Applications of Robots in the Port and Shipping Area

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Abstract: In the past decades, the robot industry has been developing fast. According to the reports of International Federation of Robotics (IFR), global robot installations increased by 6% in 2018. Robots greatly facilitate the industry process. Among all the areas of national economy, the port and shipping areas play an important part. As the intelligent transportation system (ITS) flourishes, robots will be more and more important in future. In this paper, several types of robots were introduced. Applications of robots in port and shipping areas were systematically summarized. Besides, the trend of robot applications in the port and shipping areas was mentioned.

1. Introduction

With the rapid improvement of scientific and technological progress in last decades, the robot industry has been booming. According to IFR report, demand for industrial robots has risen considerably since 2010 toward automation and continued technical innovations in industrial robots. From 2013 to 2018, annual installations increased by 19% on average per year. Until 2015, annual installations had more than doubled to almost 254,000 units. In 2016, the mark of 300,000 installations per year was crossed and in 2017, installations surged to almost 400,000 units [1]. The figure 1 shows the annul installations of industrial robots from 2016 to 2018.

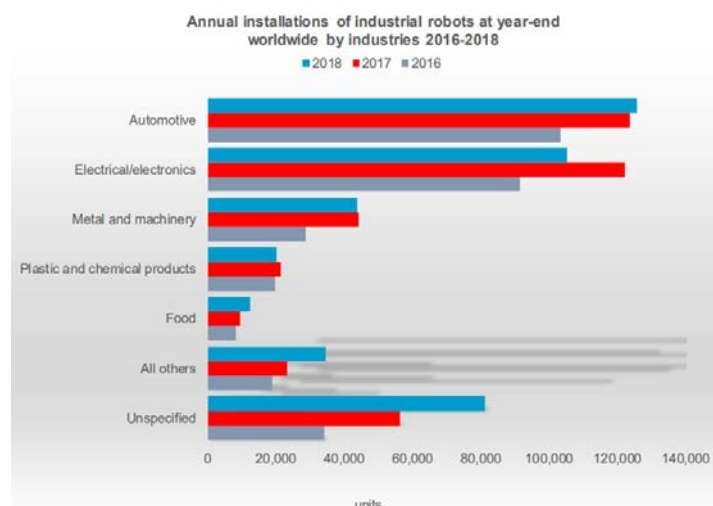Figure 1. Annul installations of industrial robots from 2016 to 2018[1]

The Port and shipping industry shown in Figure 2 is an important part of national economy. Compared to other areas of national economy, robots have not been widely used in the port and shipping areas. But as ITS develops, the application of robot in the port and shipping area will be more and more popular [2].

In this paper, several types of robots were introduced. Applications of robots were systematically summarized. Besides, the trend of robot applications in the port and shipping areas was mentioned.
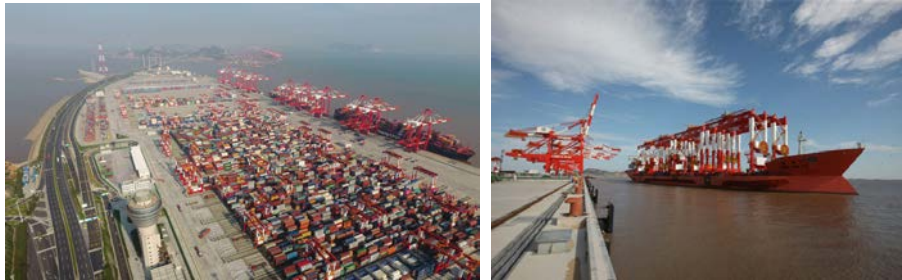

Figure 2. Some pictures of the port and shipping industry

2. Application of mobile robots in automated container terminals

In automated container terminals, mobile robots are widely put into use. The automated guided vehicles (AGVs) can provide an efficient connection between the harbor quay and the stack yard in terminals shown in Figure 3. The AGVs are unmanned and software-controlled to provide efficient horizontal transportation in port. Take AGVS used in Qingdao Automated container terminal for example, the terminal equipped 73 sets of AGVs in the stack yard. The AGVs are guided by magnetic makers. The technology of vehicle control based on the magnetic makers is one of the core research item in ITS [3, 4]. The terminal operation system (TOS) coordinate all the AGVs to accomplish the horizontal transportation.

Figure 3. AGVs used in automated container terminal

Lift AGVs shown in Figure 4 are a further development of the AGV technology. Unlike conventional AGVs, the lift AGV is equipped with two active lifting platforms. The structures enable the vehicle to lift and place containers independently on transfer racks in the interchange zone in front of the stacking cranes. Two 20-feet containers can be handled independently of each other or one container of any size.
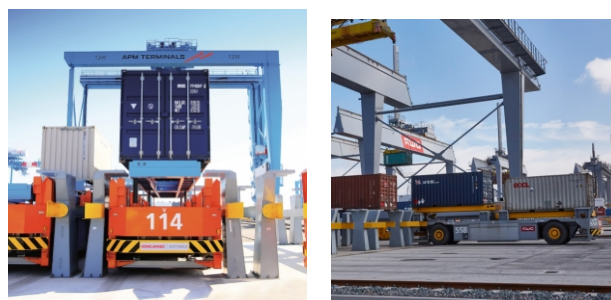

Figure 4. The lift AGVs used in automated container terminal

With a new development stage of 5-generation communication, artificial intelligence and sensing technology in recent years, companies are doing research on intelligent guided vehicles (IGVs) which is guided by the high-resolution map system and sensing technology instead of the magnetic markers. If the AGVs are widely put into application, construction cost for the automated container terminal will greatly decrease because of high cost of the magnetic markers.

