Development of Automatic Guided Mobile Robot Using Magnetic Position Meter

Geun-Mo Kim, and Young-Jae Ryoo

Abstract**—**In this paper, an automatic guided mobile robot using a new magnetic position meter is described. In order to measure the lateral position of a mobile robot, a new magnetic position meter is developed. The magnetic position meter can detect the position of a magnetic wire on the center of road. A mobile robot in designed with a sensing system, a steering system and a driving system. The designed mobile robot is tested to verify the performance of automatic guidance.

Keywords**—**Autonomous Vehicle, Magnetic Position Meter, Steering, Magnet.

I. Introduction

A sudden increment of vehicles since 1980 years and gridlock and waste of energy, environmental pollution, corporation's distribution cost increase, human damage by traffic accidents, traffic accidents processing expense is becoming social issue. Researches for Intelligence Transport System (ITS) are continued worldwide by countermeasure about these problems because Vision method senses lane of road by camera, when lane does not look well to do driving, become a problem. And because position awareness method to use magnetic uses magnet of semi-permanent life by devised method to supplement shortcoming of method that use GPS, Power Wire, Vision, because there is inexpensive preservation repair expense and noise strong advantage, it is the most suitable method at practical use[1-2]. By the way, magnetic strength and to judge intuitionally in 3-dimensional phenomenon have direction hard[3-4].

This paper presents an automatic guided mobile robot using magnetic position meter. For experiment test an automatic guided mobile robot is designed. The designed mobile robot consists of a sensing system, a steering system, and driving system. A new magnetic position meter is developed to measure the position of magnetic wire. The sensing system with the new magnetic position meter in installed to the robot. The steering system with BLDC motor and the driving system with DC motor are controlled by the designed control algorithm. The driving performances are evaluated by the experimental tests.

Manuscript received August 7, 2007. This research was financially supported by the Ministry of Commerce, Industry and Energy (MOCIE) and Korea Industrial Technology Foundation (KOTEF) through the Human Resource Training Project for Regional Innovation.

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II. Magnetic Position Meter

A. Magnetic Wire

While the previous magnetic guidance system uses magnetic markers, the proposed system uses magnetic wire composed of rubber-magnets. The width and thickness of magnetic wire are 9 and 25mm. The advantages of magnetic wire are cheep cost and flexibility to install on road. So, magnetic wires are suitable to commercialize magnetic guidance systems.

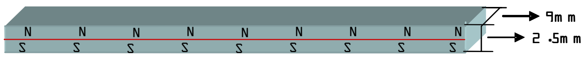

Fig. 1 Magnetic Wire

B. Magnetic Position Meter

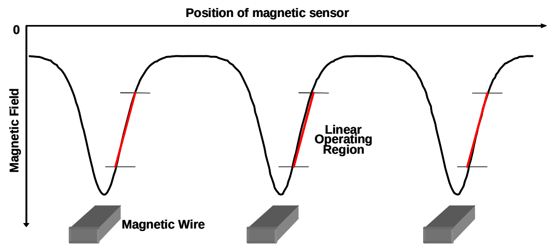

Fig. 2 The vertical field and a magnetic wire

Fig. 2 illustrates a variation of the vertical field to the location of magnetic wire during the position of magnetic sensor the vertical field has the strongest value just above the magnetic wire and is decreased away from the magnetic wire. The data of a magnetic field versus a magnetic wire position has a non-linear characteristics. But, the region between the above magnetic wire and the earth field is linear. In this region, we can obtain the information of regular relationship on the magnetic field and magnetic wire position.

In the Fig. 2 the linear operating regions are on two sides of the marker. Since these linear regions are bilateral symmetry, such as an equilateral triangle, it can be not distinguish from only the measured vertical field. Thus in this paper, the magnetic sensors array is adapted for discrimination of two linear regions.

Fig. 3 shows the position sensor using 1-dimensional magnetic sensors array. The stationary each sensor measures to magnetic field at different displacement. The two closed sensors have a common area, such as ‘A’ and ‘B’ in the Fig. 3. The common area of two closed sensors is the linear operating region in the Fig. 2; ‘A’ is the linear region of the sensor 1, and ‘B’ is the sensor 3 in the Fig. 3. Using the data of sensor 2 to reference, it can be distinguish with bilateral region of the sensor 1 and the sensor 3.

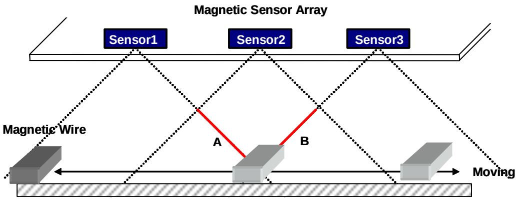

Fig. 3 The 1-dimensional magnetic sensors array

For a precision positioning and a good operating condition, this position sensor is required some consideration; the space between each sensor, the height between a sensor and a magnetic marker, operating magnetic field range. Three considerations are closely connected. The space between each sensor in the sensor’s array is dependent on the field magnitude of the magnetic wire and the desired system’s accuracy. The height between the sensor’s array and the magnetic wire is finalized according to the each sensor’s linear output range. If the height is varied, the measured field is varied too. Also, when the space reduced for high accuracy, many sensors are required. Thus, the space and the height should be determinate according to the required system accuracy and the magnetic field of magnetic wire. And, the number of sensors and the space between each sensor in the array should be determined by positioning length.

