Automatic mechanical device design for detecting corn spacing

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Abstract. The grain combine harvester is the most important grain harvesting machine in China. The lack of adaptability of domestic harvesters to different planting habits in different regions of China is an urgent problem to be solved. This paper proposes and mechanically designs and constructs the structure for the automatic detection of grain planting spacing by the harvester, and realizes the automatic control of the plant by PLC technology, thus realizing the automatic measurement of the grain spacing of the grain harvesting machine by the harvester.

1. Perface
As a large agricultural country, China attaches great importance to agriculture. The importance of grain as the most common food crop in China can be seen. The most important harvesting machine for grain is the grain combine harvester. However, the current domestic grain combine harvester is not highly intelligent [1-4], and it is unable to adapt to different planting habits in different regions of China, especially in adapting to different grain planting spacings [5-6]. In order to solve this problem, a device designed to automatically detect the spacing of field grain plantings was developed.

2. Scheme study of line spacing measuring device

2.1. Device Working Environment and Principle
Based on the Dongfeng 4yz-8 (2000) harvester design, in order to detect the grain spacing of the grain planting but can not affect the normal operation of the harvester, the device can be designed to be stretched back and forth along the body direction at the bottom of the harvester, and the head can be extended to the head. In the interval between the planting of grain in the field, the head part then realizes the function of measuring the spacing of the grain planting in the field. Because the image is mainly rectangular and the function is detection, it is named as the probe mechanism.

2.2. Hardware Design of the Probe Mechanism
The figure above shows: 1, Probe switch rear stroke switch 2, probe mechanism front stroke switch 3, probe mechanism left limit stroke switch 4, probe mechanism right limit stroke switch 5, probe mechanism left limit switch 6, Probe mechanism right stroke switch 7, stepper motor (left and right motion) 8, stepper motor (front and rear motion).
The probe mechanism has two stepping motors as a stepping motor (left and right motion) and a stepping motor (forward and backward motion). The stepping motor (front and rear motion) drives the probe mechanism along the entire rack through the rack and pinion, and is mounted thereon. Six stroke switches are used to realize the function of detecting the spacing of the planting rows. The front and rear direction of the probe mechanism, that is, its longer moving direction is consistent with the front and rear direction of the harvester, and the shorter direction is consistent with the left and right direction of the harvester.

When detecting the spacing of the corn rows by using the probe mechanism, firstly, the stepping motor that drives the probe mechanism to move forward and backward drives the probe mechanism to move forward integrally until the front stroke switch installed along the front and rear direction of the probe mechanism is triggered. The stepping motor that drives the probe mechanism to move in the front-rear direction stops (the head of the probe mechanism has already reached the outside of the header, that is, between two rows of corn), and at the same time drives the head of the probe mechanism (the claw) to move left and right. The stepping motor starts to move in the right direction with the head of the probe mechanism until the stroke switch on the right side of the head of the probe mechanism is triggered to touch the crop, and the stepping motor with the head of the probe mechanism moves to the left and right. The head of the rod mechanism moves in the left direction. When the stroke switch on the left side of the head of the probe mechanism is triggered by the crop, the stepping motor with the head of the probe mechanism moving left and right continues to move to the left direction with the head of the probe mechanism, and simultaneously drives the probe mechanism. The stepping motor running in the direction moves backwards with our probe mechanism as a whole until the rear stroke switch installed along the front and rear direction of the probe mechanism is triggered, and the stepping motor that drives the probe mechanism to move forward and backward stops. At this point, the head of the probe mechanism has been retracted to the bottom of the vehicle. The stroke switch on the left side of the head of the probe mechanism is triggered. After the crop is triggered, the head of the probe mechanism is still being driven to the left. The stroke switch at the left limit position is touched. The head of the probe mechanism is driven to the right, and is delayed by 8 s. After returning to the initial position, the stepping motor with the head of the probe mechanism moving left and right stops. At this point, the movement of the probe mechanism is stopped. The above is a five-stroke switch, and a travel switch is placed at the extreme position on the right side of the probe mechanism head to cope with the movement of the probe mechanism head to the right side because the right stroke switch does not touch the corn. In this special case, during the movement of the probe mechanism, the measurement of the spacing of the crop rows is triggered as the stroke switches on the left and right sides of the head of the probe mechanism are triggered.
3. Software development of the probe mechanism

The above is the workflow of the probe mechanism, and the ability to add logic control is also needed. There are many control methods that can be taken at present, such as PLC control, relay control, and single-chip control. Each control method has its own advantages and disadvantages and applicable occasions. The harvester can meet the large space requirements of the PLC, and the PLC can give the harvester a stable logic control, so the PLC is selected as the system controller. In the current market, there are many types of PLCs, and because the working conditions of the harvester are more complicated, the Siemens CPU module ST60 is selected. The table below shows the PLC part port table.

| PLC port | Specific Function                  | PLC port | Specific Function                  |
|----------|------------------------------------|----------|------------------------------------|
| 10.0     | Probe mechanism switch             | 10.2     | Probe front stroke switch normally open |
| 10.3     | Detecting the right stroke switch normally open | 10.4     | Detecting the left stroke switch normally open |
| 10.5     | Post-stroke switch normally open   | 10.6     | Probe head left limit stroke switch normally open |
| 10.7     | Probe head right limit stroke switch normally open | Q0.0     | Front and rear motor pulse signal of probe mechanism |
| Q0.1     | Probe mechanism left and right motor pulse signal | Q0.2     | Front and rear motor direction signal of probe mechanism |
| Q0.4     | Probe mechanism left and right motor direction signal |

The DC stepper motor is used to realize the structure function of the probe. The DC motor driver is needed. The partial wiring diagram of the specific PLC is shown in Figure 2.

![Figure 2. Schematic diagram of the probe mechanism](image)
According to the working process of the probe mechanism, combined with the kinematics theory, the control logic flow chart shown in Figure 3 is obtained, and the harvester is controlled by the same asynchronous joint control method, which can make the function of the harvester work smoothly and save time. And asynchronous joint control method can avoid mutual interference.

![Figure 3. Schematic diagram of the probe mechanism](image)

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