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STUDENT SUMMER INTERNSHIP TECHNICAL REPORT

IMU integration into Sensor suite for Inspection of H-Canyon

DOE-FIU SCIENCE & TECHNOLOGY WORKFORCE DEVELOPMENT PROGRAM

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ABSTRACT

The Purpose of this internship was to Integrate the sensor suite which will be mounted onto a robotic inspection tool used to survey the H-Canyon Air Exhaust (CAEX) tunnel the Savannah River Site. This sensor suite incorporates 3D-mapping of its surroundings, along with a 360 degree picture of its surroundings stitched in with the li-dar readings. Incorporation of the IMU would enable us to track the position of the robot inside the cave, such that the robot handlers can know where inside the exhaust tunnel the scans have been taken. The Inertial Measurement Unit (IMU) used had ROS compatibility, allowing for high leavel programming and ease of software modification. The sensor transmitted Data in the form of Acceleration. A good portion of the internship concerned the investigation of discrete integration techniques, such that we can acquire precise position information quickly.

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1. INTRODUCTION

The H-Canyon at Savannah Rivers National Lab (SRNL) is the only operational hardened nuclear chemical separations plant in the United States. H-Canyon uses chemical separation to process and recover uranium-235 and neptunium-237 from enriched uranium fuel tubes. H-Canyon is currently used to eliminate nuclear material, the exhaust air from the chemical separation is routed through the Canyon Air Exhaust (CAEX), it is made of reinforced concrete and rebar. Due to various chemical hazards in the air the tunnel has proven quite difficult to inspect. The chemicals inhabiting the tunnel include: Alpha contamination, Beta-gamma dose rates (1,000mRem/hr), Pools of water of unknown depth, Debris and other physical obstacles.

Up until now the physical debris have placed the biggest strain on robots, many of them have gotten stuck trying to climb over an uneven surface or hill of rubble, and due to their sheer size where not pulled out of the tunnel. The sensor suite is aimed at supplementing inspection data which up until now has been low resolution video. Advanced tunnel data such as 3D mapping would enable engineers to obtain quantitative data of the tunnel surface and erosion occurring for a more thorough structural analysis and for future planning. The creation and integration of the sensor suite will provide this data to include an understanding of the degree to which the rebar is exposed in the highly eroded areas. The creation and integration of the sensor suite will solve this problem because the amount of exposed rebar can be known, and any uneven surfaces can be detected before the robot attempts to climb something that cannot be climbed.

2. EXECUTIVE SUMMARY

This research work has been supported by the DOE-FIU Science & Technology Workforce Initiative, an innovative program developed by the US Department of Energy's Environmental Management (DOE-EM) and Florida International University's Applied Research Center (FIU-ARC). During the summer of 2018, a DOE Fellow intern Manuel Losada spent 10 weeks doing a summer internship at Savannah River National Lab under the supervision and guidance of insert Project Manager Jean Plummer. The intern's project was initiated on May 29th, 2018, and continued through August 8th, 2018 with the objective of Integrating Position acquisition capabilities into the sensor suite.

3. RESEARCH DESCRIPTION

3.1 Robotic Operating System

The system developed at SRNL synchronized position tracking Li-Dar mapping, and 3D imaging into a nicely packaged user friendly interface which any inspection technician can use to perform an inspection of the Tunnels. ROS uses a system of nodes (sensors) and topics (data streams) to create a generalized framework for component communication. ROS makes robotics easier by taking out the lower leavel program: writing drivers, programming registers, and communication protocols. With ROS all that a sensor has to do is publish its information to a topic, and the user simply has to subscribe to that topic to receive and process that data. ROS also has a plethora of debugging utilities such as auto generated graphs, and charts pointing out what data is being received and what sensor is communicating with what other sensor

3.2 RVIZ

RVIS stands for Robot visualization, and it is a tool used to reconstruct a visual representation of the information acquired by sensors. It is extremely useful for trying to figure out what exactly the robot thinks is going on, I used R-viz to craft a visual representation of the position and orientation of the IMU.

3.3 Inertial Measurement Unit (IMU)

This is the main sensor I was working with, and it is a sensor suite in it of itself and IMU contains an accelerometer, gyroscope and magnometer. What we are really concerned with is orientation provided by the gyroscope and acceleration provided by the accelerometer. In its raw form the data from the accelerometer is of little use to us what we need is position so using an integration technique called Simpsons rule we are able to integrate discrete data twice and acquire the position information from our acceleration data.

3.4 Test Platform

The lab was able to procure an old crawler form supper droids and I was tasked with modifying the software to outfit our needs. Since our sensor suite is modular, we were simply able to attach it to this test bot drive around and take scans of the warehouse.

4. RESULTS AND ANALYSIS

After extensive testing, and data acquisition we concluded that the IMU had far too much drift on it by its visualization on R-viz, this drift contributed greatly between the actual position and the position observed from the sensor. This accumulated error was due to hardware, yet the hardware on our unit could not be modified, hence the need for a software implementation of a kalman filter in order to get more precise displacement readings.

5. CONCLUSION

By the end of my internship it was very much concluded that the IMU was giving far to much drift, such that the next thing that should be done is to filter out the noise in order to have less falty readings, because the sensor was bought off the shelf all of the filtering would have to be done via software.

6. REFERENCES

"ROS Tutorials." Robotic Operating System, http://wiki.ros.org/ROS/Tutorials.
"3DM-GX3-25." Documentation page, http://www.microstrain.com/inertial/3dm-gx3-25

APPENDIX A.