Review of the doctoral thesis

Vectorized Point Clouds for Mobile Robotics

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Overview

This doctoral thesis deals with processing of point clouds and subsequent search for correspondence between particular datasets (with purpose of simultaneous localization and mapping - SLAM). It addresses the issue of developing an improvement over the processing algorithms (vectoring the point cloud) and "restarting" a vector approach consideration in contemporary SLAM principles. Presented doctoral thesis takes the standard format of a solid publication and is accompanied by other documents, particularly evaluation and publication record of Ph.D. candidate. It is divided into 8 chapters and contains 145 pages, including appendixes.

Relevance to current need of the scientific community

Although much work was done in the field of robot localization in the past, there is still a wide area for optimization or particular innovations. As far as I remember, in the Czech Republic were dedicated some effort in that area in the past, but rarely in a manner corresponding to the proposed dissertation. Reconstruction and understanding of surrounding environment throughout vectorization of input point cloud is not absolutely a new idea, but laid apart in the past, due to several factors. Usually in outdoor environment there is lack of pure geometrical objects and also it is usually computaniously demanding (as a serious complication of a real-time issue). Nevertheless, there is a high probability that "vectorized" approach will get back as a standard attribute or feature of robotic navigation and "perception" algorithms. Even though that the author deals only with 2-Dimensional "portion" of the SLAM problem, the approach could be considered as innovative and challenging issue. And there still exists a clear need of robust SLAM algorithms for precise robot positioning in GPS denied applications, even under limited application constrains.

Fulfillment of the main objectives

The doctoral thesis addresses a robot localization problem throughout a vectorization of input environmental data sets and its matching estimation (calculation). Author introduced several innovations and improvement in filtering and segmentation of input point cloud described in Chapter 5, further improvement and extension of FTLS algorithm are introduced in Chapter 6 and other achievements are described in Chapter 7 concerning the registration and data association. Author also did not underestimate process of the state of the art analyses, which is apparent throughout the whole work and from the chapter of almost 200 references. The author followed the standard approaches in case of experimental evaluation, he released huge engineering/programming effort in this context and even though presented results were mainly backed by simulated "noisy" dataset in synthetic environment, author come to a valuable achievements. Considering the mentioned facts and level of solution complexity, it could be clearly stated, that the **main objectives** of the thesis **have been fulfilled** and concrete results are shortly summarized in **"Conclusion and future work"** section.

Publication effort
Sufficient publication effort supporting the thesis is apparent from the publication record analyses of corresponding author. Publications prove the origin of solution concept and indicate thesis development/roadmap within a study period.

Scientific methods application
The work follows standard scientific approaches, including proper state of the art analyses, scientific methods application, engineering/programming activities and evaluation/experimentation. The methodological approach was convenient and led to valuable results.

Main results and contributions of the work
Generally, as it was mentioned above, the main contribution of this thesis lays in innovative solution to robot localization and mapping problem throughout vectorization approach and processing. Chosen approach was limited to only a 2-Dimensional case, what could be a serious complication in real/professional applications, also I see a wide space for Hough Transform consideration, evaluation and analyses (on the other hand I appreciate mentioned reference 114, 121). Despite the mentioned constraints, 2D approach seems to be demanding enough and 2D proofs should support/encourage a 3D area of problems.

Importance of the work for further development of science
Generally, this work represents a valuable achievement, minimally on the field of the Czech robotics. It support the way for implementation of hi-performance and robust SLAM methods and contain potential for advanced navigation applications. I find content of dissertation thesis as usable for academic and in theoretical dimension for industrial or other purposes.
The work generally indicates the great effort released in its solution, accompanied by the deep understanding of the problem and scientific approach in it solution (it fulfills all criteria of scientific work by closing the loop of state of the art analyses, problem statement, solution and evaluation of the results and iterative solution improvement).

The author of the doctoral thesis proved to have an excellent ability to apply a scientific methodology, perform a research and to achieve a research results.
I recommend the thesis to be accepted for a defence and upon its successful completion to assign Aleš JELÍNEK by the Ph.D. degree.

Questions:
1. Do you plan to extend the technique to 3D and what would be the main challenges?
2. Did you consider to solve some particular problems in “Non-Euclidean” space/systems (to get rid of some constrains, to achieve correlation simplifications or performance boosts), could it bring some benefits?

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