EKF-BASED LOCALIZATION WITH LRF

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***Abstract*—This project report deals with the implementation of an extended Kalman Filter (EKF) on a mobile robot, which is equipped with a laser rangefinder (LRF). The goal of the project is to estimate the two dimensional pose of the mobile robot in real time. The available odometry information of the robot is used for the state prediction. For the observation model a map of the environment is pre-acquired and used. The laser range finder gives the observation information by scanning the robots environment in real time. Point clouds are then used for comparing the predicted and the real observations in the matching step.**

***Index Terms*—Extended Kalman Filter, Localization, Robotics, Laser Rangefinder, ROS.**

I. Introduction

MOBILE autonomous systems are fundamentally depended on localization. Their motion and task planing require knowledge about the current robot state. For mobile robots the current posture, which includes position and orientation, is an important part of their state.

For this reason the report to the group project of the experimental part within the ”Autonomous Systems” class at Instituto Superior Técnico in 2016/2017 deals with EKF-based localization with a LRF. The objective for the students is to prove their theoretical knowledge on mobile robotics localization in a practical scenario and to gain first experiences with implementing in a robot operating system (ROS) environment.

The used hardware in this project consists of a Pioneer 3DX mobile robot, a Hokuyo URG-04LX-UG01 laser rangefinder and at two laptops. The Pioneer 3DX comes with implemented motion sensors that provide odometry information. The Pioneer's integrated sonar sensors are not used.

The available odometry information can be used straight away for localization. However, relying only on odometry is inaccurate, since the errors arising from the uncertainties of the odometry model and the measurement noise of the odometric sensor are accumulating over time. To improve it's localization the robot can use available information from other sensors, such as a sonar, a camera or a laser rangefinder, each having different advantages and disadvantages. The task for this project is to use a laser rangefinder, which is more accurate in comparison to a sonar, but is not able to measure transparent objects. The additionally gained information has to be merged with the odometry information. Therefore, different kind of algorithms, so called filters, can be used.

The original Kalman Filter is the optimal estimate algorithm for linear system models with additive independent white noise in the prediction and measurement systems. To be able to apply the Kalman Filter based filtering method to non-linear systems the extended Kalman Filter uses linearization around a working point. As long as the system model is well known and accurate, the EKF is the most widely used estimation algorithm. Otherwise Monte Carlo methods, especially particle filters, will lead to better results, despite being computationally more expensive. [1]

As the considered robot system is real world non-linear system the used filter for localization has to be robust to the influence of noise and non-linearities. The movement of a wheeled mobile robot in a two dimensional environment can be described by an accurate system model. Therefore, the EKF can be used for computationally efficient localization.

This paper is organized as follows. In section II the used methods and algorithms are introduced. Afterwards the implementation of the EKF is described in section III. The results of the algorithm running on the real Pioneer 3DX robot in a test environment are then discussed in section IV. The paper then is concluded in section V.

II. Methods

The used methods will be described here. To fill the document the IST Wikipedia article is quoted. Enjoy it.

Instituto Superior Tcnico (IST) is a school of engineering,[2] part of the Universidade de Lisboa (University of Lisbon). Founded in 1911, IST is the largest and most prestigious school of engineering in Portugal. It is a public school with a large degree of scientific and financial autonomy

A. Methods XY

Methods XY are used to show how to use subsection IST, since its foundation, has been the largest school of engineering, science and technology in Portugal, at undergraduate and postgraduate levels. It has three campi, all located in the Greater Lisbon area (Alameda in Lisbon, Taguspark in Oeiras and Tecnolgico e Nuclear Campus in Loures), and consists of ten Departments that are responsible for teaching the undergraduate and postgraduate programmes. Each Department is organised in sections, which group together specific subjects within its scientific area. In addition, the laboratories of the several Departments are an important source of support to the teaching and research activities carried out at IST.

1) Method XY-Z : Method XY-Z demonstrates how to use subsubsections. IST offers 18 undergraduate programmes attended by more than 6,000 students, covering a wide range of areas of knowledge, including not only all the traditional engineering specializations, but also other modern areas such as Biomedical Engineering, Aerospace and Physics Engineering. Over 4,500 students are enrolled in 33 masters, 31 doctoral and several specialized programmes.[citation needed] IST has produced 1,292 Ph.D. holders.[citation needed]

III. Implementation

The implementation will be described here.

IST is also actively involved in several networks and international programmes to promote student mobility, both at undergraduate and postgraduate levels. Through a large number of agreements with other institutions worldwide, IST participates in more than 20 Dual Master programmes, and joint PhD programmes with MIT, CMU, UT-Austin and EPFL.

IV. Results

The used results will be presented here.

IST benefits from an IBM supercomputer built in 2007, which is one of the most powerful in Portugal (1.6 TFLOPS as of 2007).[3]

V. Conclusion

Instituto Superior Tcnico (IST) was created in 1911 from the division of the Industrial and Commercial Institute of Lisbon. Alfredo Bensade, an engineer, was IST's first dean (19111922) and promoted a wide-rang reform in the Portuguese higher technical education, including the first engineering courses at IST: mining, civil, mechanical, electrical, and chemical-industrial. IST's second dean was Duarte Pacheco (19271932), also an engineer, who was responsible for the construction of the university campus at Alameda. The architect Porfrio Pardal Monteiro designed it. Meanwhile, IST became part of the recently created Technical University of Lisbon. Throughout the following decade, the image of engineers from IST was projected into major engineering works, promoted by Duarte Pacheco, who was by the time Minister of Public Works.

Appendix A
Proof of the First Zonklar Equation

Appendix one text goes here.

Appendix B

Appendix two text goes here.

Acknowledgment

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References

[1] S.J. Julier and J.K. Uhlmann, *Unscented filtering and nonlinear estimation*, Proceedings of the IEEE: 401422., 2004.