C. Sensing System

In this paper a new magnetic position meter is used. This sensor includes 5 1-axis magnetic transducers arranged by 40 [mm] spaces.

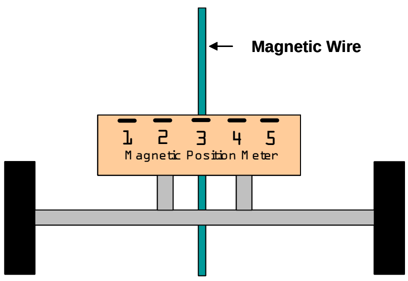

Fig. 4 Sensing system

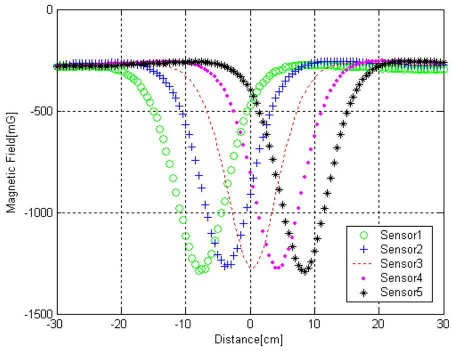

Fig. 5 Sensor output

III. Automatic Guided Mobile Robot

A. Summary of System

Automatic guided mobile robot consists of a sensing system, a steering system, a driving system. The sensing system measures the position of a magnetic wire and transmits the lateral distance by digital value to the main controller. The steering system controls the steer angle of the mobile robot to flow the guidance of a magnetic wire.

And the driving system controls the driving speed of the robot.

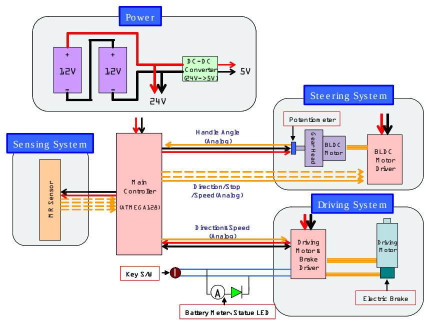

Fig. 6 System block diagram

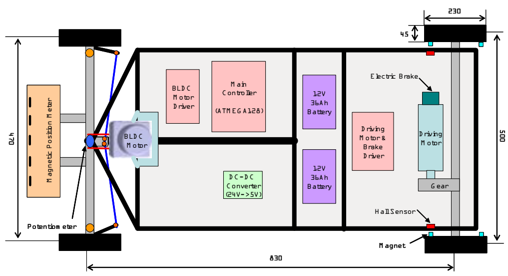

Fig. 7 System structure

B. Steering System

Motor selection should be done in order to design the steering system. Linear type motor is DC motor and is by structure that change turn by rectilinear movement because there is ball-screw on interior. Because BLDC motor has merits with Table I, the composed steering system uses a BLDC motor.

BLDC motor is connected to steering axis directly. And a Potentiometer is used to measure the steering angle.

TABLE I
MOTOR COMPARISON

	Linear type motor	BLDC Motor
Merit	- When thread small size continuously, necessity space less. - Installation is easy. - There is seldom Backlash.	- A comparative low-cost. - Because kind of motor and gear is various, width of selection is wide. - Special quality of BLDC motor, maintenance is no necessity almost. - Torque special quality is superior
Demerit	- Because there is no home production product, purchase is difficult and is high price.	- Is big comparatively. - There is Backlash in gear.

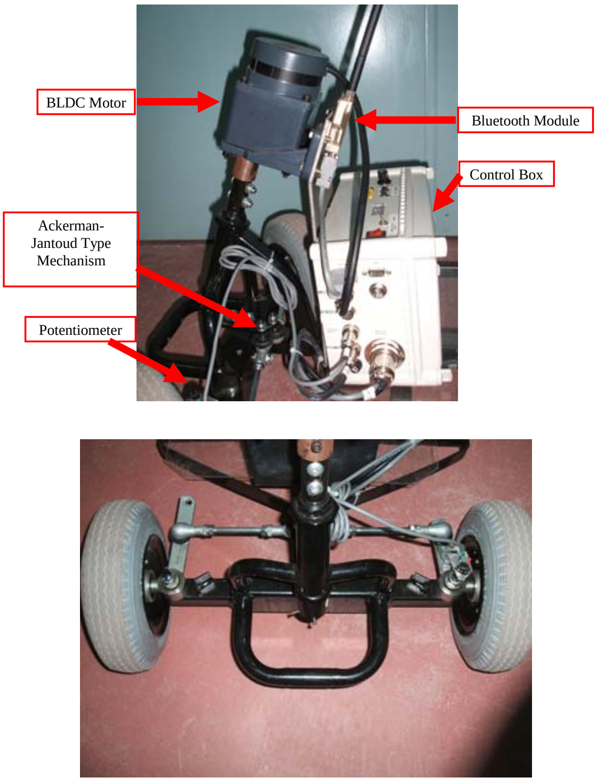

Fig. 8 Steering system structure

C. Driving System

A driving system is made by using a DC motor and a driver circuit for the differential gear and motor, and an electromagnetic brake is assembled

The used motor is 24V-320W DC motor and the electromagnetic brake controls automatically by driver circuit. And the speed of the robot is measured by hall sensors.