3. The industrial robots application used on the twist lock handling of containers.

Twist locks shown in Figure 5 are important devices used in the container transportation. The handling of twist locks is still a bottleneck in the container terminal. After the container vessel arrives at the container terminal, stevedores firstly unlock the lower lock head with a special beam in order to unload the containers. While the upper lock head is still attached to the upper container. Quayside container cranes are applied to unload containers. However, before containers are placed on the horizontal transportation vehicles, the upper lock head of the twist lock has to be unlocked and removed from containers.

Figure 5. Twist locks used in the container transportation

In 2015, China Waterborne Transport Research Institute (WTI) put forward a solution for the twist lock handling shown in Figure 6. The system is mainly consisted of a robot, twist lock boxes, a manipulator and a visual system which can tell different kinds of twist locks [5]. When a container is placed on the handling platform. Twist locks are unlocked by the manipulator after the visual system tell the types of twist locks. And then the robot place the twist lock into the twist lock box. Different kinds of twist locks are place on the different location of the box in order to facilitate the container loading process.
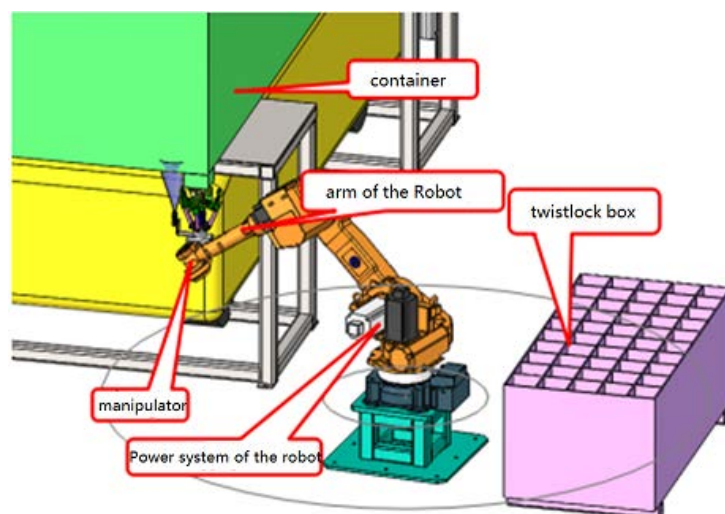

Figure 6. The device proposed by WTI

Afterwards, Qingdao Port put forward a different kind of twist lock handling system shown in Figure 7 [6]. Robots are mounted on rails so that robots can handle all twist locks of containers. The twist locks removed from the containers are placed on a belt conveyor and then are transferred to the centralized processing points. Another kind of handling system shown in Figure 8 was developed by ZPMC .the system was consisted of six robots which can remove all twist locks of a 40-feet container or two 20-feet containers [7].

Figure 7. The twist lock handling system developed by Qingdao Port

Figure 8. The twist lock handling system developed by ZPMC

4. Application of robots on the ship-shore cooperation

As the smart shipping emerges in recent years, ABB provided a solution for the shore power connection system. The company applied a kind of robots (IRB7600) to realize the power cable access to the shore power system [8].

When a 3D laser scanning system detects that the distance from the shore to the ferry is 4 meters, the ferry will automatically send a signal, and then the robot hatch and the ship hatch are opened; when the distance is 0.4 meters away from the shore, the robot automatically extends the mechanical arm and pulls the cable to connect the charging station. After the connection process is completed, the robot retreats to its original position, and the hatch is closed at the same time in the shore charging station. The system is helpful to realize the cooperation between the ship and the shore which is a obvious trend in the port and shipping area.

Figure 8. The twist lock handling system

As shown in Figure 9, Rizhao Port applied the package stacking robots for train loading process. The stacking robots were essential parts of the whole system. The system could carry out the stacking operation for the bagged material in accordance with specific types of train carriage. Six stacking robots covered the whole working area. Each robot is responsible for a specific region according to the procedures. Intelligent control was applied to ensure the stacking process reasonable and orderly [9].

There are several characteristics for the robotic package stacking of train loading system.

Working environment was greatly improved and working region was made best use of.

The robotic package stacking train loading system ran automatically and automation of package stacking was greatly improved.

The robotic package stacking train loading system provides chances for the bulk grain handling innovation.

Figure 9. The workshop scenarios of robotic package-stacking

5. Conclusion

With fast technological improvement of robotics, automation in all fields of national economy has been greatly improved. In this paper, robot application in automated container terminal, ship and shore cooperation and bulk grain train loading were introduced. Compared with other economic fields, applications of robots on port and shipping field is just getting started. In future, it is believed that robots will play more important role in the port and shipping area.

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