment and can be used for the localization problem, while the image sequence provides information about the spatial structure of the environment and can be used for reactive navigation and obstacle avoidance.

We present a robot vehicle equipped with a camera and real-time 'remote-brain' processing, which is able to perform simple navigation tasks in an indoor environment. The system uses the optic flow field (the visual motion induced by a

moving camera) providing information about the structure of the environment and the relative motion of the observer.

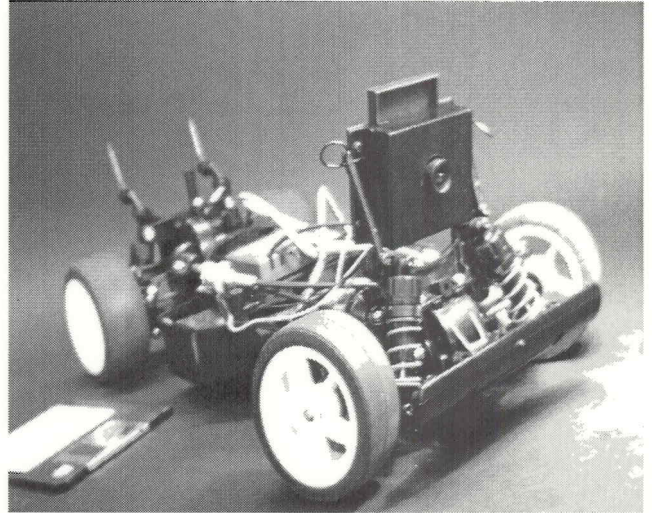


Figure 1: The robot vehicle

3. Set-up

The robot vehicle is a customized small radio-graphic controlled cart (Figure 1), of which we removed the receiver. A simple 8 bit μ processor on the cart takes care of the servo motors for propulsion and steering, and takes care of the emergency stops and watchdog. The processor communicates via a wireless RS232 connection with a host computer, which is a Pentium-based PC. A process running on the PC sends the desired speed and curvature to the vehicle. A small CCD camera is mounted on top of the vehicle. The video-signal is sent via a radio-link to a receiver, which is connected to the frame-grabber mounted in the PC system. Images can be grabbed and stored in memory continuously. From a sequence of images the motion field is computed with the method reported in [2]. The motion field will be used for two tasks:

- predicting the future course of the system, in particular the future collisions.

4. Corridor following

The motion field is used to make a depth map. This depth map contains the relative distance to the camera per pixel. We use the depth map to find the orientation of the cart subject to the corridor.

From the depth map we can find the position of the end of the corridor, which can be used to determine the rotation of the cart subject to the corridor. The position of the cart from the middle of the corridor can be found by calculating the distances to the left and the right of the cart to the corridor.

5. Collision prediction

The spatial information which is present in an image sequence can be used to derive an explicit (geometric) model of the environment. Combined with information about the locomotion of the vehicle, points of collision with objects in the environment can be computed. In an earlier paper [1] we showed that the optic flow field can be used for computing collision points without deriving a model of the environment. This is advantageous if obstacles (or targets) are specified in the image domain. In figure 2 an example is given of a simulated scene, a flowfield and the computed collision course. We will present course predictions on real images, such as presented in [2].

References

- [1] A. Dev, B.J.A. Kröse, L. Dorst and F.C.A. Groen , Observer curve and object detection from the optic flow. RWC 94 TR-94-037 94-SNN-2 Technical Report CS-94-11, Dept. of Comp. Sys. University of Amsterdam, Juli, 1994
- [2] A. Dev, B.J.A. Kröse and F.C.A. Groen , Confidence measures for image motion estimation. Submitted to RWCP, 1996.

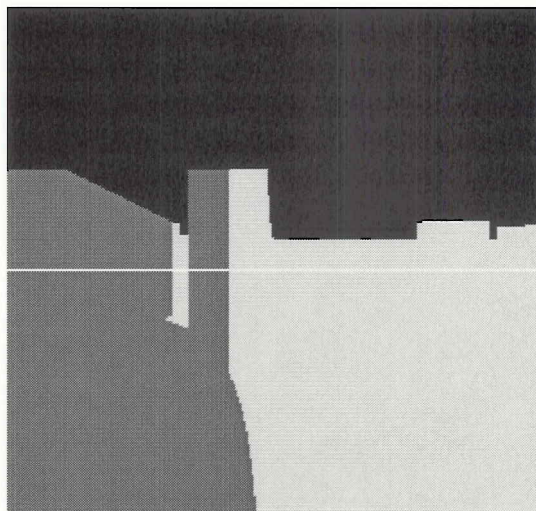
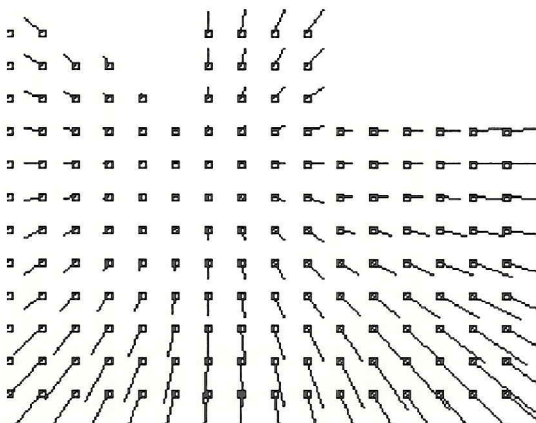
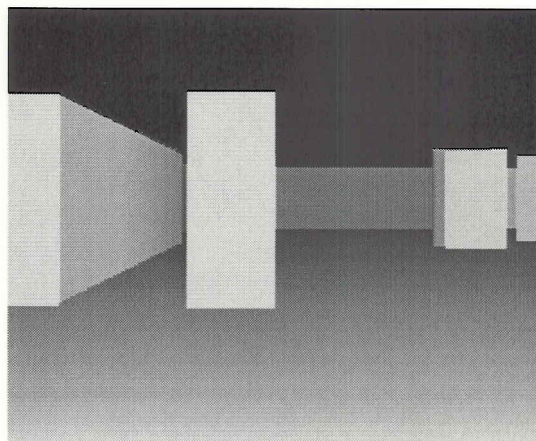


Figure 2: Top to bottom: The environment as seen by the camera. The flow field induced by the moving camera. The collision course. Points in the light gray area will be passed on the left while points in the dark gray area will be passed to the right