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Blind Mapping and Localisation for Small-Scale Mining Robots

Master's thesis

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Pime kaardistamine ja lokaliseerimine väikesemõõdulistele kaevandusrobotitele

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Author’s declaration of originality

I hereby certify that I am the sole author of this thesis. All the used materials, references to the literature and the work of others have been referred to. This thesis has not been presented for examination anywhere else.

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Abstract

An autonomous robot is required to have the means to map the environment and localise itself within the environment for successful operation. The solution to this challenge is dependent on the sensors available to the robot and the environment. Common state-of-the-art approaches solve the challenge by using visual sensors in a SLAM framework.

In this thesis, the solutions to the online mapping and localisation problem in low-visibility and multi-phase conditions are investigated on utilizing a passive tactile whisker sensor grid. A proof-of-concept is provided on the basis of a simulation by showing the accuracy of a SLAM algorithm compared to odometry. The approach is shown to be effective in simulation over varying scenarios of movement, with the proposed SLAM algorithm achieving higher pose estimation accuracy over pure odometry.

The results of this thesis provide a basis for real-world experiments and further improvements on the developed algorithms. Furthermore, the results improve the possibility to adopt an unconventional sensor modality for autonomous small-scale mining robots.

This thesis is written in English and is 44 pages long, including 5 chapters and 31 figures.

Annotatsioon

Pime kaardistamine ja lokaliseerimine väikesemõõdulistele kaevandusrobotitele

Keskkonnas liikumiseks vajavad autonoomsed robotid vahendeid ümbritseva kaardistamiseks ja enda lokaliseerimiseks. Kaardistamise ja lokaliseerimise meetodi valik sõltub töökeskkonnast ning robotil kasutatavatest sensoritest. Kaasaegsetes lahendustes kasutakse erinevaid visuaalseid sensoreid samaaegse lokaliseerimise ja kaardistamise (SLAM) raamistikes.

Käesolevas töös kasutatakse passiivset taktiilset tehisvurrudel baseeruvat sensormaatriksit, et uurida lahendusi reaalajas kaardistamise ja lokaliseerimise probleemile halvas nähtavuses ning mitmefaasilistes tingimustes. SLAMi algoritmi kontseptsiooni testimine ja valideerimine teostatakse simuleeritud keskkonnas, võrreldes SLAMi algoritmi täpsust roboti odomeetriaga. Antud töös näidatakse, et valitud lähenemine on efektiivne erinevate liikumis-stsenaariumite juures, kusjuures loodud lahenduse asukohahinnang on täpsem odomeetria abil leitud asukohahinnangust.

Käesolev lõputöö loob aluse edasisteks reaalseteks eksperimentideks füüsilise sensormaatriksiga ning edasisteks täiendusteks väljatöötatud algoritmile. Lisaks sellele pakuvad tulemused võimalusi uut tüüpi sensori kasutuselevõtuks autonoomsetele väikesemõõdulistele kaevandusrobotitele.

Lõputöö on kirjutatud inglise keeles ning sisaldab teksti 44 leheküljel, 5 peatükki ja 31 joonist.

Summary

This thesis set out to create a proof-of-concept for a SLAM algorithm based on a tactile whisker sensor grid. For the purposes of achieving this goal, a state-of-the-art lidar SLAM algorithm was modified to work with the whisker sensor grid measurement data. To evaluate the performance of the SLAM algorithm, a simulation framework for the sensor grid was developed and test scenarios were run in simulation.

To validate the resulting SLAM framework, five different scenarios were run, with each of these covering a different set of movements. In addition, the repeatability of the results was tested, by performing 10 reruns of SLAM on the same scenario.

Based on the simulated test scenarios, the SLAM algorithm performed better than odometry in vehicle position estimation, suggesting improved localisation capabilities. The map representations produced by the algorithm were visually similar to the ground truth.

The results from experiments were not identical in each run, but repeatable. These results provide a proof-of-concept, that a whisker sensor grid can be used for mapping and localisation purposes, while highlighting limitations and possible improvements. To further evaluate the concept, real-world testing is necessary.