Development of Unmanned Transport System for Automated Systems

Hyunhak Cho
Department of Interdisciplinary Cooperative Course: Robot, Pusan National University,
10313, 2, Busandaehak-ro 63beon-gil, Geumjeong-gu, Busan, 609-735, Korea

Jungwon Yu, Yeongsang Jeong, Hansoo Lee, Sungshin Kim
Department of Electrical and Computer Engineering, Pusan National University,
10313, 2, Busandaehak-ro 63beon-gil, Geumjeong-gu, Busan, 609-735, Korea
E-mail: {darkruby1004, garden0312, dalpangi03, hansoo, sskim}@pusan.ac.kr
www.pusan.ac.kr

Abstract

Unmanned transport systems are used in many industries owing to their high efficiency, such as transport of high loads, 24 hour a day use and low cost. Many components of industry are being changed to unmanned transport system. Therefore, this paper introduces application and composition of the unmanned transport systems in industry to the transport, and describes the selected method by the environment conditions. Unmanned transport system is comprised of an Automatic Guidance Vehicle and a Monitoring system. The applied AGV is guided by localization information, which is measured by a laser navigation guidance system with encoders and gyroscope. AGV require a virtual driving path method with map information from conveyor positions and rotation points in an environment, as well as automatic load/unload system for cargo transport, an emergency system for safety, and a communication system with an automatic charger and monitoring system.

Keywords: Autonomous guidance system, Localization, Telescope Load/Unload System

1. Introduction

Many industries; manufacturing plants, warehouses, port facilities and so on are changing to automatic systems through the development of unmanned robot technology. Automatic production systems in various industrial systems have many components, and the material handling system of components is very important because of its potential to reduce cost. Material handling system means a load /unload/ transport/storage system.

Recently, there has been increasing interest in unmanned transport system to satisfy the flexibility and efficiency of material handling system. The unmanned transport system is an aggregate of various technologies, such as localization, driving control, load/unload system, path planning, monitoring system, and so on. The technologies of the unmanned transport system are general, and detailed technologies for the LGV are selected according to the conditions of the environment. The AGVs are a changed guidance system; floor state, plant size, maintenance, and so on, wheel type; floor state, oil, and so on, load/unload; conveyor, palette type, and so on system according to the conditions of the environment [1]-[6].

This article introduces the application of the unmanned transport system; AGV and Monitoring system with the combined technology of the mentioned content to the industry field. Among the range of wireless guidance systems available, this study used encoders, a gyroscope and laser navigation. In addition, virtual path planning was used for the wireless guidance system, the driving wheel structure was the differential driving structure, and the controller was an industrial PC. Load/unload system for the cargo used the telescopic type due to the type of palette and conveyor.

Chapter 2 discusses the hardware configuration of the unmanned transport system; load/unload system, body frame of AGV Chapter 3 presents the software configuration of the unmanned transport system; localization, driving controller, virtual path planning. Chapter 4 presents the conclusion.

2. Hardware Configuration

In this article, unmanned transport system; AGV, Monitoring system was designed by the present and ATIS (Company in Korea). Fig 1 shows the appearance of the manufactured LGV. Laser navigation, encoders and a gyroscope were used for the localization of LGV. The global position (*x, y, t*) of localization information was measured using laser navigation. The local position (*x, y, t*) of localization information was calculated by the kinematics with encoders and a gyroscope.

The load/unload system is affected by cargo, conveyor and pallets. Therefore, the telescopic type load/unload system was selected. The system was composed a fixed frame, body frame for moving; left, right and two arms on the body frame for settling the pallet; cargo. The detailed components are the left-right motor for the body frame, up-down motor 2 for the arms.

