Combining Structure from Motion with Visual SLAM

For the Katwijk Beach dataset

1 Introduction

SLAM stands for Simultaneous Localisation and Mapping, it consists of multiple techniques which record and map the surroundings and location of a sensor, without the use of GPS. This makes it ideal for unknown terrains like Mars. SLAM needs to be tested before its application on Mars to ensure its ability to map this unique type of terrain.

The Katwijk beach dataset is recorded by a Heavy Duty Planetary Rover (HDPR) (Hewitt et al., 2018). The rover moved along three routes on a simulated martian terrain. The dataset itself is publicly available for testing SLAM methods.

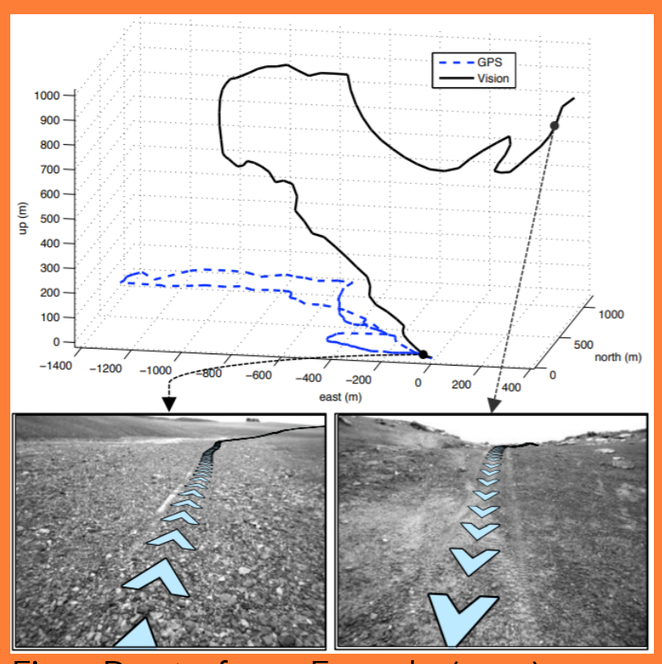

Fig. 1 Route from Furgale (2011)

2 Related work

In his thesis Furgale (2011) researched how a stereo camera and LiDAR can be used in combination with Structure from Motion. The accuracy of the route calculated by Furgale can be seen in Figure 1. The route deviates greatly from the groundtruth. However, locally the route is correct as can be seen in the two images taken at the same location

3 RQ and hypothesis

What are the potential outcomes of mapping route 3 travelled by the HDPR when calculated through: Visual SLAM, Structure from Motion, and a combination of both SLAM techniques.

By combining the visually attractive map from visual SLAM with the accurate location estimation from Structure from Motion better results would be achieved.

4 Methods

Visual SLAM

The stereo camera images are used to produce an RGB pointclouds, which merge to create a map. The rigid transformation between images describes the movement of the rover, and when combined forms a route.

Structure from Motion

This technique uses key points to make location estimations. The locations are improved through bundle adjustment to produce a colourless pointcloud map.

Combined Method

This combines the RGB pointclouds from visual SLAM with the better location estimation from SFM. In order to combine these the camera coordinate system used in SFM needed to be translated to a meter coordinate system.

