THE POSSIBILITY OF USING LIDAR SYSTEMS

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1 INTRODUCTION

The ambition of this thesis is a technical description of the basic characteristic that are used by laser detection and localization scanners, also referred to as LIDAR systems. Focus of this work is to analyze the principle of operation of the leading laser scanners and the possibilities of their applications for mapping 2D plane and 3D space. The first chapter is devoted to the analysis of the current lidar systems, chapter describes the basic principle used in laser scanners. The second section analyzes the leading lidar systems used for mapping and scanning the plane. The next chapter extends the third part analysis for the possibility of using lidar systems in 3D space and technical solutions scan 3D space planar laser scanner. The next chapter discusses eventuality of obtaining information of mobile application platforms. The last chapter describes proposal of simulation model lidar system for mapping space. This analysis points out that the main problem is the number of factors that adversely affect the accuracy of the measurements.

2 PRINCIPLES OF EPRATION

LIDAR stands for,, Light Detection And Ranging ", which is an optical detection and surveillance system, which is used mainly for optical distance measurement. This system uses optical spectrum signals, which includes ultraviolet, visible and infrared parts of the beam to scan a narrow laser beam of different objects shape and materials, including natural materials, aerosols and cloud. Laser range system operates in one of two possible principles of measuring distances:

- Phase method that uses the measurement of phase shift signal by reflection from the obstacle.

AB(cos(f.dt) - cos(2.ft-f.dt))/2

Where: *A* - amplitude of the transmitted signal

- *B* amplitude of the received signal
- f frequency of the transmitted signal
- *t* instant posting wool
- (t-dt) time change of the received signal

- Radar principle (pulse method), used to measure short pulse of light and the distance evaluates half the time between the emission and signal reception.

Since LIDAR devices are referred to as laser detection and range scan we specify them.

Detection can be described as a decision sensor on the presence or absence of an object within the sensor field sensor without any restriction irradiated object . Information output by the sensor , the decision whether the subject is in the field or not . Higher Council 's detection sensors already calculated using the before defined areas of the obstacles or the buildings that are not relevant to the field of the detected space.

Ranging is the identification of the position of the object in the known area bounded by scanning sensor measuring range . Condition object in the effective scanning range sensor evaluates an ideal location with a tolerance of tenths of a millimeter . Real measurements reported in ranges up to ten meters error units of inches , but at a range of ten meters an error occurs one to two percent of the measurements . By treating the sum of all points of effective localization sensor field to create a digital image of 2D plane or 3D space scanning area.

3 CONTENTS REQUIREMENTS POSED ON PAPERS CONTENTS

Hokuyo URG - 04lx as the name is a product based company HOKUYO and Intelligent Robot Laboratory of the University of Tsukuba . Hokuyo URG - 04lx is the first product of the company in this field with mass production . This particular product is putting on the market because of its low cost of operation and for its small compact size and a number of other benefits. Essential characteristics may be seen already from the picture No.5, where you see the art product with the appropriate detection area .

Laser used in this release, as most devices Hokuyo relies on wavelength 785 nm transmitted amplitude modulated

Scanning area , which describes the laser beam in one cycle is 239.765625 $^\circ$ in the shape of an incomplete circle .

Used laser has a range of 5600 mm but producers declared effective scan area of up to 4000 mm .

Sensor error arising and gaining influence measurement , manufacturers divided into two specific intervals . The first interval is in the range of 20 to 1000 mm from the scanning device , which integrates the measurement error of \pm 10 mm on the final lot. The second period is from 1000 mm to 4000 mm at which integrates \pm 1 % of measurement error . This error occurs even internal arrangement of the laser scanner itself .



Figure. 1 Structure of arrangement Hokuyo URG - 04lx

Experimental measurements form the results measured on non color treatment. The basic experiment foresees three different basic colors for which were chosen red, green and blue color finish. The results of measurements undertaken in the basic composition of the three colors is shown in the following figure 2.



Figure. 2 Characteristics influence detection of basic color palette to measure distance

From the characteristics in figure 2 for the effect of basic color palettes on the surface of the measured object, it is clear that a change in the color of the surface affects the accuracy of the measurement. Absolute and relative measurement error is changing not only the distance but will also have an impact angle of incidence of the laser beam. The influence of different angles of impact and the resulting absolute and relative measurement error in the picture 3.



Figure. 3 Absolute and relative measurement error as a function of inclination

Ways to collect data from laser scanning space and creating three dimensional maps in a few dimensions. Which creates a major dilemma variety of products to choose for a given application. At one end of the scale are very accurate scanning devices offered by companies such as Riegl or low-cost products manufactured by the above-mentioned companies SICK and Hokuyo. Third dimension scanning is achieved by rotating the sensor about the axis marked green. Influence of spatial orientation on the sensor should be no change to the measured parameters.



