RAIL INSPECTION ROBOT USING THE AHRS ALGORITHMS

[1]YUN-SEOK LEE, [2]EUN KIM, [3]YOUNG-BEAK KIM, [4]JONG-MIN KIM, [5]YOUNG-SUB KIM

[1,2,4,5]LKSmart, [3]Extriple
E-mail: lysis2jt@naver.com, sil7777@nate.com, baroaleum@extriple.com, runamini@lksmart.co.kr, yonggarman@lksmart.co.kr

Abstract— Today, the interest in carbon emissions continues to increase. Consequently, the railroad is in the spotlight as low-carbon vehicles. In these environments, it occurs the continuous human and temporal costs in railway construction and maintenance. This occurs because of problem that verify the rail is correct constructed and to check the status of the rail in the maintenance process. In order to solve this problem, it was the use of expensive manned exploration equipment. In this paper, in order to solve this problem, we propose an unmanned rail robot that can inspect such as the rail surface and a distortional rail with running on the rail. In this rail robot is equipped with the algorithm AHRS(Attitude Heading Reference System), thus, they can enjoy information of their position and the rail status. Through this, it can be proceed with the effective railway construction and the maintenance.

Index Terms— Rail Robot, Rail Inspection, AHRS.

I. INTRODUCTION

Today, it appears such as the serious environmental pollution problems, many countries are making efforts to reduce carbon emissions through transport by train or ship transport than using a car. In such an environment, effective railway construction and the maintenance method is an essential part in the expanding rail industry[1]-[8]. Especially, rail flaw detection equipment that be used to test to secure the rail station are composed of very large and expensive equipment. Typically it has equipped with ultrasonic equipment for detecting a crack[1][3]. This inspection vehicle is usually proceeded the inspection by boarding about 3 people. At this point, it passes after displaying a colored ink in problem area during the inspection. Afterwards, the person repairs the problem area by going to that location and manually precise inspects. The inspection about the rail with such process is proceeded, the largest two problems are a cost and time at this time. And due to this, there is a time-consuming problem, because of a small number of inspection vehicles. This may affect the safety railway[1]. In this paper, in order to solve this problem, we propose an unmanned rail flaw detection robot that can travel without people on board. In the unmanned exploration rail robot is mounted the AHRS algorithm. Thus, it can also be measured the problem that it could not be confirmed such as a distortional rail, the ground subsidence exist detection equipment. In chapter 2 presents the problem of existing inspection methods, also presents the design and construction of the rail robots in chapter 3. We draw the analysis in chapter 4, and finally also draw the conclusions in chapter 5.

II. RELATED WORKS

There is a type of rail flaw detection equipment to proceed with the flaw in the traditional railway environment that one person has a manual inspection device for inspect by going direct. And there is a railway vehicle type of inspection device to proceed by three or more persons on board.



Fig 1. The Manual Inspection Equipment

As shown Fig.1, the manual inspection system is a device which enables a low-speed precision inspection. Thus, it inspects manually and directly the marking part by a inspection vehicle. And also, checks the exact point and then, fixes the corresponding area. And a vehicle-type inspection equipment can be inspected the both sides of rail by using an ultrasonic device that attached to bottom of the railway[1] [3]. This equipment is capable of high-speed inspection compared with the manual inspection equipment. And it can cover the large area[3]. However, there are disadvantages that it is very expensive compared with a manual inspection equipment and it is needed at least three persons of inspection staff. In this paper, in order to solve this problem, we propose a method to manage the information effectively and to detect the rail flaw without any person.

III. OUR PROPOSE DEVICE

In this paper, we propose a method to inspect by using the equipped with the AHRS algorithms rail robot that it can automatically move on above rail.

