Transactions on Computational and Scientific Methods | Vo. 3, No. 1, 2023
ISSN: 2998-8780
https://pspress.org/index.php/tcsm
Pinnacle Science Press

Virtual Simulation and Dynamic Design of Delta Parallel Robot for Enhanced Product Packaging: A RobotStudio Approach

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Abstract: The Delta parallel robot, a prominent three-degree-of-freedom parallel robot in contemporary industry, is renowned for its compact structure, robust load-bearing capacity, and excellent dynamic performance. This project focuses on the Delta parallel robot as the research subject, utilizing RobotStudio virtual simulation technology to design the dynamic aspects of the smart component within the product delivery chain of a packaging workstation. This encompasses the dynamic simulation of the parallel robot and the development of the product grabbing program. Ultimately, the packaging workstation design will facilitate functions such as packaging, sorting, and light handling, effectively reducing labor intensity, enhancing production efficiency, significantly increasing the level of automation, and possessing substantial practical application value.

Keywords: Delta parallel robot, product packaging, robotstudio, virtual simulation.

1. Introduction

The research institutions of parallel robots are all over the world, including EPFL University in Switzerland, lirmm-cnrs laboratory in France, ABB Robot company, etc., and Yanshan University and Tianjin University in China.With the rapid development of advanced manufacturing technology and the further improvement of production automation level, parallel robot is developing rapidly.Delta parallel robot, with its unique parallel structure, has the characteristics of high speed, compactness, accuracy and durability. It can accurately locate the moving target and achieve rapid grabbing. It has good dynamic performance and no accumulated error, especially in the aspects of grabbing, arranging, labeling, packaging and sorting of materials.Therefore, delta parallel robot is widely used in food, medicine, electronics,daily chemical and other light industries[1-3].

This topic focuses on the practical application of Delta Parallel Robot in the process of product packaging. The main innovation lies in the use of new technology robotstudio virtual simulation technology[4,5], three-dimensional modeling technology, the realization of parallel robot's dynamic pick-up of products, palletizing and packing and other functions, the realization of Delta Parallel Robot's product sorting and series robot's finished product palletizing, which can greatly improve the design cycle.

The significance of this topic is that it uses the off-line simulation function of the robot Studio software, and uses the virtual workstation built to simulate a series of actions of the Delta Parallel Robot in the product packaging work without the need to go to the site for testing, which can truly reproduce the situation of the production site of the delta parallel robot productpackaging.

2. Design of Delta Parallel Robot packaging workstation

The workstation based on the product packaging layout design of delta parallel robot consists of robot body, end actuator vacuum sucker, belt conveyor chain, packing fixture, safety fence, etc. the layout of workstation is shown in Figure 1.

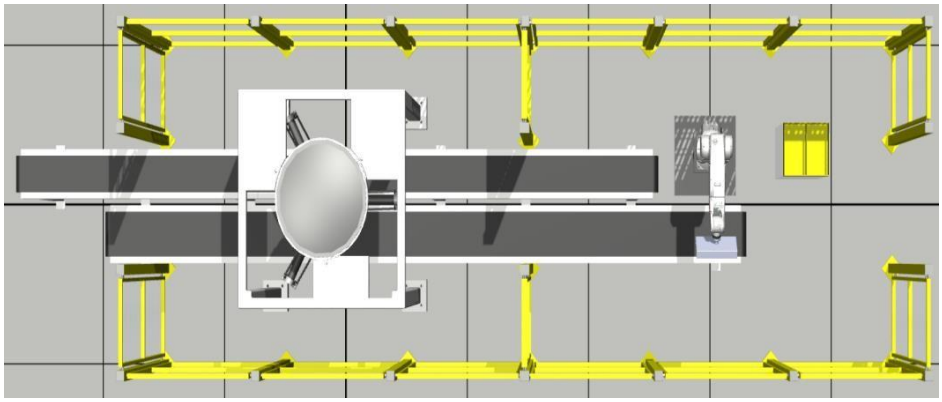

Figure 1. The layout of workstation

Working station principle: the front ends of the two conveyor chains generate copies of "product" and "product box" respectively, and move forward with the conveyor chain to reach the corresponding sensor sensing area to stop, triggering the action of delta parallel robot thathas been waiting over the grabbing position. The parallel robot uses the end actuator "vacuumsuction cup" to pick up the product and place it in the product box to complete the product sorting of delta parallel robot.