Figure. 4 The principle of using 2D LIDAR system to scan the 3D space

The initial test of this measurement is laser scanner rotation angles of 0°, +90° (turning right), -90° (rotation to the left), 180° (flip). From the measurement of the impact of spatial orientation Hokuyo laser scanner urg-04lx characterization was made in the following figure 5.



Figure. 5 Characteristics influence spatial orientation Hokuyo URG-04lx distance measuring

4 LIDAR IN MANAGEMENT OF AUTONOMOUS PLATFORMS

Reasons for the use of robotic platforms can be defined in the following points:

- Reduce human effort and effort
- Perform the same monotonous work without reducing performance or errors
- Moving in areas that pose a danger to humans
- When actions have greater accuracy than people

There are many different types of robots available, each designed for different tasks and different platforms.

The International Civil Aviation Organization named these platforms as remotely piloted aircraft under the acronym RPA (remotely piloted aircraft), so it is an aircraft without a human crew on board. Designation remotely piloted aircraft are used rarely as are also referred to as drones UAVs (unmanned aerial vehicle) optionally unmanned UAS (unmanned aircraft system) and many others. UAV flying platform you can develop along with the fundamental conditions and themselves.





LIDAR system is described in chapters throughout this work , it is necessary to mention only the correct choice as some options may not be suitable for this kind of platform , where appropriate, its rate of motion or limited to storage.

GNSS stands for Global Navigation and Positioning System mainly used for proper positioning in the space using satellites in orbit . The accuracy of the position increases with the number of satellites from which it receives data . To determine the position in threedimensional space are necessary information from at least four satellites .

IMU (inertial measurement unit) unit is used to determine the individual components of velocity, gravity, orientation platform in the space using a combination of gyroscopes and accelerometers.

Microcontroller can also be called the control member is a computer unit for which aid software and managed UAV ground station platform in terms of flight control, collects information from the measuring sensors in this case LIDAR sensors while they can save or send to the ground control station.

Hardware is the building block of all UAVs and thus significantly affect increasing or decreasing the complexity of the control systems and functional use .

5 SIMULATION MODEL OF LASER SCENER

Simulation model of the laser scanner is designed in Matlab program. Matlab is a mathematical laboratory in an interactive environment for numerical computation, visualization, programming, where it is possible to analyze data, and develop algorithms to create different models or applications. For these reasons, it was used interactive MATLAB.

Basic variables as well as in any programming language that are defined at the very beginning of the simulation model with an initial 50% probability of occupancy of the field.

This simulation program calculates and then searches for the six pre-defined barriers to the size of ten points of the sensor field in the shape of a square.

4.3 Equation

Equations quoted further in the text are to be numbered in round brackets (1),(2), etc. at the end of each line or a bit below the line level. The size of the letters in equations should roughly be of the same size (10 points) as those used in the main text. Decimal numbers should be set off using periods, e.g. 3.14 or 12.56 and (if need be) as for example in 4.25x 10 -. Avoid using extremely long expressions.



Obr. 7 Art crawl known dimension of the world would progress from the first to the third picture

After initialization crawl occurs examination known dimension of the world in terms as illustrated above picture and searched area is displayed as shown in the following figure with bare position of obstacles.



Obr. 8 Illustration scanned array with exposed obstacles

The second variant is the location of "Start" and "Goal" in the grid search space. After the initializations are scanning the original box with the unveiling of obstacles by a simulated movement of the robotic platform from position "START" position "Goal" as shown in the following illustration.



Obr. 9 Illustration scanned array with exposed obstacles and consequences of the movement of the robotic platform

5 CONCLUSION

The aim of this study was to analyze the basic working principles of laser scanners type known as LIDAR systems whose internal structure as the mechanical as well as electronic and optical section I described.

More rigorous analysis of one product from Hokuyo I discovered the advantages and disadvantages of this device , especially in the conditions under which measurements are made . The use of low-cost lidar systems for mapping the 3D space is performed mainly by mechanical scanning device by turning 90 ° angle from the initial position , which is considered normal sequence mapping acquires 3D model . This solution is used in relying on low-cost versions and thus the possibility of solving 3D scanning device without modification , from the perspective of producers unreasonable overpricing products.

One of the goals of this work is to analyze the possibility of using laser scanners in mapping of mobile platforms , as well as management capabilities of autonomous mobile platforms such skenermi. Analýza this field describes the minimum required number of components that are necessary for the operation and control of these robotic platforms .

