Research on Quasi - Stop Control of AGV

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Abstract. Automatic guiding vehicle (AGV) is one of the most important transportation tools in modern manufacturing system. In order to deliver goods to destination safely, accurately and in real time, AGV needs to have accurate parking functions. This paper first analyzes the three factors affecting AGV quasi-stop, such as load, quasi-stop initial speed and quasi-stop control trigger. Secondly, we studied the quasi-stop control system, and a quasi-stop control method based on the influence factors of quasi-stop is proposed. The efficiency and precision which was achieved by the method are verified experimentally. The results show that the control method improves the accuracy and efficiency of the quasi-stop of AGV.

1. Introduction

Automatic guiding vehicle is a kind of transportation equipment which was widely used in modern factories to transport materials or tools from one place to another quickly, accurately and reliably[1]. Therefore, in order to complete the connection with the next link and realize the normal loading and unloading work, AGV must have the function of accurate parking. Existing AGV is generally through the constant deceleration curve to slow down[2]. But, in practical work AGV will be affected by load, must stop velocity, must stop control trigger and a series of factors, this leads to use the same deceleration curve will appear larger parking error. Therefore, the study of quasi-stop control under multiple factors is of great significance.

2. QUASI - STOP INFLUENCING FACTORS

The influence factors of the magnetic navigation AGV quasi-stop control studied in this paper are mainly as follows: load, initial velocity of quasi-stop, and trigger of quasi-stop control. In practice, due to different working conditions AGV is required to carry different loads. If AGV decelerates according to the constant deceleration curve, it will cause deviation between AGV and the ideal parking point due to different inertia, resulting in a large parking error. Quasi-stopping initial velocity is also a very important factor. When the constant deceleration curve is used for deceleration and parking, too high initial quasi-stopping speed will result in AGV stop after the ideal parking position and too low initial quasi-stopping speed will result in AGV stop before the ideal parking position.

3. THE MEASUREMENT OF QUASI-STOPPING INFLUENCING FACTORS

3.1. Accurate measurement of load

If the load size is directly measured by weighing instrument, it is necessary to install weighing device on the AGV system, which will greatly increase the cost of AGV, and weighing is not very convenient. Since there is a positive correlation between the load and the current of the AGV drive.
motor. Therefore, the load can be indirectly reflected by measuring the current of the drive motor and finding out the relationship between the load and the current. The accuracy of current measurement affects the accuracy of load. In order to realize the accurate measurement of current, the following methods are adopted:

The automatic guiding trolley studied is driven by brushless dc servo motors, and its internal connection types are connected by three-phase star bridge connection[^3]. In order to realize accurate sampling of the current, hall current sensor is used to measure the current. Hall current sensor can directly connect the detected current signal with the A/D channel of the controller, and store the digital signal after A/D conversion in the controller. Figure 1 shows the principle of the internal winding of the servo motor and the installation position of the hall current sensor. It can be seen from figure 1 that phase current sampling can be realized as long as there is two-phase conduction. For example, when Q1 and Q2 are switched on, we'll know the phase current between A and B. But when the power switch transistor was shut off, the power switch transistor and a fly-wheel diode bridge arm form fly-wheel circuit, such as Q2 disconnected Q1 and D2 form a loop, the current will not flow through the hall current sensor, the hall current sensor can't detect the current signal so current sensor can only be detected during the power transistor opening current signal[^4].

![Figure 1](image1.png)

**Figure 1.** Schematic diagram of installation position of motor current sampling sensor.

The power transistor generates peak current at the moment of opening and closing, which can’t accurately express the relationship with the load[^5]. Therefore, it is necessary to design appropriate sampling points to avoid peak current. To ensure that in each switch cycle to determine a fixed sampling points, and away from the switch point, using the controller in the timer trigger A/D conversion and guarantee sampling during the midpoint of the power transistor opening period the power transistor opening (during high level of PWM) the sampling method of average current so well to avoid the effects of the switch noise, guarantee the accuracy of sampling[^6]. The sequence diagram of sampling control is shown in figure 2.