3. Software Configuration

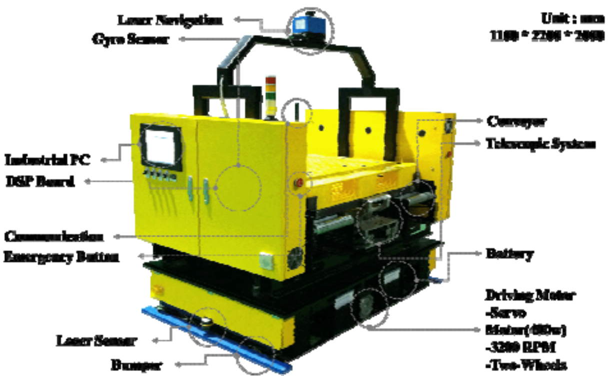

Fig. 1. Autonomous Guidance Vehicle

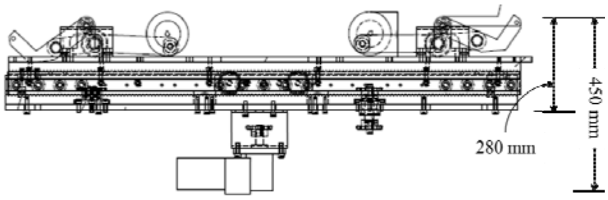

Fig. 2. Telescopic Load/Unload System

The LGV is guided by the laser navigation, encoders and gyroscope of the localization sensors. The laser navigation sensor measured the difference distance and angle between the header of the laser navigation and attached reflectors in the field through a time delay; transmit-receive. The laser navigation calculated the current position of the LGV through a triangulation method using the measured information and saved position information of the reflectors.

AGV with a wireless guidance system is controlled by the error angle. The control system using this method was unstable because of the large increase in the error angle when the distance between the AGV position and destination point was close. Therefore, in this study, the error angle and derailment distance between the current position and driving path was used in equation 1.

$$E = E_d \times a + E_\theta \times (1-a) \tag{1}$$

The a in the equation is the ratio, and E_d and E_θ are the derailment distance and error angle. The composition of the equation is the same as shown in Fig 3.

$$E_d = \frac{|aA_x + bA_y + c|}{\sqrt{a^2+b^2}} \tag{2}$$

$$\begin{aligned} E_\theta &= D_\theta + T_\theta \\ D_\theta &= N_\theta - S_\theta \\ T_\theta &= N_\theta - A_\theta \end{aligned} \tag{3}$$

D_θ in the equation is the difference between the angles (angle of LGV position Destination position, angle of Virtual Path Destination position). T_θ is the angle of the LGV. The voltage difference of the wheels was calculated by E in Equation 6 with a PD controller, and the

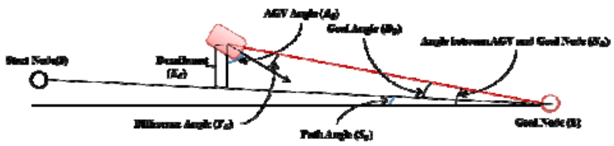

Fig. 3. Error Calculation

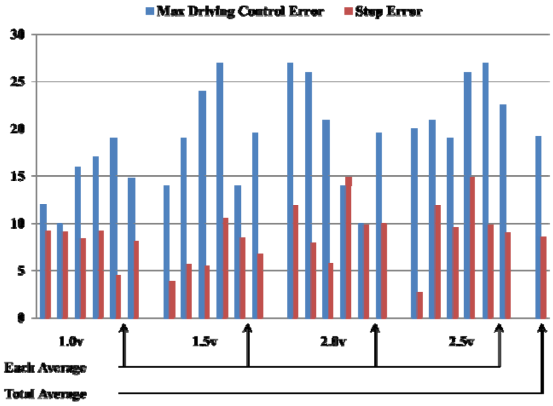

Fig. 4. Result Graph of Localization and Control

LGV was controlled by the difference in voltage.

Fig 4 presents a graph of the experiment results. The driving and stop accuracy of the experiment results are sufficient due to the greater than required accuracy (±30 and ±15 mm). When the LGV stops, 0.7v (less 200 mm distance between AGV position and destination point), and 0.4v (less 100 mm), and 0.2v (less than 30 mm) were applied to prevent a collision between the LGV and fixed conveyors.

Virtual Path Planning is a very important configuration in the LGV, and it was used to guide from the start point to the destination point. The configuration form of the conveyor appears like a straight line. In practice, however, the configuration form of the conveyor in the field is a zigzag conformation. In practice, the configuration from of the conveyor in the field is a zigzag conformation. The nodes of virtual path a zigzag path planning to prevent a collision with conveyor, planning are composed of the conveyor position, rotation position, and special position.

Fig 5 shows the configuration of the modified tree structure. The search direction of the virtual path planning method is bidirectional, because the driving direction of the LGV through the Main monitoring system is forward and backward. The modified tree structure is expressed by the adjacent nodes, the node mean conveyor, rotation node, and charger. The link line is the virtual driving path. Whenever searching the virtual path from a new position in map, it should create a tree structure continually. Therefore, a recursive structure was used to solve the previous problem.