The last requirement, and the aim of this thesis was to create a simulation model of a laser scanner type LIDAR mapping obstacles and the surrounding area in an interactive environment Matlab. The simulation model is part of the latest chapter in which I describe the options mapping in 2D space in a virtual dimension to scan , detect and reveal themselves obstacles in this environment

The conclusion of this work, I would like to point out another opportunity to create more sophisticated simulation model in terms of the expansion of more specific types of autonomous platforms. I went by supplementing scanning device on the other modes of operation which could replace several types of these scanners. Completion of the work in this area I would consider making autonomous mobile platforms controlled LIDAR systems for use in the universal environment.

BIBLIOGRAPHY

- [1]. GENERETION ROBOTS, updated 7-4-2014 T 19:06, available on the Internet: <u>http://www.generationrobots.com/localize-with-</u> <u>a-hokuyo-laser-range-finder,us,8,82.cfm</u>
- [2]. RIEGL LASER MEASUREMENT SYSTEMS, updated 7-4-2014 T 19:06, available on the Internet: <u>http://www.riegl.com/uploads/tx_pxpriegldownl</u>

oads/10 DataSheet LMS-Z210ii-S 07-06-2010.pdf

- [3]. KNEIP, Laurent TACHE, Fabien CAPRARI, Gilles - SIEGWART, Roland: Characterization of the compact Hokuyo URG-04LX 2D laser range scanner
- [4]. YOICHI, Okubo CANG, Ye BORENSTEIN, Johann : Charakterization of the Hokuyo URG-04LX Laser Rangefinder for Mobile Robot Obstacle Negotiation
- [5]. Hokuyo URG-04LX, updated 4-4-2014, available on the Internet: <u>http://www.hokuyoaut.jp/02sensor/07scanner/urg_04lx.html</u>
- [6]. Hokuyo URG-04LX-UG01, updated 4-4-2014, available on the Internet: <u>http://www.hokuyoaut.jp/02sensor/07scanner/urg_04lx_ug01.html</u>
- [7]. Hokuyo UBG-04-LX-F01, updated 4-4-2014, available on the Internet: <u>http://www.hokuyoaut.jp/02sensor/07scanner/ubg_041x_f01.html</u>
- [8]. Hokuyo Utm-30-LX, updated 5-4-2014, available on the Internet: <u>http://www.hokuyoaut.jp/02sensor/07scanner/utm_30lx.html</u>
- [9]. Sick Sensor Intelligence: Detection and Ranging Solutions, updated 7-4-2014 available on the Internet: <u>https://www.mysick.com/saqqara/pdf.aspx?id=i</u> m0044207
- [10]. RIEGL LASER MEASUREMENT SYSTEMS, updated 8-4-2014, available on the Internet: <u>http://riegl.com/nc/products/mobile-</u> <u>scanning/</u>
- [11]. Sick Sensor Intelligence, updated 9-4-2014, available on the Internet: <u>http://www.sick.com/group/EN/home/products/p</u> <u>roduct_portfolio/laser_measurement_systems/Pa</u> <u>ges/indoor_laser_measurement_technology.aspx</u>
- [12]. WULF, Oliver WAGNER, Bernardo: Fast 3D scanning methods for laser measurement systems. In: International Conference on Control Systems and Computer Science, 2003
- [13]. SHEN, R. JAMALI, N. KADOUS, M. W. – SAMMUT, C.: A Low-Cost, Compact, Lightweight 3D Range Sensors, updated 7-4-2014, available on the Internet: <u>http://rsheh.raybot.com.au/publications/sheh06lo</u> wcost-acra.pdf
- [14]. LEEDEKERKEN, J. C. FALLON, M. F. – LEONARD, J. J.: Mapping Complex Marine Environments with Autonomous Surface Craft, updated 7-4-2014, available on the Internet: <u>http://groups.csail.mit.edu/marine/pub/Leedeker</u> ken10iser.pdf
- [15]. Lidar news, updated 20-4-2014, available on the Internet: <u>http://www.lidarnews.com/component/option,co</u> <u>m_frontpage/Itemid,1/</u>

- [16]. Robotplatform, updated 8-5-2014, available on the Internet: <u>http://www.robotplatform.com/knowledge/Comp</u> <u>lete Robot building guide/grand robot tutorial.</u> <u>html</u>
- [17]. Diydrones, updated 5-5-2014, available on the Internet: <u>http://diydrones.com/forum/topics/ardupilotmega-with-rosonboard?commentId=705844%3AComment%3</u> <u>A1203701&xg_source=activity</u>

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