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Real-time monocular image-based path detection

A GPU-based embedded solution for on-board execution on mobile robots

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Abstract In this work, we present a new real-time image-based monocular path detection method. It does not require camera calibration and works on semi-structured outdoor paths. The core of the method is based on segmenting images and classifying each super-pixel to infer a contour of navigable space. This method allows a mobile robot equipped with a monocular camera to follow different naturally delimited paths. The contour shape can be used to calculate the forward and steering speed of the robot. To achieve real-time computation necessary for on-board execution in mobile robots, the image segmentation is implemented on a low-power embedded GPU. The validity of our approach has been verified with an image dataset of various outdoor paths as well as with a real mobile robot.

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1 Introduction

One of the current challenges of mobile robotics is to achieve complete autonomy, i.e. to develop a robot that can carry out its tasks without the need of a human operator. The ability to safely move in one's environment is fundamental for an autonomous mobile robotic system. To navigate in the real world, a mobile robot needs not only to avoid collisions, but also to detect those portions of the world that are forbidden, dangerous or impossible to traverse. For a large class of terrestrial reactive navigation problems, the world in front of the robot can be modeled as a flat plane, and any detected point that deviates from the planar model can be considered to be an obstacle. Many obstacle avoidance algorithms use active sensors such as sonars [4], laser range finders [33], radars [15] and 3D cameras based on time of flight [21] and structured light [14]. These sensors are inherently suited for the task of obstacle detection and can be used easily because they directly measure the distances from obstacles to the robot.

However, ultrasonic sensors suffer from specular reflections and poor angular resolution. Standard laser range finders are precise, but they only provide measurements in one plane. Three-dimensional laser rangefinders, as well as most radars, are not suitable for small robot applications because of size, weight and energy consumption. Most 3D cameras illuminate the perceived scene by infrared light and do not work outdoors due to the presence of sunlight. Since All active sensors transmit signals, these might interfere with each other if multiple sensors or multiple robots are present in the same environment. Moreover, the distance measurements provided by these sensors are not suitable to distinguish between different types of ground surfaces or recognize the shape of a road without the presence of bounding structures such as

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