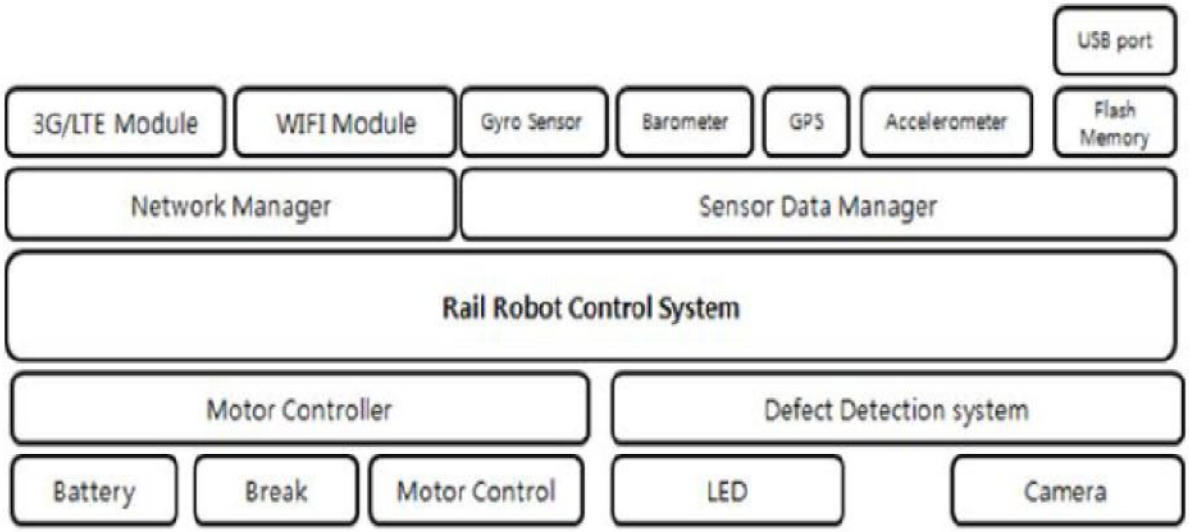


Fig 2.Rail Robot Structure

As shown Fig.2, Rail Robot Control System is composed of a Sensor Data Manager, Network Manager, Defect Detection System and finally Motor Controller. In the role of each section is as follows.

A. Rail Robot Control System

As shown Fig.3, the Rail Robot Control System is responsible for the direct control of the sensor data manager, the network manager, the detection system and the drive control system. The Rail Robot Control System is a space that is mounted AHRS algorithm. Thus, it controls the drive control section on the basis of obtained information of position and place from the sensor section. And the received data is in progress important roles to store and manage. And it is responsible for control of the robot by using the obtained control information from the network manager. The control for the rail robot has a command to analyze such as a verification service of location information for performing the mission, a speed control for the robot, the emergency notification service, the traffic control system. Rail Robot Control System is instructed to allow the mission to operate a specific section from the control system. Its mission is moved by receiving one of two between the time and distance. At this point, in order to determine the correct state for the mission, there are attached an encoder for distance measurement in four wheels. This is utilized when it is calculated the exact position information via the GPS information. The reason for performing the position calculation, it is to proceed to a repair, when the discovery or more rails such as cracks to accurately identify the location.

B. Network Manager

The Network Manager is used to transmit information for all situations that may be occurred in the course of the inspection robot rails to the control system. And it is also used to receive the obtained control information from the control system. At this point, the communication module is used the 3G/LTE and WIFI. The control system checks the status of the rail robot.

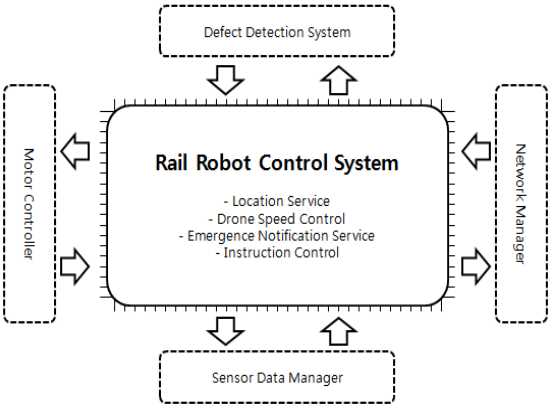


Fig 2.Rail Robot Control System

And it refers to a control to cope with an emergency. The Network Manager determines the status of to be used communication module. And it has a responsible to select a network of useful state and to manage for performing the communication.

C. Sensor Data Manager

The Sensor Data Manager is a core manager module to operate the AHRS algorithms.