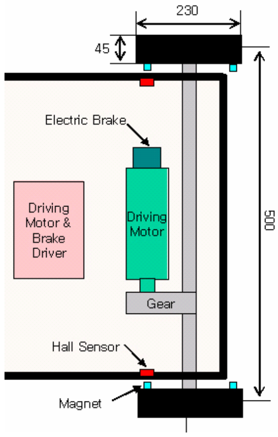

Fig. 9 Driving system structure

D. Control Algorithm

The steering system is operated by the control algorithm. The controller decides a command angle by the measured the position of magnetic wire calculates the command of steering angle and drives steering motor. At the same time, the controller calculates the speed of robot because the driving system receives the hall sensor's output.

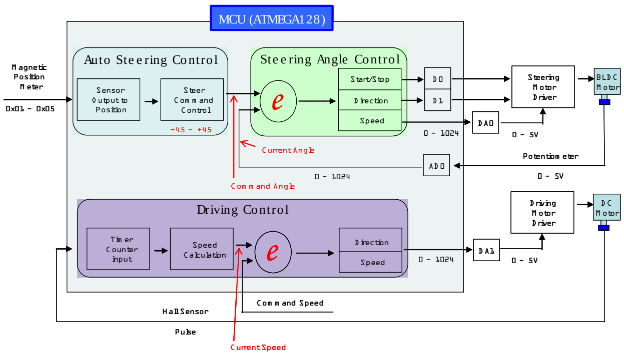

Fig. 10 Control algorithm structure

IV. EXPERIMENT AND RESULT

A. Comparison with Previous Automatic Guided System

Because the previous system uses 3-axis sensors, it is way to analyze 3-dimensional data of driving, side, height direction and do driving. In order to measure the components of 3-axis magnetic field and analyze 3-dimensional data, the complicated calculation and the high speed microprocessors are required.

However, the proposed magnetic position meter can process rapidly and exactly by simple calculation of IF-THEN ELSE and normal speed microprocessor.

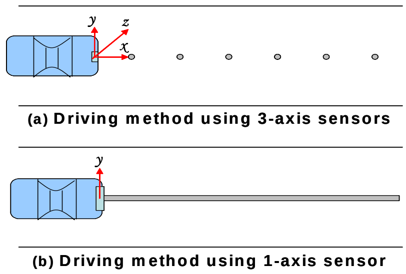

Fig. 11 Comparison with the previous system

B. *Experiment Environment*

Fig. 12 Experiment in straight course and curved course

The test track consists of straight course of 5m and curved course of about 5m.

C. *Experiment Result*

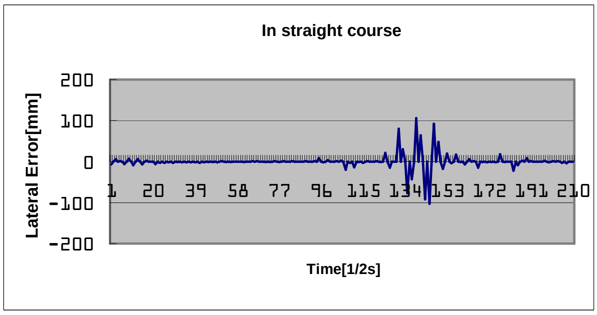

Fig. 13 Experimental result in straight course

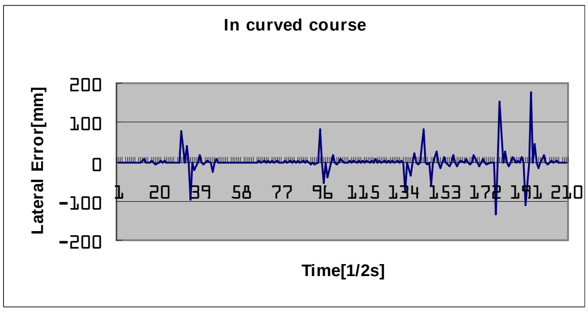

Fig. 14 Experimental result in curved course

Fig. 13 shows the experimental results in straight course. Fig. 14 is data gathered in the curved course. In the straight course, the error is smaller than in the curved course.

V. Conclusion

This paper presents an automatic guided mobile robot using magnetic position meter. For experiment test an automatic guided mobile robot is designed. The designed mobile robot consists of a sensing system, a steering system, and driving system. A new magnetic position meter is developed to measure the position of magnetic wire. The sensing system with the new magnetic position meter in installed to the robot. The steering system with BLDC motor and the driving system with DC motor are controlled by the designed control algorithm. The driving performances are evaluated by the experimental tests.

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