![Figure 2](image2.png)

**Figure 2.** Current sampling control timing diagram.

### 3.2. Quasi-stop initial velocity measurement

Study adopts brushless dc servo motor drive with velocity feedback port, synchronization with the operation of the motor output shaft, the motor output shaft turn each output a certain number of pulse
signal, so that the rotational speed of the motor can be calculated by measuring the output pulse frequency of output port.

3.3. Quasi-stop control trigger

In order to realize accurate control of accurate trigger, this research USES laser ranging to trigger, as shown in figure 3, the AGV vehicle equipped with a laser range sensor, when the RFID card reader on the AGV detected deceleration of the L2 distance reflection plate location site, trigger laser range sensor, laser ranging sensor launch a laser beam to the target reflection board, according to the laser beam to be accepted by the launch time, with the target via internal algorithm calculates the AGV baffle distance, when detected the distance of AGV and baffle is L1 triggered slowing down, to realize the quasi-stop control of accurate trigger.

![Diagram](image)

**Figure 3.** AGV quasi-stop control trigger schematic diagram.

4. THE COMPOSITION OF QUASI-STOP CONTROL SYSTEM

The quasi-stop control system of AGV is mainly composed of the controller execution module, information acquisition module, human-computer interaction module and safety module. As shown in figure 4.

Figure 5 shown the control process of the control system, information collection module sends the information to the controller, the controller send control commands to perform after data processing module, execution module to perform the relevant orders, at the same time, the controller will collect data information sent to the human-computer interaction module, convenient for offline data processing, when security module found obstacles, The obstacle information is sent to the controller, and after the information processing, the controller sends instructions to the driver module, and the driver module carries out relevant actions.

![Diagram](image)

**Figure 4.** AGV quasi-stop control system block diagram.
5. Establishment method of quasi-stop control deceleration model

In order to establish the deceleration model, PI closed-loop speed control is adopted, and the establishment process is as follows: As shown in figure 6 when AGV run under a load to the deceleration point D, according to the experience setting goal speed points between D and E in some position, through the speed sensor to the system of real-time feedback current speed, the laser ranging sensor to the system real-time feedback distance information and by the analysis of controller of distance and velocity, corresponding PI control parameters are given, to ensure that the target speed is reached at the specified position and the control block diagram is shown in figure 6. When the AGV is parked observe the error between the parking position and the target position, according to the error size and vehicle running status, change the PI control parameters, continue to experiment, observing the parking point error and the stability of vehicle running, and continue to modify the PI control parameters, Until the desired parking position and operating status are reached, record speed curve at this time. Changing the load of AGV and continuing the experiment, After several sets of experiments, the ideal speed curves under different loads as shown in Fig. 7, the speed curves were analyzed and processed. Fitting the deceleration model between the load and the speed curve, Experiment and observation, to determine the model of quasi-stop control deceleration.

Figure 5. Workflow of quasi - stop control.

Figure 6. PI control block diagram.

Figure 7. Speed graph under different loads.

Figure 8. AGV accurate parking accuracy.
6. EXPERIMENTAL VERIFICATION OF QUASI - STOP CONTROLEFFECT
To illustrate the effectiveness of the must stop control method and accuracy, the same velocity, the same stopping distance under different load, comparing the control error according to the constant deceleration curve and using quasi control method reduction of parking to slow down and stop. As shown in figure 8, Y2 is according to the constant deceleration curve to reduction and after then the relationship between load and parking error curve. Y1 is according to the constant deceleration curve to reduction and after then the relationship between load and parking error curve.

It can be seen from figure 8 that the deceleration and parking error in accordance with the constant deceleration curve is approximately within 10mm. After deceleration in accordance with the quasi-stop control method, the parking error can be controlled within 2mm, and the parking accuracy has been greatly improved.

7. Conclusion
In order to improve the parking precision of the AGV, a must stop control method is discussed in this paper, the method solves issue that the AGV constant deceleration curve under different load have large stop error, improves the efficiency of the quasi stop precision of the AGV, at last experiments show that the control method can reduce the error from 10mm to within 2mm, which indicates the feasibility and effectiveness of the control method and provides a feasible method for the accurate parking of AGV.

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