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TRAJECTOGRAPHY ESTIMATION FOR A SMART POWERED WHEELCHAIR ORB-SLAM2 vs RTAB-MAP

A PREPRINT

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ABSTRACT

This work is part of the ADAPT project relating to the implementation of a trajectography functionality that aims to measure the path travelled by a patient during the clinical trials. This system (hardware and software) must be reliable, quickly integrable, low-cost and real-time. Therefore, our choices have been naturally made towards visual SLAM-based solutions coupled with an Intel real-sense consumer sensors. This paper is a comparison of two well-known visual SLAM algorithms in the scientific community, ORB-SLAM2 and RTAB-Map, evaluated in different path configurations. The added value of our work lies in the accurate estimation of the trajectories achieved through the use of a VICON motion capture system.

Keywords Visual SLAM · ORB-SLAM2 · RTAB-Map

1 Introduction

Estimating the camera trajectory while simultaneously reconstructing the environment is a key and well-know problem in robotics and computer vision. This can be achieved by the use of different measuring means (LIDAR, RADAR) and algorithms (particle filter, extended Kalman filter, GraphSLAM). When cameras are used SLAM techniques are named as visual SLAM (vSLAM). vSLAM algorithms have been widely proposed in the field of computer vision, robotics. Taketomi & al. [1] proposes an exhaustive survey of real-time vSLAM algorithms developed from 2010 to 2016. In this paper we compare two well-known vSLAM algorithms: ORB-SLAM2 proposed by Mur-Atal & al in 2017 [3]

and RTAB-Map proposed by Labbé & al. in 2018[4]. This comparison fits within the framework of the ADAPT project ("Assistive Devices for empowering disAbled People through robotic Technologies") for which driving assistance functionalities are implemented on a standard powered wheelchair to ensure the patient a safely driving. One requirement is related to the estimation of the path carried out by the patient during the clinical trials so as to evaluate the driving capabilities or the effect of the driving assistances in relation with an ideal trajectory. Both algorithms have been evaluated for an Intel real-sense camera 435D mounted on top of the ESIGELEC's robotics wheelchair which runs a ROS platform. ORB-SLAM2 has been tested for a monocular, stereo and RGB-D camera, while RTAB-Map, has been evaluated for a monocular and RGB-D camera. Several experiments have been carried out in a controlled indoor environment at the ESIGELEC's Autonomous Navigation Laboratory. These experiments are supported by the use of the VICON motion capture system used as a ground-truth to validate our results [2]. Different motion scenarios have been implemented to test and benchmark both vSLAM algorithms: straight-line, straight-line and back, circular path with loop closure.

The paper is organized as follows: section 2 presents the ESIGELEC's robotics wheelchair. Section 3 gives an overview of ORB-SLAM2 and RTAB-Map. Section 4 illustrates preliminary results related to the benchmarking of both vSLAM algorithms. The last section 5 gives a conclusion and perspectives.

2 Robotics Wheelchair Architecture

The robotics electrical powered wheelchair from the ESIGELEC's lab is an Invacare, model Bora from which all the proprietary electronics has been removed and replaced by an embedded PC running a Linux Ubuntu 16.04 LTS distribution, a motor driver from Roboteq, Xbox joystick in place of the original one which can be connected to the wheelchair through a USB or Bluetooth connection. The wheelchair software is fully developed under the ROS robotics middleware. Figures 1a and 1b show the device and a schematic of the integrated hardware.

