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3D-objecttracking with a mixed omnidirectional stereo camera system

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ABSTRACT

This paper presents a novel technique of stereo vision based on the combination of an omnidirectional camera and a perspective camera. The technique combines the 360° field of view of the omnidirectional camera with the long field of view of a perspective camera. We describe the setup of such a camera system and how it can be used to achieve 3D-position estimates. Furthermore, we develop a maximum likelihood approach and a Bayesian approach that are able to fuse monocular and binocular observations of the same object to estimate its position and movement and show how this technique can be applied successfully in the RoboCup MiddleSizeLeague.

1. Introduction

Autonomous robots heavily depend on sensors which provide information about their position and their environment. Beside laser range scanners video based approaches have been implemented successfully during recent years. In the domain of autonomous soccer playing robots [1] vision based systems have replaced other sensing systems almost completely and play a major role in the perception of the environment.

Using a state-of-the-art digital camera with standard lenses on top of an autonomous robot provides a field of view that is long but narrow. Usually the aperture angle is less than 90° while the maximal distance at which objects of the size of a soccer ball can be recognized is more than 12 m. While the length of the field of view is large enough for many applications, the aperture angle is too small and provides a very limited view.

To overcome the problem of limited aperture angle, catadioptric cameras [2] have been developed which provide a 360° panoramic view. In contrast to pan cameras and multi-camera arrays they provide an extension of the aperture angle with little additional effort and without moving parts. However, the advantage of obtaining a bird's eye view with only a single camera comes at the cost of reduced range of vision. For instance, using the catadioptric sensor mounted on the soccer robots of the *RoboCup MiddleSizeLeague*-team *Brainstormers Tribots* [3], the image of a soccer ball at a distance of more than 5 m is only round about one pixel large.[1]

Beside the fact that an autonomous robot needs a wide and large field of view it must also be capable to determine the three-dimensional position of objects in its environment and to estimate their movement. In the RoboCup MiddleSizeLeague the game has become three-dimensional since the robots started to perform chip kicks some years ago. Especially for a defender or a goalie robot it has become essential to recognize a raised ball. Former approaches for ball recognition and tracking [4] will be misled since they assume that the ball never leaves the ground.

To overcome this problem we propose a new technique that combines the catadioptric camera with a second, perspective camera that observes the area in front of the robot. By doing so, we can combine the advantages of the 360° field of view of the catadioptric camera with the long field of view of the perspective camera. Moreover, in the overlapping part of the fields of view we obtain stereo vision and can determine the position of objects in 3D.

However, the completely different mappings of the two cameras require another form of disparity calculation than in the classical case of stereo vision systems with identical cameras. Furthermore, the special configuration of the two fields of view might lead to situations in which we see an object sometimes with only one camera (monocular observation) and sometimes with both cameras (binocular observation). We will propose an estimation procedure that is able to combine monocular and binocular observations within the same framework and which benefits from both

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[1] Here, the camera is mounted at a height of 75 cm above ground and the resolution of the camera was 640 × 480 pixels.

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