L.U.N.A. - A Laser-Mapping Unidirectional Navigation Actuator

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Abstract The abstract goes here. README: Feel free to change and cut content as you see fit! I've written down everything that came to my mind fairly independent of its quality. - A.

1 Introduction

In today's world, autonomous robots have found their way into everyday life in a variety of ways. This includes, but isn't limited to, the vacuum cleaner that independently navigates one's living-room or mobile robots employed for exploration of areas that are too dangerous for humans. To foster new advances in the latter, specifically for underground environments, the Defense Advanced Research Projects Agency (DARPA) of the US Defense Department established the yearly "SubT" Challenge in 2017. In this challenge, teams are tasked to "Drive novel approaches and technologies to allow warfighters and first-responders to rapidly map, navigate, and search dynamic underground environments." [1] proving the demand for further research in this domain. One difficulty of this challenge is building an accurate 3D model of the environment, i.e. mapping the surroundings. The teams that participate in the DARPA challenge take advantage of high-quality hardware, such as state-of-the-art 3D laser-scanners and cameras, thus making their solutions rather expensive. However, the demand for mapping-solutions in the low-cost sector is non-negligible. For example a set of disposable mapping devices could be used to create a 3D model of an area from different initial locations.

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One such approach using a 2D laser scanner to scan 3D indoor environments has been proposed in [4]. The authors mounted a 2D laser scanner on a cylindrical structure. An operator then initiated a rolling movement by manually pushing the contraption. This enabled the scanner to sense the 3D environment with great results. However, manually pushing the scanner is not practical, especially for long scans.

Previous work was also done at the Julius-Maximilians University Würzburg [2]. The RADLER (RADial LasER scanning device) consists of a 2D laser scanner attached to the axle of a unicycle. An operator then pushes the unicycle along a requested path. The inherent rotation of the wheel then creates a radial 3D laser-scanning pattern. However, this approach still requires an operator, therefore does not fulfill the autonomy requirements.

A more autonomous approach was taken in [3]. The authors mounted a rotating 2D laser-scanner on top of a turtle-bot thus removing the need of an operator. In contrast to the RADLER however, the turtle-bot does not provide an inherent rotation. Therefore an extra actuator is required to create the radial 3D scanning-pattern.

This paper builds upon the results of the RADLER and has a specific application of mapping lunar craters autonomously in mind. We propose a novel approach to low-cost 3D laser-scanning using a 2D laser-scanner inside a spherical robot based on conversation of angular momentum (COAM): the L.U.N.A. - sphere (Laser-mapping Unidirectional Navigation Actuator). The 2D laser-scanner is fixed to the spherical structure, hence a similar situation as with the RADLER is given: the inherent rotation of the sphere creates a radial 3D scanning pattern. Using the format of a spherical robot permits the system to be designed more compact. Furthermore, an operator is no longer required given the drive implemented in the robot.

2 State of the Art

Add small intro to State of the art

2.1 Spherical Robots

Add description of different spherical robots

2.2 3D Laser Scanning

Talk about 3D laser scanning. Specifically on mobile robots

3 Technical Approach

Small intro to technical approach

3.1 Hardware Setup

Talk about hardware setup

3.2 Sensor Integration

Talk about sensor integration

4 Experimental Results

4.1 3D Laser Scanning

4.2 COAM Drive

5 Conclusions

Add conclusion

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References

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3. Zheng Fang, Shibo Zhao, Shiguang Wen, and Yu Zhang. A real-time 3d perception and reconstruction system based on a 2d laser scanner. *Journal of Sensors*, 2018:1–14, 05 2018.

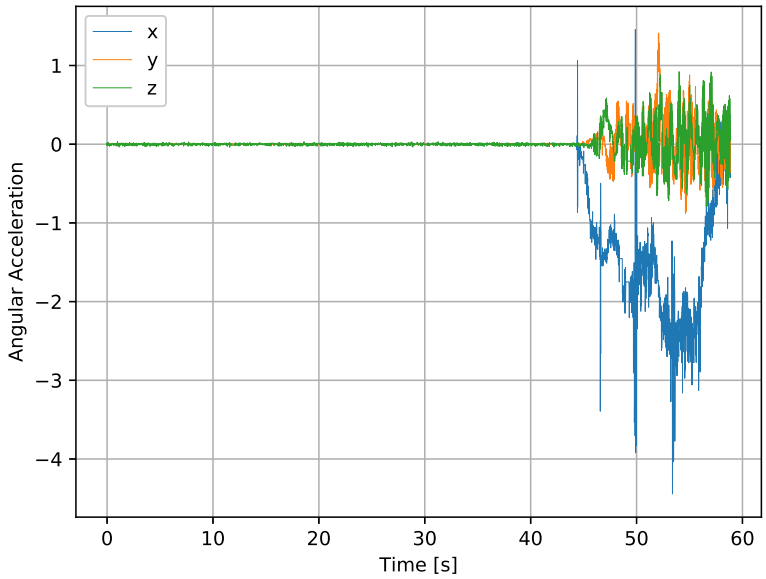

Fig. 1 Angular velocities of the L.U.N.A. - sphere during a test run. The flywheels rotate around the x-axis in positive direction. Velocities in the other direction can mostly be contributed to vibrations and tilt of the robot.

4. Ville Lehtola, Juho-Pekka Virtanen, Antero Kukko, Harri Kaartinen, and Hannu Hyypp. Localization of mobile laser scanner using classical mechanics. *ISPRS Journal of Photogrammetry and Remote Sensing*, 99:25 – 29, 01 2015.