Thus, as shown Fig.4, it has a right meter, GPS, Accelerometer and gyro sensors. In addition, it advances the data management through a Flash Memory and a USB port. The Sensor Data Manager to use such a above sensor, it provides data to analyze a distortional rail, a windingness and ground subsidence around the gyro sensor. In addition, when detecting the cracks of the rails by using the GPS, it is allowed to record the precise location in the image as sending a corresponding value of the GPS to the Defect Detection System. The recorded information of GPS and distance as the meta data of images are used to calculate the correct position during the repair of the rail.

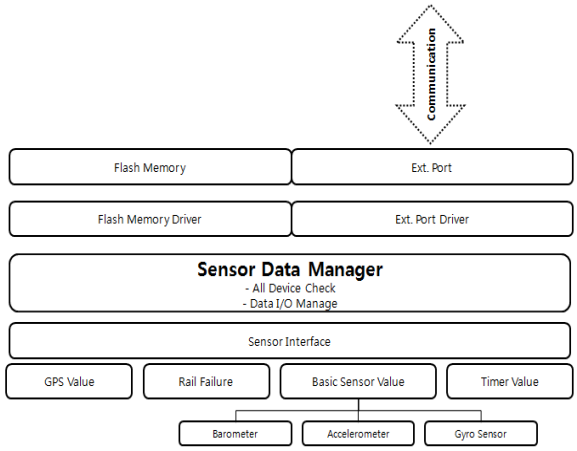


Fig 3.The Structure of the Sensor Data Manager

The gyro sensor has a value of the gyroscope(Roll, Pitch and Yaw). In case of the Pitch, it is used to detect the ground subsidence of the rails. Yaw is used to detect such as a distortional rail and a strange angle. And Roll is used to verify the slope and the exact construction. Of course, Pitch and Roll are also used to verify with respect to ground subsidence. The details about Roll, Pitch, Yaw are as shown in Fig.5.

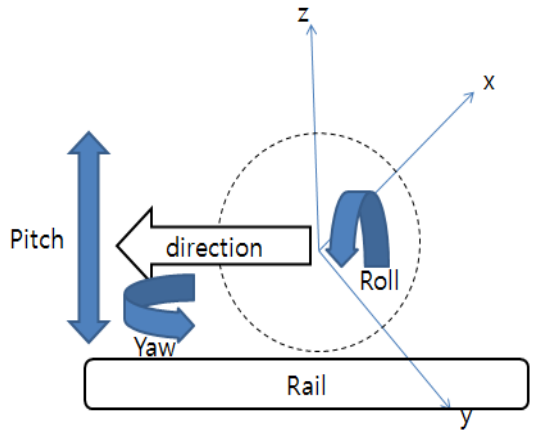


Fig 4.Roll, Pitch, Yaw according to the progress of the robot rails

D. Motor Controller

The Motor Controller operates the motor equipped with a separate battery for motor driving. To operate the battery separately, it is to cope with an emergency situation during the operation of the rail robot. To operate above the rail may also be liable to produce a very dangerous situation. The problem may be occurred during the unmanedoperationbecause of equipment defect. If itis happen this situation, it cannot be the response for this. Thus, in order to minimize such as that situation, there were minimized the possibility of failure because in the drive unit has a separate battery. And it is proceed the brake for a steady driving of the rail robot. And it controls the respective wheel. At this time, it is operated to perform the functions of drive and stop based on the received information from Rail Robot Control System

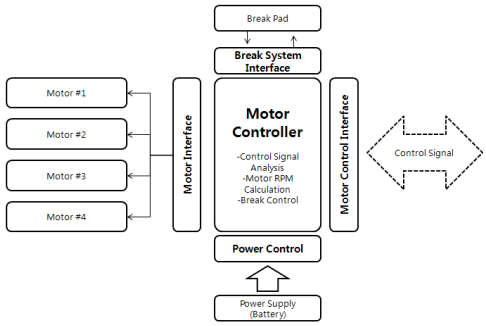


Fig 6. Motor controller

E. Defect Detection System

It is a system for detecting the problems of therails, it detects the surface crack through the image processing. The mo necessary for the image processing, it is to provide a uniform image acquisition environment. To make these environments, it is made a rectangular module by area between the rail and the lens. And then, it removes debris by putting the brush in the upper rail. And it uses the LED lights to the picked image acquisition. Thus, it adjusts the environment to enable the obtaining uniform images. And images are obtained through a line camera. And then, it detects the surface cracks after analyzing the image data.