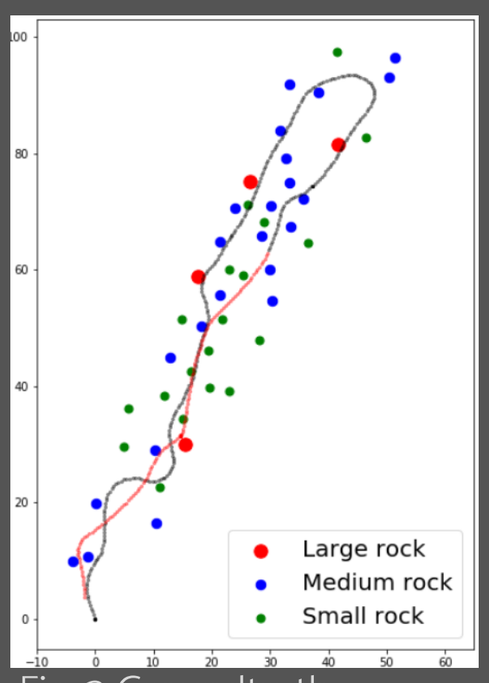

Fig. 3 Groundtruth

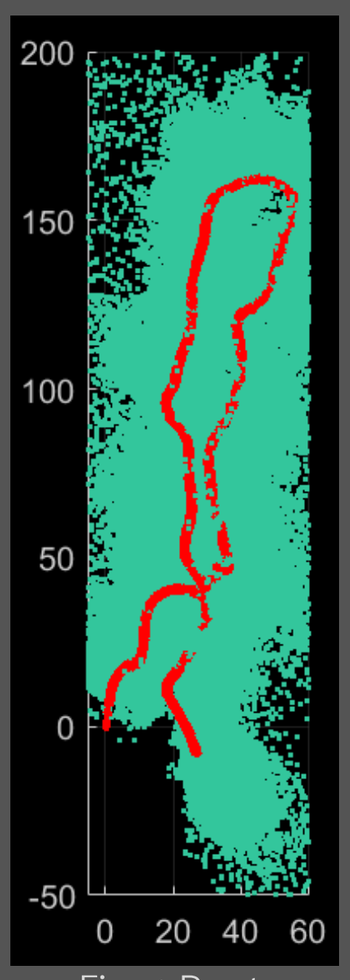

Fig. 4 Route according to SFM

5 Results

The visual SLAM map had a lot of problems with merging which led to an inaccurate route and a rotational error (Figure 2 and 3).

The route according to SFM was more accurate (Figure 3 and 4), though the map is visually incomprehensible.

The route from the combined method is the same as the route from SFM. The map suffers from the same merging problem as Visual SLAM, however there is no rotational error.

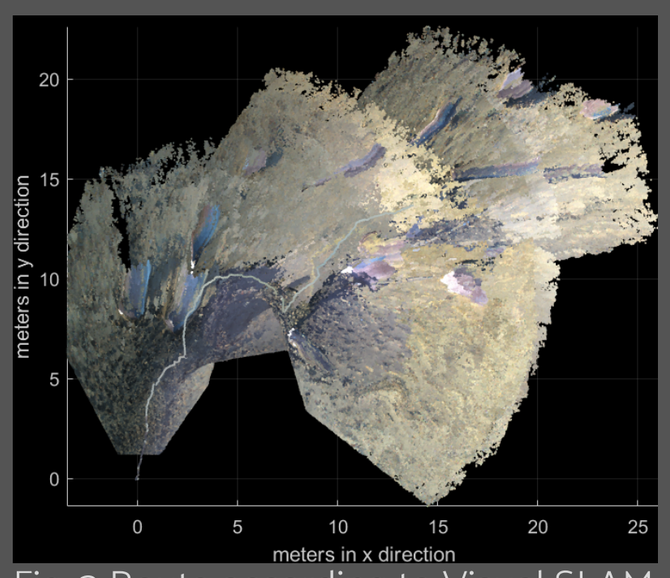

Fig. 2 Route according to Visual SLAM

6 conclusion

The rigid transformation computed via SFM has a better rotational estimation, but the merging remains a problem. This is likely due to an inaccurate conversion from coordinate systems and inaccuracies present in the SFM location estimations. The combined method has a slight map improvement, however more research is necessary to improve merging.

References

de Jong, M.B.: SLAM at the Katwijk beach. Bachelor thesis, Universiteit van Amsterdam (July 2020)

Paul Timothy Furgale. *Extensions to the visual odometry pipeline for the explorationof planetary surfaces*. Citeseer, 2011.

Robert A Hewitt, Evangelos Boukas, Martin Azkarate, Marco Pagnamenta,Joshua A Marshall, Antonios Gasteratos, and Gianfranco Visentin. The Katwijkbeach planetary rover dataset. *The International Journal of Robotics Research* 37(1):3–12, 2018.

Marlon de Jong
Supervisor: Arnoud Visser