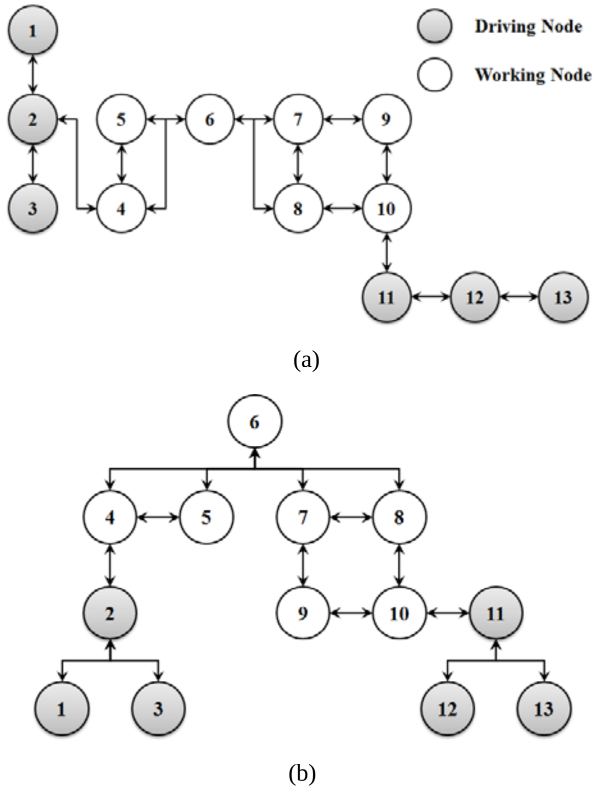

Fig. 5. Result Graph of Localization and Control; (a) Node structure, (b) Tree structure

4. Conclusion

The proposed unmanned transport system is composed of a LGV, conveyor and monitoring system, and the LGV contains a different driving system, a telescopic type (for transporting cargo with a high load) and a communication system. The conveyor type is classified as the A, B and C type through the pallet type or attached equipment. The LGV is guided by the controller using laser navigation but the stability of the system is low. To solve this problem, encoders and a gyroscope are used. The LGV is controlled by the error angle and derailment distance, and LGV is driving through the virtual path from the start node to the destination node.

In the present study, the unmanned transport system, which is an aggregate system of various technologies, such as navigation systems, a driving system, load /unload system, path planning, monitoring system, and emergency system, was examined closely.

Acknowledgment

This work was supported by BK21PLUS, Creative Human Resource Development Program for IT Convergence and was supported by the MOTIE (Ministry of Trade, Industry & Energy), Korea, under the Industry Convergence Liaison Robotics Creative Graduates Education Program supervised by the KIAT (N0001126).

References

1. J. L. Crowley, Navigation for an intelligent mobile robot, *IEEE Journal of Robotics and Automation*, 1(1) (1985), pp. 31-41.
2. S. Y. Jung, J. M. Kim and S. S. Kim, Simultaneous localization and mapping of a wheel-based autonomous vehicle with ultrasonic sensors, *Artificial Life and Robotics*, 14(2) (2009), pp. 186-190.
3. M. Gunes and A. F. Baba, Speed and position control of autonomous mobile robot on variable trajectory depending on its curvature, *Journal of Scientific & Industrial Research*, 68(6) (2009), pp. 513-521.
4. J. Lee, S. I. Han and J. M. Lee, Decoupled Dynamic Control for Pitch and Roll Axes of the Unicycle Robot, *IEEE Transactions on Industrial Electronics*, 60(9) (2013), pp. 3814-3822.
5. E. DiGiampaolo and F. Martinelli, A Passive UHF-RFID System for the Localization of an Indoor Autonomous Vehicle, *IEEE Transactions on Industrial Electronics*, 59(10) (2012), pp. 3961-3970.
6. G. Zhao, K. Xuan and D. Taniar, Path kNN Query Processing in Mobile Systems, *IEEE Transactions on Industrial Electronics*, 60(3) (2013), pp. 1099-1107.

©The 2015 International Conference on Artificial Life and Robotics (ICAROB 2015), Jan. 10-12, Oita, Japan