Gantry type rotating platform obstacle avoidance crane

Yu Zhang¹, Yun Chen*¹
¹Department of Mechanical Engineering and Automation, Wuhan University of Technology, Wuhan, Hubei, 430070, China
* Corresponding author’s e-mail: chenyunhbwh@163.com

Abstract: The rapid development of modern logistics industry has higher requirements for logistics machinery and equipment. As an important equipment for material handling, cranes are used more and more widely in the modern production process. At present, cranes have problems such as large size, inconvenient movement, and inaccurate positioning. Based on the above background, the project team designed a gantry type rotating platform obstacle avoidance crane. The crane breaks through the transportation limitations of the original crane. It uses the direct rotation of the pan-tilt and the movement of the spreader on the track to accurately avoid obstacles, which improves the flexibility and accuracy of transportation; the entire transportation process is fully automatic control, which combines the machinery with The combination of intelligence improves transportation efficiency and realizes the accurate transportation of multiple goods.

1. Research background and significance
With the rapid development of my country's economy, the speed of port development and the pace of construction are accelerating, cranes that are essential for port handling should also continue to develop in the direction of intelligence and automation. The overall goal of crane intelligence research is to break through key intelligent technologies such as artificial intelligence, work space recognition, and life cycle management of complex equipment in complex environments, and develop intelligent equipment with high intelligence and operational safety management systems to achieve. The intelligent control of single machine and machine group has enabled my country's major construction equipment and technology to reach the international leading level.

Based on the above background, the project team designed a gantry type rotating platform obstacle avoidance crane. The crane breaks through the transportation limitations of the original crane. It uses a rotating pan/tilt to transfer goods. The movement of the spreader on the cross bar below the pan/tilt allows the crane to pass obstacles quickly, improving the flexibility and accuracy of transportation; at the same time, it is completed by fully automatic control The entire transportation process. Combine mechanical and electronic technology to improve transportation efficiency and achieve accurate transportation of multiple goods. The crane can be used in checkpoints such as warehouses and places where specific cargo needs to be accurately positioned, so that container cargo can quickly pass the scanning inspection of the checkpoint, which is convenient and quick.

2. Overall design ideas

2.1 Mechanical structure design
The purpose of this work is to provide a crane that can reduce the labor intensity of workers, improve
work efficiency, and help them complete the rapid and accurate positioning, loading and unloading, obstacle avoidance, and transportation of goods. The mechanical structure design is the core of the crane design. In order to achieve accurate and efficient picking, crossing, and unloading, the project team will implement a functional modular design of the mechanism in the work, including: lifting module, PTZ module, spreader module and Walking module. Figure 1 is a schematic diagram of crane isometric. According to the modular design concept, the institutions in the works are designed to be functionally modular to ensure that each institution can realize its individual function, and then the various functional modules are organically combined and debugged through a reasonable layout. This system relies on mechanism design and control design to realize efficient stacking and transportation of goods.

![Schematic diagram of crane isometric](image)

Figure 1. Schematic diagram of crane isometric

### 2.2 Control structure design

The control part of the gantry type rotating platform obstacle avoidance crane uses the STM32F407ZGT6 development board to realize the control of the overall system. The STM32F407ZGT6 development board is used to control the DC gear motor, the steering gear and the encoder, and realize the walking of the machine, the rotation of the pan and the lifting of the spreader; use photoelectric sensors and tracking sensors to determine the position of the goods and ensure the tracking operation of the whole machine; through the wireless communication module to compensate for the operating deviations that occur during the operation of the machine.

