Real-Time Visual Self-Localisation in Dynamic Environments
A Case Study on the Off-Road Platform RAVON

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Abstract. In this paper a real-time approach for visual self-localisation of mobile platforms in dynamic environments is presented. Vision-based approaches for improving motion estimation recently have gained a lot of attention. Yet methods banking on vision only suffer from wrong tracking of features between frames as the optical flow resulting from the robot motion cannot be distinguished from the one resulting from robot independent motion in the camera images. In the scope of this work a method for robust visual self-localisation in dynamic environments on the basis of feature prediction using wheel odometry was developed.

1 Introduction

One of the key problems in mobile robotics is the localisation of a vehicle in unknown terrain. In recent years visual methods for pose estimation have become more and more interesting as they are now computationally feasible and do not suffer from the same sources of error as traditional approaches do. In fusion with other systems the robot pose estimation should become more stable in particular on the local level.

Fig. 1. RAVON, the Robust Autonomous Vehicle for Off-road Navigation.
On the mobile off-road platform RAVON\(^1\) – which is developed by the RRLab\(^2\) at the University of Kaiserslautern – wheel odometry, a custom-built inertial measurement unit with integrated digital compass and a GPS receiver have been deployed so far. Now this suite of sensor systems shall be complemented with stereo ego motion in order to improve the local stability of the yielded pose information. Besides better results of the fused position information this extension opens the possibility to build up an absolute local obstacle map from stereo vision information in order to cover the blind angles of the camera system. In principle most visual odometry approaches follow the pattern outlined in Figure 2. The camera system captures a frame and a set of features that are suitable for tracking are selected in this image. After some time, another frame is taken. The features that have been detected in the previous frame are now tracked into the current frame. The vectors between these points contain the information about the change in orientation and translation of the robot between the two subsequent frames. The last step is an ego-motion estimation on the basis of the vectors to receive the robot pose according to a given starting point.

2 State of the Art

The idea of visual odometry was first developed by L. Matthies [2]. This approach was refined and deployed on several mars robots [3] and other researchers implemented different flavours of the original concept. The differences mostly lie in the camera system – monocular [4], omni-directional [5] or stereo [2] – used. The two first mentioned camera configurations are not an option in off-road terrain as a flat ground plane needs to be assumed in order to compute 3D coordinates from the image points. Therefore a stereo-ego-motion approach was chosen for implementation in this work.

In common outdoor scenarios a lot of dynamics come into play as people, other vehicles or tree branches and high grass affected by the wind cause vehicle motion independent movement in the camera images (See Figure 5 in Section 4).

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\(^1\) RAVON → Robust Autonomous Vehicle for Off-road Navigation [1]

\(^2\) RRLab → Robotics Research Lab (http://rrlab.informatik.uni-kl.de)