Design of Electromagnetic Sensing and Infrared Obstacle Avoidance Tracking System Based on K60

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Abstract. With the development of robot technology and industrial automation, the manufacturing mode based on robot and intelligent equipment has been started. Intelligent tracing Automatic Guided Car (AGV) is a typical application of industrial robot. Based on MK60DN512ZVLQ10 (K60), an embedded system for electromagnetic sensing and infrared obstacle avoidance is designed. Based on the 32-bit single-chip microcomputer K60 produced by NXP, an embedded tracking system for intelligent cars is designed and implemented, which is based on electromagnetic sensing and infrared obstacle avoidance. According to the electromagnetic track laid in advance, the arrangement structure of the inductance coil and the core tracking algorithm and program are designed according to the track elements, and the automatic tracking and obstacle avoidance functions of the car are realized under the condition of no human operation. This design adopts low-cost inductance coil, which is convenient to change the track path in different environment, instead of the high-cost and hard-to-switch track path in the past, and provides a reference plan for intelligent control such as unmanned driving.

Keywords: Intelligent car; Electromagnetic sensing, Infrared obstacle avoidance, Electromagnetic tracing, Embedded system
According to an intelligent car tracking electromagnetic track system set for Automatic Guided Car (AGV) in a library environment, the control plan is designed independently including sensor signal acquisition and processing, motor drive, steering gear control and control algorithm software development, and the intelligent car engineering production and debugging is completed. In order to solve the various elements of the track, an embedded system of electromagnetic sensing and infrared obstacle avoidance based on K60 is designed in this paper.

1. arrangement of inductance sensors and programming of element separation

1.1. dual horizontal inductor arrangement (solution area elements: straight, corners)

The center of the car track will be laid with an electromagnetic wire, which is connected with an alternating current of 20kHZ and 100mA. The alternating magnetic field is captured by the inductance coil of the intelligent car according to the principle of electromagnetic induction to judge the path, and the car can be driven along the track by controlling the steering gear [1]. According to Biot-Savart Law, when the horizontal inductance arranged at the front of the car deviates from the electromagnetic line, the detected induced electromotive force will decrease with the distance away from the electromagnetic line. Therefore, it shows that when the direction of the inductor is different, the induced EMF of the magnetic field is different [2].

The horizontal inductors on both sides of the straight track are equidistant from the center line of the track, and the induced electromotive forces E1 and E2 of the inductors on both sides are not deviated, so that the intelligent car does not perform steering and runs along the straight track. When the intelligent car is driving in a corner, where is the angle between the projection of the inductance on the track and the track centerline, when the inductance is perpendicular to the track centerline \( \sin \theta = 1 \), then \( E^1 = E_1/\sin \theta \), and \( E^2 = E_2/\sin \theta \). By comparing the magnitude of \( E^1 \) and \( E^2 \), the direction and deviation \( E_i = E^1 - E^2 \) of the intelligent car off-track are determined, and the PWM value is input to the steering gear, so as to control the steering gear steering[3].

1.2. dual horizontal, double tilt with intermediate inductor arrangement (solution area element: hexagon circle)

In order to solve the limitation of dual horizontal inductance and to deal with the variation of different orbital elements, this arrangement plan, as shown in Figure 1-1, can effectively solve the above problems.

![Figure 1-1. Schematic diagram of arrangement of dual horizontal inductor and double inclined inductor with intermediate inductor](image)

When this inductor arrangement is used, as shown in Figure 1-2, variation of induced electromotive force of a car as it circles an island in a hexagon.

Situation 1: When the car prospective inductor coil is about to reach but has not yet reached the intersection of the hexagonal loop and the straight wire, the data collected by the left and right horizontal inductors 1 and 2 and the middle inductor 3 are twice the data collected by the single conductor, and reach the maximum value, i.e., \( E^1 = E^2 = E^3 \). However, due to the inclination angle \( \theta \), the induced electromotive force generated by the double inclination inductor reflects the \( \sin \theta \) of the horizontal component of the magnetic field, which is about half of the horizontal component, and
therefore does not reach the maximum value [4]. At this time, the inductor 4, which does not reach the intersection point, acquires a value much smaller than that acquired by the inductor 5 because it is approximately parallel to the conductor of the right hexagonal circle. Since there is an obvious characteristic value $E^4 < E^5$ at this time, it is judged in the program that the car is about to reach the hexagonal circle island.

![Figure 1-2. Schematic diagram of the car not reaching the hexagonal circle island 1-direction of roundabout; 2-Forward direction](image)

Situation 2: when the car had just passed the intersection of the hexagonal loop and the straight wire, inductor 1 and intermediate inductor 3 are still in the maximum state, and the values collected by inductor 2 decreases markedly. At this time, the inductor 4 is not parallel to the hexagonal circle conductor on the right, while the inductor 5 is parallel to the hexagonal circle conductor on the left. Therefore, at the moment when the prospective inductor of the car passes the intersection point, the value collected by the inductor 4 is much larger than that of the inductor 5. In Situation 1, the program has already entered the preparatory circle-entering stage. Therefore, in the program design, the left 4 inductor is used to pull the right 2 inductor. The deviation value $E_d = 100 \times (E^4 - E^2)/(E^4 + E^2)$ is calculated by the sum of the differences, thereby controlling the steering gear to steer into the hexagonal circle.

2. realization of infrared obstacle avoidance programming

When the car is traveling along the electromagnetic wire, in order to simulate the real driving road conditions, a cross-sectional roadblock is placed on the electromagnetic wire as shown in Figure 2-1. As the inductance coil of the car can only detect the electromagnetic wire, it is impossible to detect whether there is a cross-sectional roadblock in front of the car. The infrared range finder can make up for this shortcoming. The analog signal received by the infrared range finder is sent to the single-chip microcomputer A/D to be converted into digital signal, which is processed into centimeter (cm) by the program algorithm. After the specific value is obtained, the program can be used to control the car to realize the obstacle avoidance function.
Figure 2-1. Schematic diagram of the car detecting the front roadblock through the infrared ranging sensor:
1-infrared range sensor; 2-crossing of roadblocks; 3-emitted infrared signals; 4-reflected infrared signals

Programming ideas:
Because of the characteristics of infrared range finder, the actual measured distance is short, when there is no obstacle at 3m in the front side, the value acquired by the infrared ranging sensor is almost zero. A roadblock is detected in front of the car when the car reaches about 50cm in front, the car is programmed to perform a maximum left steering plus delay function. However, because the car speed is different and the steering time is different, the car is allowed to pass through at a fixed speed in the obstacle avoidance stage. After the car has traveled a certain distance to the left and forward, the car is turned to the maximum right until the car inductance detects the signal of the electromagnetic wire, and the car returns to normal running.

3. program flow chart
In order to achieve the complete tracking function of the intelligent car, the program flow chart shown in Figure 3-1 is designed to summarize the above elements.
Figure 3-1. Flowchart of Program Design

4. summary
The design is to achieve automatic tracking and perfect obstacle avoidance by using electromagnetic sensor and infrared range finder based on single-chip microcomputer K60. The 32-bit K60 single-chip microcomputer is used, which is faster and more sensitive than the traditional 51 single-chip microcomputer. Inductive coils are cheaper, easier to program, and more accurate than other sensors. It has significant reference value for guiding intelligent cars and obstacle avoidance system in library environment.
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