### 3. Module design

#### 3.1 Walking module

The walking module consists of mecanum wheels, motors, encoders and tracking sensors. This module adopts the technical route of tracking and servo control methods. The crane relies on the cooperation of four wheels with different speeds to achieve omnidirectional movement. The control chip uses the feedback information from the motor encoder, and then calculates the rotation speed and forward and reverse of each wheel through the mecanum wheel kinematics control algorithm. According to the calculation result, the driver corresponding to each mecanum wheel is controlled by the fuzzy PID algorithm. The motor and encoder will form a closed-loop control, so that the motor can quickly reach the predetermined speed, which is transmitted to the corresponding mecanum wheel through the reducer to realize the predetermined movement of the crane. The schematic diagram of the fuzzy PID algorithm is shown in Figure 2.
3.2 PTZ module
This module is composed of s-shaped pan/tilt and chute bar. The structure diagram of the PTZ module is shown in Figure 3. The cross bar is under the pan/tilt and relies on the thrust ball bearings on both sides to support the load, and the middle bearing relies on the motor to rotate, so that the lower cross bar can rotate 45 degrees to achieve precise obstacle avoidance of the goods. The inside of the crossbar chute is driven by a set of belts, which drives the spreader mechanism below to achieve a straight back and forth movement, so that the spreader moves horizontally on the crossbar. The operation is simple and the structure is stable.

3.3 Spreader and lifting module
The lifting module uses a DC motor to directly drive the sliding tables on both sides to complete the lifting action. The encoder realizes the same speed of the two motors, which can ensure the synchronous movement of the sliding tables on both sides, making the lifting action smooth and efficient. A double-rod clamping mechanism is installed on both sides of the spreader, and the hook is driven by the wire rope through the rotation of the motor to realize the opening and closing of the grapple. The top of the hoisting cage is controlled to rotate by a steering gear. After the cargo is grabbed, the hoisting gear can be rotated 90 degrees accurately and stably. When grabbing the goods, the lifting mechanism is lowered, so that the goods are aligned with the center of the mechanism under the action of four guide plates with a certain slope. At the same time, the elastic hook contacts the box and the ribs are compressed, and the elastic hook continues to fall to release and resist. Hold the surface of the goods, the lifting mechanism rises, the goods are lifted, and at the same time they reach the top of the second box of goods, and grab the second box in the same way. When the goods need to be put down, the spreader can be moved down, the hook is closed to realize the decoupling, and the goods are pulled out from both sides. The spreader module is stable in grasping, convenient to unhook, and has a high fault tolerance rate. Figure 4 shows the structure of the spreader module.
4. project innovation points
(1) Accurate positioning and handling of goods can be realized.
(2) The pan/tilt module adopts arc-shaped chute, which has accurate obstacle avoidance, stable structure and convenient operation.
(3) The spreader is ingeniously designed and adopts the inclined guide block, which is stable in handling, easy to unhook, and high in fault tolerance, realizing accurate cargo grasping.
(4) Fully automatic operation avoids errors caused by human control and meets the requirements of modern automated logistics.

5. Conclusion
After reading the literature and combining the development status of cranes, the project team designed the gantry-type rotating platform obstacle avoidance crane to realize precise grasping and handling of goods at a determined location, precise positioning, rapid obstacle avoidance, stable structure and convenient operation. It can be used in checkpoints such as warehouses and places where specific goods need to be accurately located, so that containerized goods can quickly pass the scanning inspection at the checkpoint, hoping to bring convenience to the logistics industry.

Acknowledgments
First of all, I would like to thank the teachers for their careful guidance and the help and encouragement of my partners. Without their help, there would be no final results. In addition, I want to thank my parents for giving me a lot of support throughout the design process.

References
[1] Xu, G.H., Sun, Y.N., Ye, L. (2016) Status Quo and Research on Intelligent Design of Bridge Gantry Cranes. [J]. China Science and Technology, 14: 35-36.
[2] Feng, W. (2014) Talking about the application and maintenance of gantry crane [J]. China's high-tech enterprises, 21: 47-48.
[3] Liu, H.W. (2004) Mechanics of Materials. Higher Education Press, Beijing.
[4] Peng, W.S., Huang, H.L., Wang, J.R., Li, Z.M. (2003) Mechanical Design (Second Edition). Huazhong University of Science and Technology Press, Wuhan.
[5] Guo, Y., Yan, B., Hu, J.Q. (2013) Port crane. Wuhan University of Technology Press, Wuhan.