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 a sensor suite which will be mounted onto a robotic inspection tool for surveying the H-Canyon Air Exhaust (CAEX) tunnel at the Savannah River Site. This sensor suite incorporates 3D-mapping of its surroundings, a 360 degree picture of its surroundings combined with light detection and ranging (LiDAR) measurements. Incorporation of a inertial measurement unit (IMU) with the sensor suite would provide the ability to track the position of the robot inside the tunnel and provide location information for the scans collected. The IMU used had robot operating system (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 in order to acquire precise position information quickly.

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1. INTRODUCTION

The H-Canyon at Savannah Rivers National Laboratory (SRNL) is the only operational hardened nuclear chemical separations plant in the United States. This facility uses chemical separation to process and recover uranium-235 and neptunium-237 from enriched uranium fuel tubes. The exhaust air from the chemical separation is then routed through the canyon air exhaust (CAEX), made of reinforced concrete and rebar. The tunnel has proven quite difficult to inspect due to various associated hazards, including alpha contamination, beta-gamma dose rates (1,000 mRem/hr), pools of water of unknown depth, debris and other physical obstacles. To date, the physical debris has provided the biggest challenge to the inspection robots. Many of them have gotten stuck trying to climb over the uneven surface or a hill of rubble and were not retrievable.

A sensor suite has been designed and developed to help perform these robotic inspections of the H-Canyon. The low resolution images collected to date have proven to be insufficient to gauge the amount of exposed rebar, which is needed to evaluate the current structural integrity of the tunnel. The creation and integration of the sensor suite will solve these problems because the amount of exposed rebar can then be determine and uneven surfaces and debris can be detected before the robot encounters an unsurmountable challenge.

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 Laboratory under the supervision and guidance of Jean Plummer. The intern's project was initiated on May 29, 2018, and continued through August 8, 2018 with the objective of Integrating Position acquisition capabilities into the sensor suite. This internship was supported by the DOE EM Minority Serving Institutions Partnership Program (MSIPP).

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 defining the environment from the robot’s perspective. RVIZ was used during the internship to craft a visual representation of the position and orientation of the IMU.

3.3 Inertial Measurement Unit (IMU)

The IMU is the main sensor Mr. Losada worked with during his internship. An IMU is essentially a self-contained sensor suite with an accelerometer, gyroscope and magnometer. Of specific interest in this application is the orientation provided by the gyroscope and the acceleration provided by the accelerometer. In its raw form, the data from the accelerometer is of little use but, by using an integration technique called Simpsons rule, the discrete data provided can be integrated twice to acquire the needed position information.

3.4 Test Platform

SRNL was able to procure an old robotic crawler and Mr. Losada was tasked with modifying the software for use in deploying the IMU. Since the sensor suite is modular, it was simply attached to the test robotic platform and driven around to 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

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"3DM-GX3-25." Documentation page, http://www.microstrain.com/inertial/3dm-gx3-25