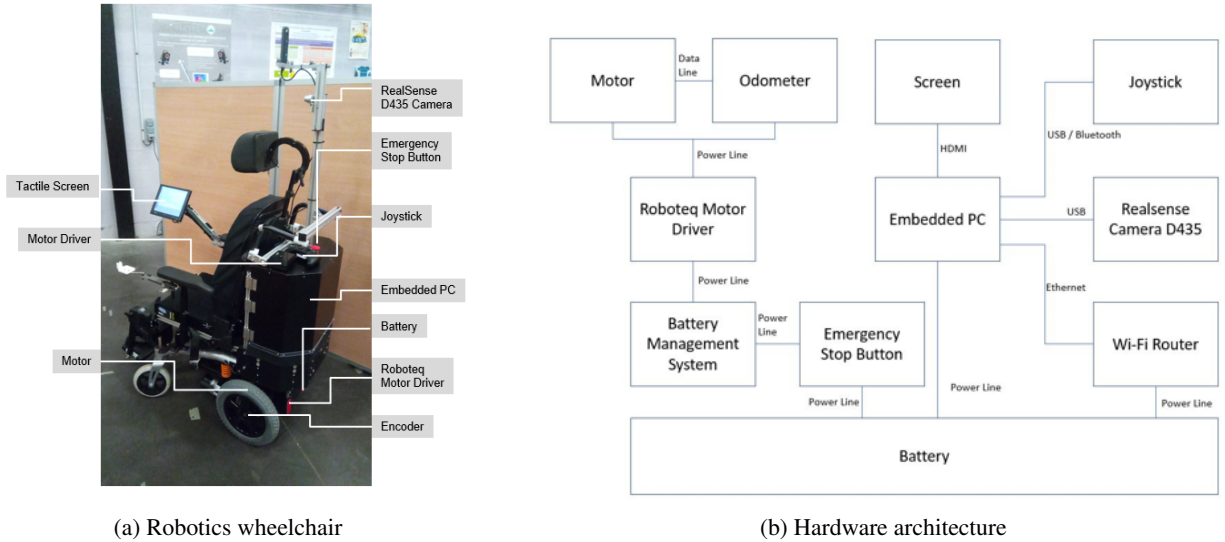


Figure 1: Overview of the ESIGELEC's robotics wheelchair

3 ORB-SLAM2 and RTAB-Map

3.1 ORB-SLAM2

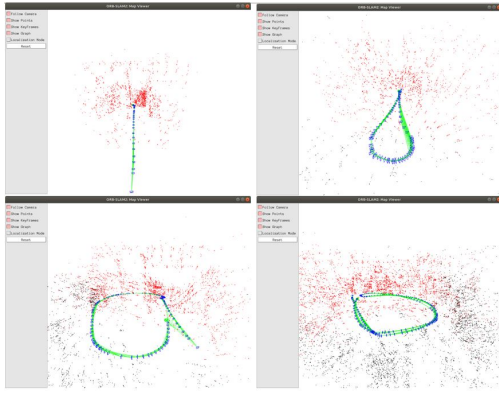
ORB-SLAM2 is a real-time SLAM library for monocular, stereo and RGB-D cameras that computes the camera trajectory and a sparse 3D reconstruction. It is able to detect loops and re-localize the camera in real time. The system works in real-time on standard CPUs in a wide variety of environments from small hand-held indoors sequences, to drones flying in industrial environments and cars driving around a city. The back-end based on bundle adjustment with monocular and stereo observations allows for accurate trajectory estimation with metric scale. The system includes a lightweight localization mode that leverages visual odometry tracks for unmapped regions and matches to map points that allow for zero-drift localization. The main functionalities of ORB-SLAM2 are: feature tracking, mapping, loop closure and localization.

3.2 RTAB-Map

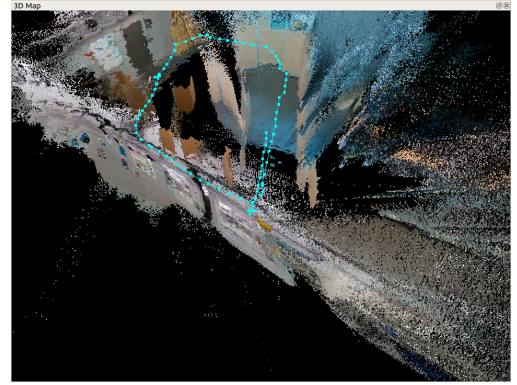
RTAB-Map stands for Real Time Appearance Based Mapping. It is distributed as an open source library since 2013. RTAB-Map started as an appearance-based loop closure detection approach with memory management to deal with large-scale and long-term online operation. It then grew to implement Simultaneous Localization and Mapping on various robots and mobile platforms. RTAB-Map supports both visual and lidar SLAM, providing in one package a tool allowing users to implement and compare a variety of 3D and 2D solutions for a wide range of applications with different robots and sensors.