After the sorting of delta robot, the "finished product" will continue to advance along with the conveying chain. The serial robot uses the end actuator "grab" to grab the finished product, complete the packing work of the serial robot, and end the virtual simulation task of the product packaging workstation of the whole Delta Parallel Robot.

2.1. The dynamic design of smart components in product conveying chain

The dynamic design of smart components of industrial robot product conveyor chain includes the setting of product source, the setting of motion attribute, the setting of limit sensor, the creation of smart component attribute and connection, and the creation of smart component signal connection.The final effect is that a product replica is automatically generated at the frontend of the conveyor chain. The replica moves with the conveyor chain, touching the sensor to trigger the conveyor chain to stop moving, until the replica in the sensor area is removed, the front end of the conveyor chain is triggered to generate the product again, and then it circulatesin turn. The design of dynamic conveyor chain is shown in Figure 2.

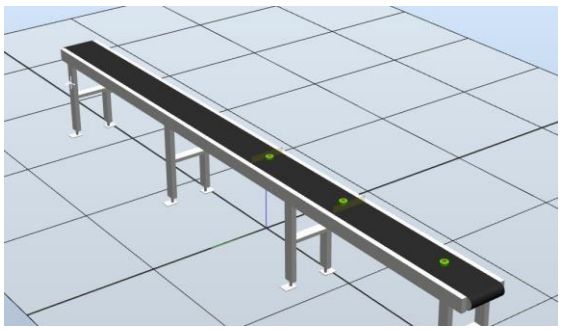

Figure 2. Dynamic Simulation of product conveying chain

2.2. Dynamic Simulation Design of Parallel Robot

Using the virtual simulation design of industrial robot, the designed geometry model is imported to the workstation for simulation setting, and the overall simulation path planning is realized by the steps of creating smart components, I/O configuration, path setting, programming, workstation logic setting, simulation debugging, etc. The overall framework design of workstation simulation is shown in Figure 3.

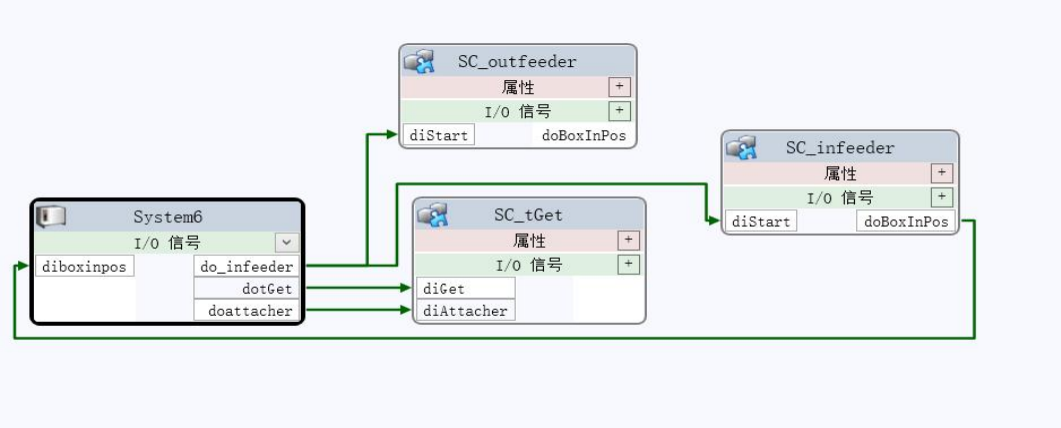

Figure 3. Overall framework design of parallel robot sorting

2.3. Program Design of Dynamic Grabbing for Parallel Robot

The sorting program of parallel robot is realized by calling a series of subroutines from the main program. The program shows the points, the main program, the subroutine and the end of endmodule determined when creating the path teaching. The subroutine path 10 is designed as follows:

```
PROC Path_10
    WaitDI diboxinpos,1;
    MoveJ Target_20,v2000,fine,tGet\WObj:=wobj0;
    WaitTime 0.1;
    Set dotGet;
    MoveJ Target_10,v2000,fine,tGet\WObj:=wobj0;
    MoveJ Target_30_2,v2000,fine,tGet\WObj:=wobj0;
    MoveJ Target_30,v2000,fine,tGet\WObj:=wobj0;
    WaitTime 0.1;
    Reset dotGet;
    Set doattacher;
    WaitTime 0.1;
    MoveJ Target_10,v2000,fine,tGet\WObj:=wobj0;
    Reset doattacher;
ENDPROC
```

