ROBOT FOR ROBOTOUR 2012

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Abstract: The aim of this article is the proposal of a method for the operation of an autonomous robot for Robotour 2012 with the help of camera and sensor usage. Key issues to be faced are the localization problem, computer vision and robot sensing uncertainty. Firstly, road extraction is achieved by using colour segmentation and principal areas detection. Secondly, for the combination of information of different uncertain sources, Kalman Filter is proposed. Finally, the information received by the camera which serves for the building of an occupancy grid map corrected by sensors is de facto the representation of environment for the robot.

Keywords: autonomous robot, colour segmentation, classification, texture, tracking, Kalman Filter, occupancy grid map, computer vision, Robotour 2012

1. INTRODUCTION

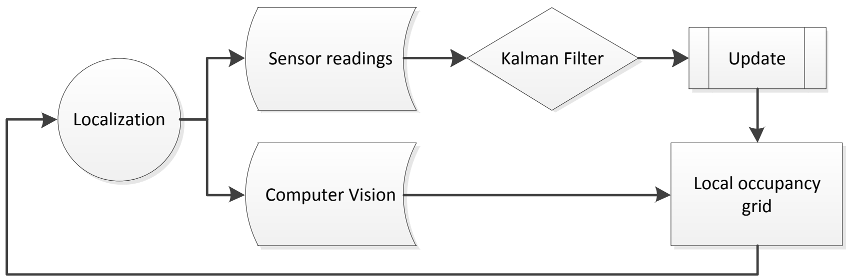
This paper addresses the problem of robots self-navigating through unknown terrain and proposes a solution for an autonomous robot for Robotour 2012. This problem arises in many well-known robot applications such as planetary exploration or autonomous guided vehicles. Powerful and flexible robotic systems exhibiting higher degrees of autonomy are able to sense, plan, and operate even in unstructured environments. In order to achieve that, the robot must be able to interact coherently with its world. It has to recover both spatial descriptions of its surroundings using sensory information and information provided by the camera and it has to be able to efficiently utilize these descriptions in appropriate short-term and long-term path planning and decision-making.

Robotour is an annual contest held by robotika.cz since 2006 as an outdoor delivery challenge. It is an original Czech contest of autonomous robots navigating on paved park roads where robots carrying payload (five litre barrel) get extra points. The rules for this year's contest are the same as last year, 2011; robots will get the goal position and a map. All robots will start concurrently. Also the payload is mandatory. The robots participating on the contest have to be able to decide how to reach the given destination without any human intervention. On their journey they must not contact obstacles and they have to deal with traffic blockage due to potential narrow roads. Contact with an obstacle means the end of the trial. If a robot gets sued for blocking the road it has to leave the area within a one minute time limit, if it fails to do so, it will be stopped and removed from the road.

1.1. ARCHITECTURE OVERVIEW

For the sake of this paper a robot from the Department of Intelligent Systems from BUT was chosen. The robot was created in 2008 as a result of a bachelor's thesis. The robot has built-in sonars, compass accelerometer and optical encoders, and nonetheless a camera [2]. To determine where the robot is, an A-GPS module from a mobile phone with Android OS is planned to be used.

Picture 1: Robot for Robotour. The left picture shows the robot's body [1] and the picture on the right shows the surveyor SRV-1 Blackfin camera [2].



Picture 2: Flow-chart showing the basic idea, how the proposed system would operate.

2. LOCALIZATION PROBLEM

The localization problem is the issue of finding the robot's current position which also includes path planning. The organizers of Robotour contest are providing an area map in OSM (Open Street Map) format [3]. When an area map is available, shortest path can be found using Uniform Cost Search (UCS) searching algorithm. The algorithm has a few advantages; it is complete and an optimal searching algorithm. This means one can be sure that if the path exists, the algorithm will find it, and if by chance there are more, it will choose the best one – the shortest one. Therefore I propose to use a version of the algorithm where the option to returns in the way is eliminated.

Robot with a map can more easily plan the path, but still, real-world terrain sensors have limited measurement resolution; similar limitations exist for cameras. Limited resolution can cause two problems with grid map building algorithms [4], one of them is that it may make impossible to detect small obstacles at a distance and as a result the terrain model may miss obstacles. The second one is that the planning part might make optimistic assumptions about the environment.

Despite knowing these limitations I propose the usage of local occupancy grid-based map making method which simplifies the robust environment by describing only the part which is necessary to navigate the robot safely. The local occupancy grid map [5] is generated with a special 2D path planning algorithm, described in chapter 4, which processes information from the camera. To make it more accurate, the robot utilizes sensors to perceive and model the outside world. Sensors utilized for this task are sonar, inertial measurement unit (IMU) [1], compass and GPS. Information received by these sensors is combined (chapter 3).

A number of other methods exist for path planning to avoid obstacles and to navigate to the goal. The usage of bug algorithms would greatly benefit from the local occupancy grid map in order to follow the path and avoid obstacles with the robot.

3. MULTI-SENSOR FUSION

Under the term Multi-sensor fusion are meant the algorithms solving the localization problem. These algorithms are combining information and position measurements to form estimates of the location where the robot is at a certain point in time.

3.1. Kalman Filters

The measurements a robot makes need to be combined to form an estimate of the location of the robot. Kalman Filter (KF) is used to combine information from sensors to estimate the state the robot is in, that is, the location the robot is at. It takes into account the different uncertainties and error sources that disturb the robot system and measurements and by representing the location space continuously as a parameterized probability density, like a Gaussian as in KF, the computations involved may be greatly reduced. The KF is essentially a set of mathematical equations that implement a predictor-corrector type estimator that is optimal in the sense that it minimizes the estimated error covariance – when some presumed conditions are met [6].

4. COMPUTER VISION

Computer vision can be used to build the local occupancy grid-based map by detecting the road and detecting obstacles on the path.

For visual navigation in natural environments, the colour segmentation should be considered as a basic operation. A colour segmentation algorithm provides a description of the scene as a set of the most representative regions for example sky, grass, rock, and tarmac. These methods use a priori knowledge where regions on a picture are characterized by attributes (colour and texture) and so their nature is identified [7]. The attributes should be identified according to a database which in fact is a variance of classes built accordingly to classification test results. After the colour segmentation the identification step supports the road extraction and as a result gives a 2D model of the outdoor scene. This phase merges together all neighbour regions with the same or similar texture and colour characteristics and as a result the road can be extracted from the image.

For the time being, in the initial state the colour palette is reduced to 16. In spite of the loss of information, particularly for the small details, this does not affect the large regions. Secondly, the noise is reduced by the median filter which preserves useful detail in the image. In the next step the grey colour is filtered out because the road in the current state is assumed to be grey. The final step, road extraction, is achieved by applying Canny edge detector.

Picture 3: Different phases of the road extraction method.

5. CONLUSION

This article has presented a possible solution how to navigate a mobile robot in an unknown environment. It has shown different approaches how to solve the localization problem. Furthermore it has proposed the local occupancy grid-based map method, built using computer vision, to represent the environment in a way that the robot can make assumptions where it is, and where it can go. Part of this article presented a way how to combine all sensor data, which takes in account all the possible measurement errors and helps to build a more accurate occupancy grid map. Being able to implement the proposed solution the robot should be able to successfully participate on the contest Robotour 2012.

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