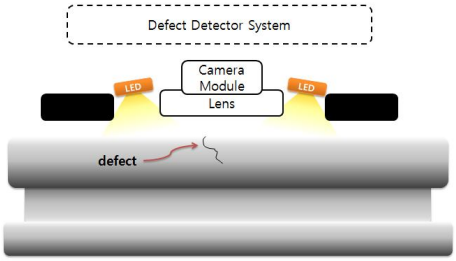


Fig 7.Defect Detector System

IV. ANALYSIS

Our proposed method in this paper is a scheme that can detect such as the surface of the rail, a distortional rail and ground subsidence using a rail robot. The core module in this phase is just AHRS algorithm. This algorithm is configured with 3-axis gyro sensor, geomagnetic sensor, Barometer and Accelerometer. It is a rail robot equipped with a AHRS algorithm that it is used in exist drones and robots. It is not simply used for the purpose of controlling the posture of the robot. Therefore, it is used for the purpose of confirmation and verifying the state of the rail. It is a method that checks the rail status by using this rail robot. Thus firstly, it is possible to effectively verify in the construction process. The earlier method is to verify whether the measurement using the measurement machine by person directly. However, proposed method is validated by checking the rotation at the time of a distortional rail, the rail height and rotation by running above the rail after the end of construction. Thus, our proposed method can be reduced the

surveying cost in the temporal side and the human side after construction. And the construction data is stored in the DB. Thus, we designed that it can be recalled and compared to previous data, to enable efficient verification of the messages. And the robot runs above the rail to obtain the status of the rails during operation. And the obtained data brings information of corresponding interval from stored database. Compared with this, the error value as the greater the range is displayed. And then, it is shown the position information to the users. It performs the verification for the effective rail status by this way.

CONCLUSION

In this paper, in order to solve biggest problem of the cost aspect, we propose method to use the rail robot. The rail robot can be controlled transmit the rail information via the control system. The rail robot was equipped and operated with a AHRS algorithm to determine the status of the rails. It can be surveyed status information rail such as a distortional rail, ground subsidence, rotation angle through AHRS algorithm. And also, we designed to can be allowed the inspection of the surface of the rails with by using the VPS(video processing device).

ACKNOWLEDGMENTS

This paper has received the support of the Research and Business Development(R&BD), Ministry of Trade, Republic of Korea(C0332683).

REFERENCES

[1] Q. Li, Z. Zhong, Z. Liang, and Y. Liang, “Rail Inspection Meets Big Data:Methods and Trends,” International Conference on Network-Based Information Systems, pp. 302-308, Sept, 2015.

[2] M. P. Papaelias, C. Roberts and C. L. Davis, “A review on non-destructive evaluation of rails:State-of-the-art and future development,” Proc. Inst. Mech. Eng. F, J. Rail Rapid Transit, vol. 222, no. 4, pp. 367-384, 2008

[3] Y. Li, H. Trinh, N. Haas, C. Otto, and S. Pankanti, “Rail Component Detection, Optimization, and Assessment for Automatic Rail Track Inspection,” IEEE Trans. On Intelligent Transportation System, Vol. 15, pp. 760-770, Dec, 2013.

[4] Y. Chen, H. Qian, and Y. Xu, “Optimization for rail-type climbing robot in space,” IEEE International Conference on Mechatronics and Automation, pp.1540-1545, 2013

[5] S. M. Moon, D. Hong, S. W. Kim, and S. Park, “Building wall maintenance robot based on built-in guide rail,” pp. 498-503, ICIT 2012.

[6] D. H. Kim, S. Lee, M. S. Kang, B. I. Chun, and C. S. Han, “Proposal of built-in guide-rail type building façade cleaning robot and its motion planning algorithm,”pp. 1004-1009, CASE 2012.

[7] Z. G. Hou, and M. M. Gupta, “A rail damage detection and measurement system using neural networks,” pp.4-9, CIMSA 2004

[8] Z. Liu, W. Li, F. Xue, J. Xiafang, B. Bu, and Z. Yi, “Eletromagnetic Tomography Rail Defect Inspection,” IEEE Trans. On Magnetics, vol. 51, Oct 2015.

★★★