The effect of path 10 program: when receiving the diboxinpos signal sent by the controller, therobot reaches the grab position and waits for 0.1 seconds, triggers the sucker pick-up action, moves over the placement position, moves to the placement position, delays 0.1 seconds, resetsthe sucker pick-up action, triggers the sucker release action, delays 0.1 seconds, returns to the standby area, resets the release action, and ends path 10. The same is true for other subroutines.

3. The Whole Virtual Simulation Debugging of Packaging Workstation

The overall virtual simulation operation effect of the packaging workstation is as follows: the front ends of the two conveyor chains respectively generate replicas at the same time, and move along the

conveyor chain, and the replicas respectively arrive at the designated sensing area of the conveyor chain to stop; the parallel robot receives the product in place signal, picks it up with the end actuator "suction cup" and places it at the designated position of the product box; cycles in turn until eight replicates are transported After the product, the delta robot returns to the waiting position to complete the "single sorting" of the delta robot. After debugging, the final working time of delta robot "single sorting" is 13.9 seconds, and the simulation process is shown in Figure 4.

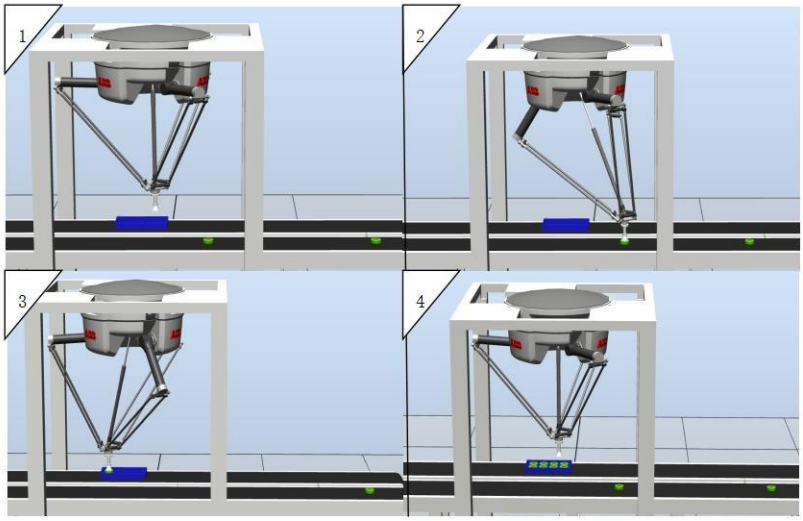

Figure 4. Virtual simulation process of parallel robot sorting

Through the simulation test, we can see that the conveyor chain respectively transports the product and the product box, reaches the respective sensor area to stop, and triggers the delta parallel robot to use the suction cup for rapid packaging work. This not only realizes the virtual simulation of the packaging workstation and completes the requirements of packaging production, but also fully embodies the characteristics of delta parallel robot, such as high- speed, compact, precise and durable. After testing, delta parallel robot has the fastest grasping speed up to 2-4 times / second, which is very suitable for the high-speed pick-up and release action in the production line. Parallel robot has the advantages and characteristics that serial robot can not match.

After sorting, the "finished products" continue to move forward along with the conveyor chain, and stop at the next designated induction area; trigger the action of the series robot, and the series robot grabs the "finished products" to complete the overall production of the packaging workstation.

4. Conclusion

This project takes delta parallel robot as the research object, uses robot studio virtual simulation technology to design packaging and sorting workstation, realizes the process of workstation dynamic transportation, parallel robot sorting and packaging and serial robot packing, and verifies the feasibility through simulation test analysis, at the same time, virtual simulation application can greatly improve the design cycle.

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