Tracking the Absolute Position of a Mobile Robot Using Vision-Based Monte Carlo Localization

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Abstract

We present a technique for localization of a mobile robot on a checkerboard-painted field. In conjunction with additional non-periodic attributes of the environment, the absolute position of the robot may be estimated.

It is known that particle filters are highly efficient and robust in localization tasks. We describe an application of the Monte Carlo Localization (MCL) algorithm on the data acquired using a web-camera, performing real-time absolute localization on a low cost hardware. Since the large field of view is important to avoid lack of trackable features in the camera image, a solution using catadioptric omnidirectional visual sensor is presented and compared to a standard perspective camera.

The operation field for my mobile robot is the playing table of the Eurobot^{open} 2005 robotic contest – a rectangle of 2.1 x 3.64 meters consisting of two fields with a brown-beige checkerboard pattern separated by a blue ditch. For every iteration of the algorithm, the camera image is first thresholded to identify these three colours. The thresholded image is then passed to the MCL algorithm, which consists of two phases – the prediction and the correction. In the prediction phase, the information from odometry is applied to a set of samples representing the probability of the robot position. In the correction phase, each of the samples is verified against a fix count of random pixels from the thresholded image: the function representing a transformation from the image plane to the plane of the playing field is applied to the selected pixels to determine the match of the viewpoint of the sample to the current observations. The transformation is pre-calculated and stored in a matrix to reach high speed of execution. The entire algorithm iterates at the pace of camera frame-rate.

The sampling-based approximation of the probability distribution enables to model almost any distribution, which helps in adding more robustness to the algorithm. Several samples may, for example, be instantiated on random positions of the playing field, to deal with unexpected motion – such as collision with another robot. The incremental nature of the MCL algorithm gives continuity to the image processing (in cases where it fails to decode the captured image, when it is blurred because of fast motion for example) – current state of the position probability is preserved without the need to detect such failure.

This new method employs the composition of fast colour thresholding, look-up coordinate transformation and Monte Carlo Localization to gain fast and robust absolute localization which is crucial namely in robot competitions when robot has to orient quickly and reliably.