



TALLINNA TEHNIKAÜLIKOOL
INSENERITEADUSKOND

Elektroenergeetika ja mehhatroonika instituut

ROBOTSÕIDUKIGA MAASTIKU KAARDISTAMINE
VIRTUAALMUDELI LOOMISEKS

MAPPING TERRAIN WITH A ROBOTIC VEHICLE TO CREATE A VIRTUAL MODEL

BAKALAUREUSETÖÖ

Üliõpilane: Hanno Artur Särg

Üliõpilaskood: 142970MAHB

Juhendaja: Raivo Sell, vanemteadur

Kaasjuhendaja: Saleh Ragheb Saleh Alsaleh, insener

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6 KOKKUVÕTE

Töö eesmärk oli leida sobiv tehnoloogiate kombinatsioon, millega saaks teostada maastikul maapinnalt alade kaardistamist niimoodi, et kaardistamise andmeid oleks võimalik hiljem kombineerida õhust kaardistamise andmetega. Pärast kombineerimist peavad andmed sobima simulaatori maailma loomiseks, kus erinevaid UGV-tehnoloogiaid katsetada saaks.

Kättesaadavate mõõdistamisvahendite seast valiti töös välja Velodyne VLP-16 lidar, millega katsetati kaardistamist erinevate sõidukitega ja erinevate juhtseadmetega koos. Lidari andmed salvestati salvestusseadmesse, kasutades ROS tarkvara, mis salvestas lidari tagastatud ümbrust kirjeldavad kaadrid .bag formaadis. Seejärel avati .bag fail töötlemisseadmega ning kohandati faili sisule NDT-kaardistamise algoritmi Autoware'i tarkvara abil. Pärast NDT-kaardistamist salvestati valminud terviklik punktipilv .pcd formaadis. Õhust ja maapinnalt salvestatud andmete kombineerijad vajavad andmeid .las formaadis, seega konverteeriti andmed Point Data Abstraction Library (PDAL) abil .las formaati.

Töö käigus teostati mitu kaardistamist. Esimesed katsed viidi läbi laboris ja lidar oli statsionaarne. Kui tehnoloogia toimimine oli saanud kinnitust, toimus järgmine proovikaardistamine testalal TalTechi kõrval, kus lidar kinnitati Mitsubishi sõiduauto külge. Viimane proovikaardistamine leidis aset pilootalal Humala vanas sõjaväelinnakus Harjumaal, kus peamine eesmärk oli anda andmete kombineerijatele testandmeid nii õhust kui maapinnalt kaardistades. Selleks toimus õhust ja maapinnalt kaardistamine samal ajal ja samas kohas.

Lõpuks pärast ettevalmistusi viidi läbi testala lõplik kaardistamine, kus sõidukina kasutati TalTechi isejuhtivate sõidukite labori UGV-d UKU, mille peale oli paigaldatud lidar ja mida juhiti puldiga. See imiteeris kõige realistlikumalt Milremi UGV käitumist ja maastiku läbimist. Kaardistamise tulemuseks on kaks erineva lidari pöörlemissagedusega (10 Hz ja 20 Hz) loodud salvestist, mis töödeldi Autoware'i kasutades ka tervikliku punktipilve formaati ja salvestati .pcd failina. Punktipilved konverteeriti PDAL-i kasutades .las failiformaati ja edastati andmete kombineerijatele ja simulatsiooni loojatele kasutamiseks.

Töö põhieesmärk on saavutatud: on leitud tehnoloogia maastikul alade kaardistamiseks, meetodit on katsetatud ja aladest on loodud esimesed 3D-mudelid. Töö käigus saavutati ka teisene eesmärk ehk hinnata, kas lidari tagastatavate andmete pealt on võimalik hinnata erinevate pindade tekstuuri. Lidari andmete ebapiisava täpsuse ja tiheduse tõttu järeldati, et see pole piisava täpsusega võimalik.

Pinna tekstuuri hindamiseks oleks parem tehnoloogiavalik kaamera, mis tagastab fotopilti. Värvilise pildi pealt on võimalik näiteks masinõppe abil tuvastada erinevaid enimesinevaid pindu ja panna UGV vastavalt erinevatele pindadele käituma.

