Universidad de Ibagué

Comprometidos con el desarrollo regional

Título de la tesis o trabajo de investigación

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Facultad Ingeniería
Ingeniería Electrónica
Ibagué, 2021

Título de la tesis o trabajo de investigación

Nombres y apellidos completos del autor

Trabajo de grado que se presenta como requisito parcial para optar al título de:
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Facultad Ingeniería
Ingeniería Electrónica
Ibagué, 2021

Agradecimientos

Este proyecto de grado se desarrolló en el marco del proyecto de investigación <XX-XXX-INT> titulado "NOMBRE DEL PROYECTO" financiado por la Universidad de Ibagué. Los resultados presentados han sido obtenidos con la asistencia de estudiantes del semillero de <NOMBRE DEL SEMILLLERO> de la Universidad de Ibagué <SIGLA SEMILLERO> del grupo D+TEC de la misma Universidad.

(Opcional) Debo agradecer cualquier ayuda que haya recibido (por ejemplo, del personal técnico) o la aportación de, por ejemplo, una empresa. Así como también de Familiares, y amigos que fueron pieza clave en la formación integral del estudiante en el transcurso de su carrera.

Resumen

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Palabras Clave: palabra1, palabra2, palabra3, palabra4 ...

Abstract

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Keywords: word1, word2, word3, word4 ...

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Nomenclatura

Abreviaturas	Término
CPU	Central Processing Unit
FOV	Field Of View
FPS	Frames Per Second
GPS	Global Positioning System
ICP	Iterative Closest Point
IMU	Inertial Measurement Unit
LiDAR	Light Detection and Ranging
LOAM	Lidar Odometry And Mapping
PCB	Printed Circuit Board
PCL	Point Cloud Library
RAM	Random Access Memory
ROS	Robot Operating System
SLAM	Simultaneous Localization And Mapping
TOF	Time Of Flight

Símbolo	Término	Unidad SI	Definición
AAE	Error angular absoluto	$(^o)$	Ecuación (??)
ATE	Error de trajectoria absoluto	(m)	Ecuación (??)
AVG. CPU	Consumo promedio de CPU	(%)	Ecuación (??)
AVG. RAM	Consumo promedio de RAM	(%)	Ecuación (??)
E_{trans}	Error de translación relativo	(%)	Ecuación (??)
E_{rot}	Error de rotación relativo	$(^o/m)$	Ecuación (??)
RMSE	Error cuadrático medio	(m) | $(^o)$	Ecuación (??)
SIM. TIME	Tiempo de simulación	(min)	Ecuación (??)

Capítulo 1

Introducción

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2.1.2 Tema 2

2.1.2.1 Subtema 1

2.1.2.2 Subtema 2

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4.2 Resultados de simulación

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5.1 Conclusiones

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5.2 Recomendaciones

A continuación, se describen una serie de recomendaciones alusivas al trabajo en cuestión y sus funcionalidades:

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5.3 Aportes

- Participación en <XXª> Muestra Estudiantil de Trabajos de Ingeniería Electrónica en la universidad de Ibagué (METIE) ciudad de Ibagué-Tolima. Semestre <XXXXA/B>.
- Participación en la categoría de investigación en <NOMBRE-EVENTO> Semestre <XXXXA/B>.
- Paper para el evento <NOMBRE-EVENTO>. Semestre <XXXXA/B>. [Anexo A1].
- Repositorio del software <**NOMBRE-DESARROLLO**> el cual se encuentra disponible en el siguiente enlace: https://github.com/HaroldMurcia/NOMBRE-DESARROLLO
- ...

Capítulo A1

Anexos

Concepto/herramienta 1: Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.

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A Comparison of Lidar Odometry and Mapping Techniques

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***Abstract*—Light detection and ranging LIDAR systems onboard mobile platforms are in rapid advancement for real-time mapping applications. Modern 3D laser scanners have a high data rate which, coupled with the complexity of their processing methods, makes simultaneous online localisation and mapping (SLAM) a computational challenge. Different 3D LiDAR SLAM algorithms have emerged in recent years, most notably LiDAR Odometry and Mapping and its derivatives. This paper performs an implementation of A-LOAM, ISC-LOAM and LeGO-LOAM algorithms and a respective comparison with the total sequences of the Kitti database which includes different environments and routes from a Velodyne HDL-64E sensor. Our code implementation is available online https://github.com/HaroldMurcia/LOaM-comparison.**

***Index Terms*—Simultaneous localization and mapping, LiDAR, ROS, kitti database, real-time pose estimation**

I. INTRODUCTION

Simultaneous Location and Mapping SLAM is a well-established research area in robotics, which is mainly concerned with solving the problem of estimating the trajectory of a moving robot and constructing a map of its surrounding environment. However, 3D mapping is a technology that has become increasingly popular over the last few years and its applications have transcended into different application areas such as inspection [1], topography [2], mining [3], [4], heritage [5] registration, agriculture [6], [7], forest inventory [8], autonomous vehicle navigation [9], among others. Within the mapping possibilities, LiDAR sensor-based mapping stands out, which is based on the principle of range measurement with high sampling rates. In this context, a true-to-reality mapping requires knowledge of the position of the moving element in order to locate the spatial measurements with respect to a fixed refraction frame. A simple solution to this problem is to use positioning sensors such as GPS/INS, or combined sensor systems such as vehicle wheel encoders, Inertial Measurement Units IMU or visual odometry to estimate the position $P_{(x,y,z,\phi,\theta,\gamma,t)}$ in a mapping space. Another set of methods use the same 3D point cloud sample to perform a LiDAR odometry and register the data at the same time in a cumulative point cloud. These methods are recognized as LiDAR Odometry and Mapping LOAM and since its introduction in 2014 by Zhang et all, different variants have been presented in research works under the same working principle [10].

LiDAR-SLAM methods estimate motion by finding rigid transformations between the point clouds provided by this type of sensor, leaving the use of GPS/INS or other sensing elements as optional. Although they are often more computationally expensive than conventional vision methods, they are less sensitive to changes in illumination and take advantage of the three-dimensional geometric structure of the environment.

This paper presents a comparison of LiDAR-SLAM methods based solely on 3D LiDAR for mobile position estimation using evaluation criteria that allow determining metrics in each chosen method with some requirements such as: flexibility, easy implementation, and compatibility with Robotic Operating System ROS and the Kitti database, a standard odometry dataset highly welcomed by the research community, which provides 3D LiDAR point cloud information.

II. RELATED WORK

SLAM with 3D LiDAR sensors is a topic that has been addressed several times by the robotics research community. They are ideal for precise non-contact measurement of distance, path and position, widely used to perform tasks in outdoor environments. Major implementations of 3D LiDAR-based odometry have gained popularity since the initial work of Zhang [10], who proposed the LOAM algorithm. This algorithm is one of the best SLAM frameworks dealing with 3D point clouds. It can create a robust, low-drift 3D map online, and can effectively handle 3D point clouds from the Velodyne sensor without the need for loop closure to correct for drift. A-LOAM [11] is an advanced implementation of LOAM in which odometry and mapping are decoupled to be performed at a faster speed in theory by simplifying the code structure (it is cleaner and simpler without complicated mathematical derivations and redundant operations) and poses are computed by matching edge and plane features in the scans. FLOAM [12] is an optimized version of A-LOAM and LOAM with the computational cost reduced by up to 3 times. Its fundamental principles and processes have not changed. The first is point cloud reprocessing, then edge and plane features are extracted, the pose is estimated by matching, and finally the pose is