Fast Monocular Visual Compass for a Computationally Limited Robot

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Abstract. This paper introduces an extremely computationally inexpensive method for estimating monocular, feature-based, heading-only visual odometry - a visual compass. The method is shown to reduce the odometric uncertainty of an uncalibrated humanoid robot by 73%, while remaining robust to the presence of independently moving objects. High efficiency is achieved by exploiting the planar motion assumption in both the feature extraction process and in the pose estimation problem. On the relatively low powered Intel Atom processor this visual compass takes only 6.5ms per camera frame and was used effectively to assist localisation in the UNSW Standard Platform League entry in RoboCup 2012.

1 INTRODUCTION

Bipedal robots need to walk on a variety of floor surfaces that can cause them to slip to varying degrees while walking. They can also be bumped or impeded by undetected obstacles. Accurate navigation therefore requires an autonomous robot to estimate its own odometry, rather than assuming that motion commands will be executed perfectly.

If a robot is fitted with one or more cameras, visual odometry algorithms can be used to estimate the relative motion of the robot between subsequent camera images. However, these methods are typically computationally expensive for resource constrained robots operating in real time. To overcome this problem, this paper exploits the planar motion assumption in both the image feature extraction process, and in the calculation of relative pose estimates. The result is an extremely computationally inexpensive method for estimating heading-only visual odometry using a monocular camera and 1-dimensional (1D) SURF features.

This technique was developed and used in the RoboCup Standard Platform League (SPL) robot soccer competition, and implemented on an Aldebaran Nao v4 humanoid robot. The Nao is equipped with a 1.6 GHz Intel Atom processor and two 30 fps cameras. These cameras have minimal field of view overlap, necessitating the use of monocular visual odometry methods. As the Nao is not fitted with a vertical-axis gyroscope, heading odometry can only be estimated using visual methods.