Tulevikus võiks lisada lidari andmetele ka kaameraandmed. Kuigi praegu õhust kaardistamisel kasutatakse kaameraid ja õhust kaameraga kaardistades on objektide ja pindade värvid kättesaadavad, siis maapinnalt kaardistades praegu värvide andmeid ei ole. Kuna andmete kombineerijad peavad vajalikuks ka maapinnalt kaardistamisel objektide ja pindade värvide jäädvustamist, oleks mõistlik lisada lidarile 360-kraadise vaatenurgaga kaamera, mis jäädvustab kogu UGV ümbrust sarnaselt lidarile. Üheskoos lidari andmetega objektide kauguse kohta oleks võimalik need andmed ühendada ning saada värviline 3D-mudel koos väga täpsete mõõtetudega. Selle eesmärgiga valiti välja ka sobiv 360-kraadise vaatenurgaga kaamera Insta360 One X [29], kuid kuna kaamerale töö teostamise jooksul ligipääs puudus, siis kaamera ja lidariga koos kaardistamist siin töös ei käsitleta.

7 SUMMARY

The goal of this thesis was to find the combination of technologies that could be used to map terrain in such a way that the data could later be combined with the aerial mapping data. After the combining process the data has to be fit for creating the simulation where different UGV technologies could be tested out.

From all the measuring devices available the Velodyne VLP-16 lidar was chosen for the mapping and it was used in combination with different vehicles and controlling devices. The lidar data was saved to a storage device using ROS software that stored the lidar frames descriptive of the surrounding areas in the .bag file format. After that the .bag file was opened on the processing device and the NDT-mapping algorithm was applied in Autoware software. The resulting complete point cloud of the NDT-mapping was saved in .pcd format. For the combining of aerial and ground mapping data the point cloud is needed in .las file format, so the .pcd file was converted to .las format using the Point Data Abstraction Library (PDAL).

Multiple mappings were carried out in the process of this thesis. The first mappings took place in a laboratory and the lidar was stationary. When the operation of the technology stack was confirmed, the next trial mapping took place on the Test mapping area next to TalTech where the lidar was attached to a Mitsubishi passenger vehicle. The last trial mapping took place at the Pilot mapping area in an old military base in Humala, Harjumaa where the main goal was to provide testing data for the combining of aerial and ground mapping data. For that purpose the aerial and ground mapping processes took place simultaneously in the same area.

Finally after the preparations the final mapping of the Test mapping area was carried out, using the TalTech self-driving vehicle laboratory's UGV called UKU for the lidar vehicle. The lidar was attached on the UGV and the UGV was controlled with a remote. This was the most realistic way to imitate the behaviour and landscape capabilities of the Milrem UGV. The result of the mapping process is two separate recordings made with different lidar rotation rates (10 Hz and 20 Hz) and they were subsequently processed using the Autoware software to save the complete point clouds in the .pcd format. Point clouds were converted to .las file format using PDAL and have been submitted for combining with aerial data and for the use in the simulation.

The main goal of the thesis has been reached: a technology has been found for mapping terrain, the technology stack has been tested out and first 3D models of the testing areas have been constructed.

A secondary goal has been reached as well to evaluate whether the lidar data could be used to identify the texture of different surfaces. Because of the insufficient accuracy and density of the point cloud it was concluded that this is not possible. A better way to identify the texture of a surface would be to use a camera that supplies a photographic image. A coloured image could then be used in a machine learning algorithm to detect the most common materials in surfaces and have the UGV react to different surfaces accordingly.

In the future the camera data could also be added to the lidar data. Even though cameras are used right now for aerial mapping and the colour data is available from the aerial mapping, the ground mapping data is missing colours. Because for the aerial and ground mapping data combining process it is favourable to have colour data from the ground mapping as well, it would be reasonable to add a 360 degrees field of view camera in addition to the lidar, that could record the surroundings of the UGV similar to the lidar. Along with the lidar data it would be possible to combine the data from lidar and the 360 camera to create a coloured 3D model with very accurate dimensions. With this purpose in mind a suitable 360 camera Insta360 One X [29] was chosen, but since the camera was inaccessible for the duration of this thesis, the combination of the camera and the lidar is not touched upon in this thesis.