Dean
Prof. Zdeněk Němeček

Faculty of Mathematics and Physics
Charles University
Ke Karlovu 3,
121 16 Praha 2
Czech Republic

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Doctoral candidate David Obdržálek submitted to Charles University in Prague, Czech Republic, Faculty of Mathematics and Physics thesis entitled “Robot Localization”. University authorities assigned me as referee to examine thesis and write the report.

The thesis presents research work of the author spanned over years and is mainly dealing with indoor precise localization problem in small size spaces like playgrounds for robot competitions. Additionally, in the last part of the thesis, use of GPS as additional input to control algorithm for outdoor usage is introduced. Usability and validity of already developed localization algorithm was proved.

In the First part of the work, an extensive overview of main localization methods used in robotics is presented (dead-reckoning, odometry, probabilistic localization and satellite localization). Their basic characteristics (advantages and drawbacks) are discussed, two of them (probabilistic localization and localization using GPS) in more details. Probabilistic localization and specifically the Monte Carlo Localization (MCL) as the method which has been implemented in a couple of robots described in the thesis was discussed from both, theoretical and practical point of views, in case of Satellite localization (as now very easily available absolute localization system which can be well used in outdoor robotics) attention was focused more on practical aspects and information about many different satellite localization systems is given.

The Second main part is devoted to implementation and testing of selected localization methods, on different robotic platforms that were developed in author’s lab. Following robotic platforms were developed: robots Logion and MART (both successfully tested during Eurobot 2008 and 2009 contests), and MOB-2 robotic platform used for robotic-oriented courses at the Faculty of Mathematics and Physics of Charles University in Prague. At the end, outdoor application of MCL and GPS localization using the Eduro robot is explained.

Main attention was focused on efficient, precise and reliable indoor localization. Due to uncertainty in accuracy of sensor’s measurements, as a most suitable probabilistic localization method the Monte Carlo Localization (MCL) was used, which also allows to use as many sensors as there are available on the robot.

In the first implementation (for Eurobot 2008 competition) encoders (already used for odometry) and dedicated beacon system (absolute positioning system developed just for this purpose) were applied for MCL.

For Eurobot 2009 competition, the approach was upgraded. Use of encoders signals and beacon system was improved and reworked, and vision system was added for identification of playing elements. It should be pointed out that the use of vision to extract needed information, due to its sensitivity on disturbances is not easy, but here it was successfully carried out in real-time and output used for MCL.

At the end the author presented his work on outdoor navigation where information from GPS was incorporated. Robot Eduro, which was developed for Robotour 2011 contest, was used as the testing platform. The task of this autonomous robot is to travel in a public place (a park, strictly using the pathways) from one specified place to another. It was decided to implement already developed Monte Carlo Localization system for indoors, but with addition of GPS as one of the data sources (also, the odometry information and compass readouts were used). This resulted in novel approach for using MCL for graph-based map. For this purpose a vector map of pathways in a particular park was needed. A vector map of the contest site (park) was acquired from the OpenStreetMap Project. The MCL algorithm proved to be very robust. When the robot leaves the track and later returns back, the localization can recover by itself without external help or without the considered modification.

According to my opinion, there are, at least, two points corresponding to new scientific results. The first one is a real-time use of information extracted from vision as input to MCL. The second point is a novel approach of using MCL for graph-based maps. Having in mind future expansion of robotics application areas (for example, it is expected home assistive robots while outdoor motion is unavoidable in many tasks) both results are interesting for further use and development in robotics.

I am convinced that this thesis prove ability of Doctoral candidate David Obdržálek for creative scientific work.

The work meets the requirements for doctoral thesis. I recommend to accept it as Doctoral thesis and granting David Obdržálek the PhD. title.

In case of any question do not hesitate to contact me.

With best regards

Prof. Branislav Borovac

Faculty of Technical Sciences
University of Novi Sad
Trg Dositeja Obradovića 6
Republic of Serbia

Cell: +381-63-89 36 617
e-mail: borovac@uns.ac.rs