4 Results Analysis

The tests were carried out in indoor and outdoor scenarios. The first have been conducted in the Autonomous Navigation Lab (LNA Lab) and the second in the car parking in front of the ESIGELEC building. The LNA Lab is equipped with a VICON motion capture system which was used as the ground truth to capture the wheelchair and the travelled distance. Different motion scenarios have been implemented: straight-line, straight-line and back, circular path with loop closure. The figures 2a and 2b show screenshots of the ORB-SLAM2 and RTAB-Map for different paths in an indoor environment.



(a) first caption.



(b) second caption.

Figure 2: Screenshots of ORB-SLAM2 and RTAB-Map

The figure 3 shows a comparison of trajectories estimated by ORB-SLAM2 and captured by the VICON, for straight-line and a circular path not enabling the implementation of the loop-closure.

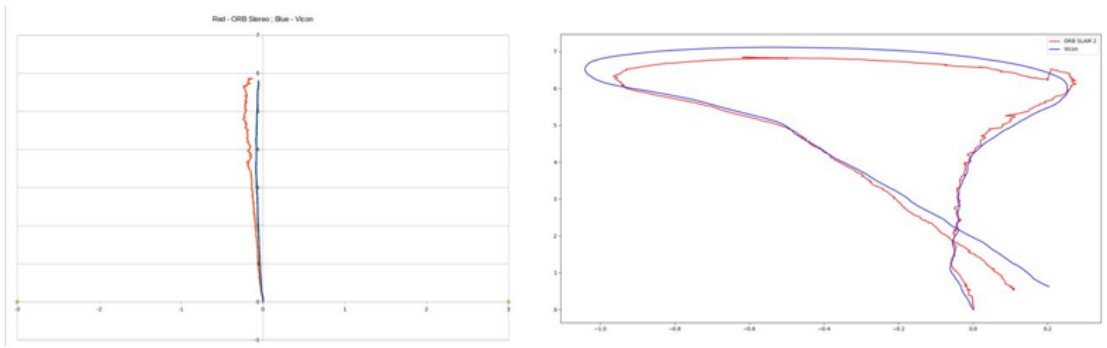


Figure 3: trajectory comparison between ORB-SLAM2 and VICON system

The tables 1 and 2 give a synthetic overview of the measured distance by the VICON system, the ones estimated by the ORB-SLAM2 algorithm with the stereovision and RGB-D acquisition modalities and the one estimated by the RTAB-Map using the RGB-D

Scenario	Ground truth	ORB stereo	ORB RGB-D
Indoor 1	7.82	7.69	7.16
Indoor 2	6.98	7.38	6.81
Indoor 3	15.05	15.49	14.32
Indoor 4	21.75	21.17	21.31
Indoor 5	29.69	21.47	22.13
Indoor 6	37.69	38.84	38.79
Outdoor 1	28	28.85	19.27
Outdoor 2	28	27.29	17.83
Outdoor 3	56	56.63	37.25
Outdoor 4	92	94.55	65.87
Outdoor 5	92	95.8	66.97
Outdoor 6	80	84.38	66.24
Outdoor 7	80	81.9	63.36
Outdoor 8	160	172.6	129.41

Table 1: Distance comparison between VICON and ORB-SLAM2 stereo & RGB-D

Scenario	Ground truth	RTAB-Map RGB-D
Indoor 1	6.48	7.69
Indoor 2	24.5	11.83
Indoor 3	23.26	31.31

Table 2: Distance comparison between VICON and RTAB-Map RGB-D

5 Conclusion

In this paper, we have presented a comparison between vSLAM algorithms for achieving a trajectography functionality for a smart powered wheelchair ; ORB-SLAM2 and RTAB-Map. They have been evaluated with the use of the Intel realsense D435 camera making stereovision and RGB-D acquisition modalities available. Works are still in progress and next we aim to better qualify both algorithms by comparing each pose estimation given by the vSLAM with the ones given by the VICON system. This step will require the calibration of the camera in the VICON frame.

Acknowledgment

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