Remote Operation Of A Thickness Testing / Carry Back Measurement Mobile Unit

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Abstract

The main of the project is to perform thickness testing by applying autonomous testing methods to replace manual interaction. This will enable specific measuring points to be collected autonomously, remotely, and securely. Applying an autonomous testing method to perform the thickness testing, will result in lower costs, increased accuracy of thickness testing, and reduced processing time. This will help the end user to make a better-informed prediction of truck body floor lifespan and to determine maintenance strategies quickly and precisely. This will take truck body inspections to a new level, making Austin Engineering the market leader through this high-quality service. The project adopts autonomous robot technology to take thickness measurements at various points on the truck body floor. This autonomous robot will make use of self-orientation functionality. The key deliverables for this project are to hand over a high-level design of the system, the prototype of the robotic vehicle with a path planning function and all corresponding codes/datasets.

1. Introduction

1.1 Background

Austin Engineering is a designer and manufacture of customized dump truck bodies, buckets, and other products used in the mining industry. The company also provides on-site and off-site repair or maintenance for client companies. The main purpose of the floor assembly maintenance service that Austin Engineering offers to the customer is to predict the lifespan of the floor assembly via calculating the wear percentage.

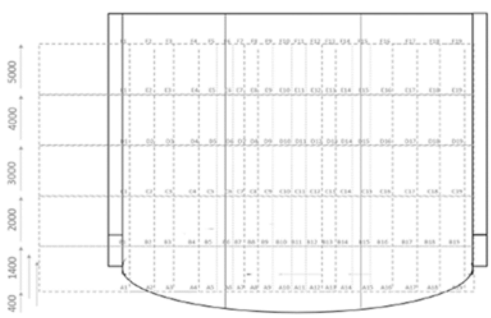

Figure 1 Thickness Testing Grid (Austin Engineering, 2019)

The floor assembly inspection method currently applied by the Austin Project is to conduct non-destructive thickness inspection at the floor. As the area of the floor is relatively large, to make a precise prediction, Austin Engineering uses a grid to divide the big area into small parts and take the measurement in each subregion, as shown in figure 1 (Austin Engineering, 2019).

1.2 Problem Statement

Collection of floor assembly thickness data is done by floor inspection around every 1,000 hours by non-destructive (NDT) testing methods. The thickness data is usually collected manually by technicians on site. The manual method is deemed ineffective and unproductive because of the long work taken by the technicians. The usual inspection takes around half day to one day while the truck is off operation. The tasks incur operating costs and labor costs, as each work inspection includes removing the truck from the operation, cleaning the floor, and data collection. To obtain accurate thickness data, it collecting data manually is inefficient.

2. Process

The project objective is to deisgn an autonomous thickness testing vehicle to solve the problem. To ensure the robot can meet the objectives of the project with good performance and accurate path planning, the plan of the project will involve the following stages:

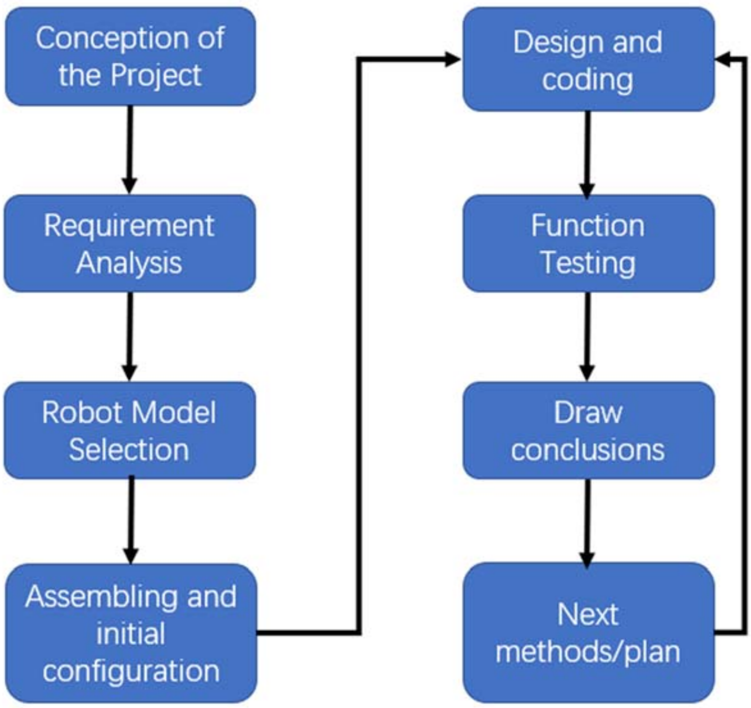

Figure 2 Overall robot vehicle design process

The basic structure of the design is shown as the figure below:

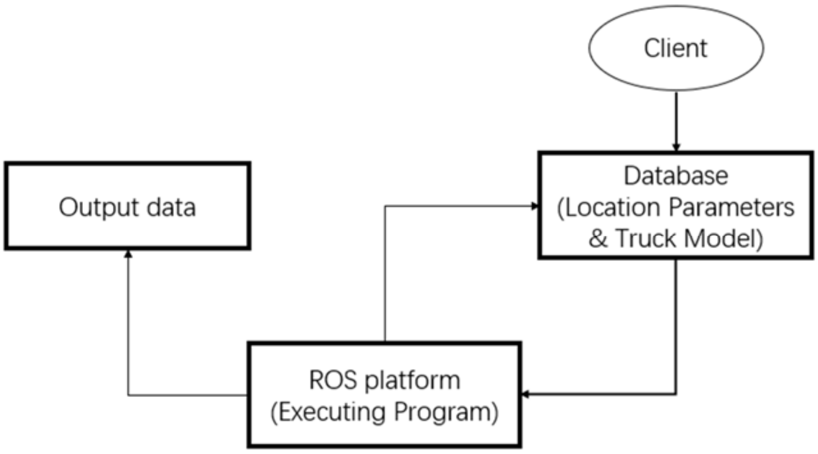

Figure 3 Design of the system

The client can access the database and change the location parameters. At this stage, the database can be read in a spreadsheet. The spreadsheet will record the locations when the client wants to take thickness measurements. The location parameters can be transmitted from the database to the ROS platform. The robot vehicle can move towards each goal point and stop for a few seconds. Then the robot will generate output data. The process consists of receiving target points, executing the program and generating output data.

2.1 Tools and Method Selected

In this project, a small robot will be selected for the path planning function test. The “Turtlebot 3 Burger” vehicle is selected for this project. The Turtlebot 3 has a scalable structure, a lidar sensor for navigation, one single-board computer for raspberry pi, and one OpenCr for controlling the DC motor.

Figure 4 Turtlebot 3 Burger

3. Results and Discussion

3.1 Initial Configuration & Lidar Testing

After assembling the Turtlebot3 model, the connection between the robot vehicle and raspberry pi needs to be built. The preliminary tests were conducted on the various components of the Turtlebot3 vehicle to test the connection between the remote PC, the function of the lidar sensor and hardware. This ensures that the robot can be connected and fully controlled by the remote device. The preliminary testing includes environment mapping, robot locating and robot driving tests.

To test the mapping function of the robot, a lab environment has been used for functional testing that is similar to the truck tray floor environment (Figure 4 left). A map of the environment was constructed when the lidar sensor testing is done. The dimension of the environment is 1.5m * 3.0m.

The lidar sensor was tested for robot locating and navigation. The robot vehicle was placed into the lab environment. Turn on the lidar sensor and execute the mapping algorithm and location algorithm. A real-time map of the lab environment can be obtained (Figure 4 right). The shadowy region shows the detecting range of the lidar sensor. The lidar sensor scans the environment simultaneously within the shadowy region and maps the scanned boundary compared to the original map.

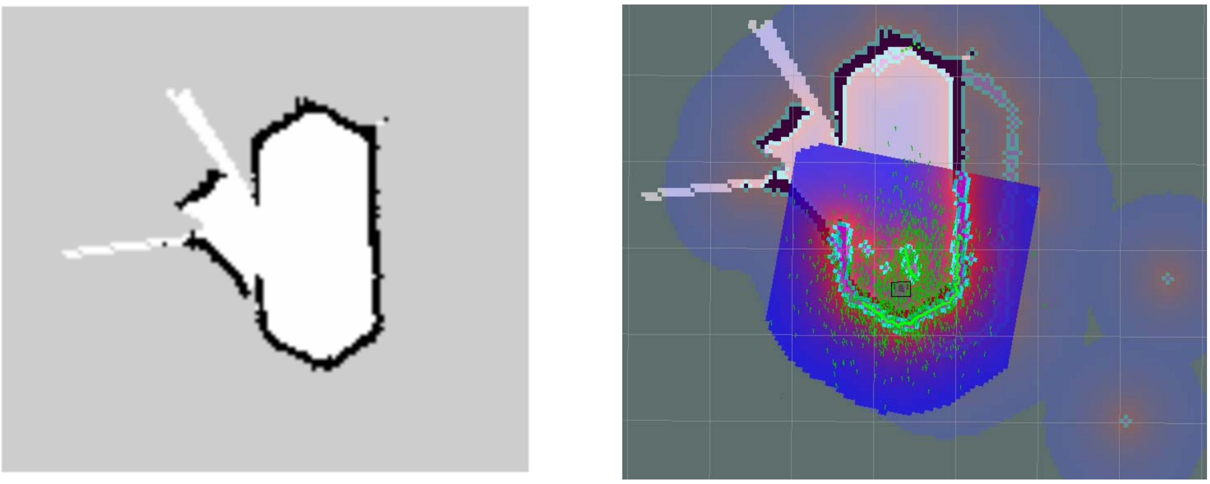

Figure 4 Lab environment

The detecting range for this lidar is around 3*3m. When the 2D pose estimate is done, the lidar could detect the lab environment accurately and the position of the robot could be acquired and shown in figure 4 (left). The actual position, the acquired position and the accuracy are shown in table 1:

Acquired Position (x,y)	Actual Position (x,y)	Accuracy % (x,y)
(0.638,0.506)	(0.63,0.49)	(1.2% ,3.2%)
(0.756,1.394)	(0.79,1.39)	(4.3%,0.29%)

(0.660,2.49)	(0.65,2.57)	(1.5% ,8%)

Table 1 Initial Position Tests

The error between the acquired position and the actual position is acceptable. The lidar sensor can estimate the position of the robot vehicle accurately in this environment. It is crucial to ensure the starting position can be estimated accurately on ROS system, which ensures the navigation function can be executed within a small error.

3.2 Driving and Navigation Testing

The navigation and path planning function can be tested after the navigation algorithm is completed. Sample goal points were set as shown in figure 5. The navigation algorithm allows the robot vehicle to move towards each goal point and stop for a few seconds. 6 points were set for lab testing to test whether the navigation function was successfully implemented. Table 2 records the position and running time when the robot arrived at the set point.

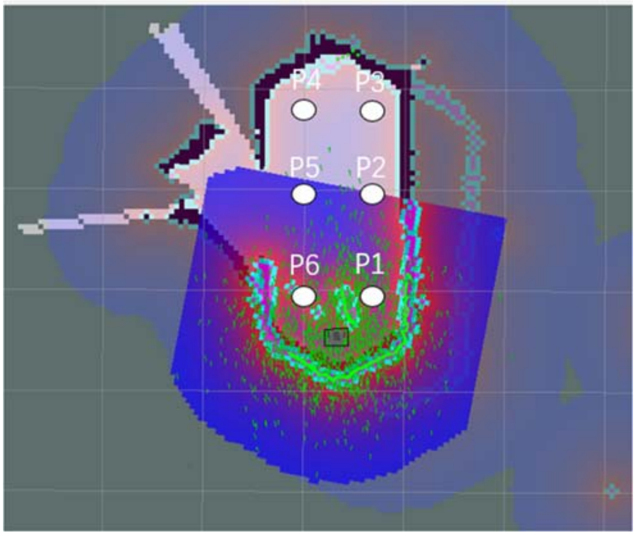

Figure 5 Location of Sample Goal Points

Goal Point	Acquired Position	Running Time (min)	Error%
(0.84 , 0.33)	(0.790 , 0.270)	1.3	(5.9% ,18%)
(1.65 , 0.33)	(1.61 , 0.33)	0.4	(2.4% ,0%)
(2.77 , 0.33)	(2.79 , 0.36)	0.6	(0.72%,9.1%)
(2.77 , 1.04)	(2.78 , 1.03)	0.5	(0.36%,0.96%)
(1.85 , 1.04)	(1.91 , 1.03)	2.5	(3.24%,0.96%)
(0.84 , 1.04)	(0.82 , 1.03)	0.4	(2.4%,0.96%)

Table 2 Navigation tests

The limitation of this navigation plan is that the system needs all environment mapping completed in advance. If the robot works in different environments, the robot needs to do preliminary environment scanning and upload it to the Raspberry Pi. The accuracy of the navigation function is influenced by the measurement accuracy from the lidar sensor and motor. The distance accuracy of the lidar sensor is $\pm 15\ mm$, where the scanned environment map has a minor difference from the actual environment.

4. Conclusions and Future Work

4.1 Conclusion

A robot vehicle with a navigation function has been successfully developed and tested in the lab environment. The robot vehicle can move to each target point in the lab test. The research has successfully yielded a high-level system design with the desired outcomes.

4.2 Future Work

In the future, Austin Engineering will apply mobile inspection applications to the actual industry. Some project goals for the mobile platform have already been established including Web development and mobile app development. According to Cyient's project proposal (Cyient, 2020), the Web and mobile app contain inspection modules, dashboard list view, and static reports. This platform could save all detection data like automating wear rate to the server and can be viewed by any other users for further analysis (Cyient, 2020).To develop the inspection network, fast and accurate thickness data collection is necessary. The scope of the project is mainly focused on Ultima 830 truck body. The outcome of the project will be easily utilized and replicated in the industry.

Due to the constraints of the Turtlebot3 Burger, the action pattern can't be tested in this stage. A color sensor or thickness testing sensor can be added to the robot in the future. The thickness data can be collected and exported to an external device. To translate the system to an industrialised robot, the designer needs to consider practical problems such as some ripples or holes on the truck tray floor. Some functions such as avoiding obstacle functions need to be developed.

5. Acknowledgements

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6. References

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