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Multi Manipulator Cooperative 3D Printing Based on Dobot Manipulator

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Abstract. "Multi manipulator cooperative 3D printing" is put forward for the problem about manufacturing difficult, high cost and large workpieces in the fields of manufacturing, Aeronautics and Astronautics. Based on the 3D printing function of the Dobot manipulator, it has been developed by the Python language to realize the program control of the manipulator. The manipulator adopts a tight coordination method to realize collaborative 3D printing and finishes the task of layered processing and scanning filling by programming.

1. Introduction

The Manipulator is an important branch of the robot, and the initial goal of their development is to liberate people from the complex, dangerous and repeatable work. 3D printing technology is an advanced control technology which is developing rapidly in an optical, electrical, computer, CNC machine, and new materials and other disciplines in one, and it is called manufacturing technology to lead the third industrial revolution ^[1]. The use of manipulator in 3D printing has also aroused the attention of more researchers.

In this paper, "multi robot arm cooperative 3D printing" is proposed for the difficult manufacturing and high cost of large workpieces in the fields of manufacturing and Aeronautics and Astronautics. In view of the prominent problems in the manufacturing process such as building structure, large mechanical components, large and medium ship components and so on. It often takes a high cost, and it takes months or even years to complete the processing and production. The introduction of multi robot cooperative work, combined with 3D printing technology, will be able to reduce the production cost greatly, and to improve the production speed. The research results of such technologies will have a positive impact on the pivotal large objects in manufacturing or the implementation of the project, which has a broad market prospects.

At present, there has been a breakthrough in the research of Robot Cooperative 3D printing abroad. The spider robot of SIEMENS has been able to collaborate in 3D printing of large objects. The MX3D bridge of Holland MX3D company that uses two welding robots to cooperate with 3D printing will also be completed in June 2018. And there is still a lot of space for the research of Robot Cooperative 3D printing in China.

This article is based on the 3D printing function of the Dobot manipulator, using Python for the development of the manipulator. After analysing the structure of large workpieces, it should assign tasks to robot arms, use ant colony algorithm to design trajectory and design parallel 3D algorithm to realize cooperative printing.



2. The development of the 3D printing function of the manipulator

2.1. The 3D printing function of the Dobot manipulator

The Dobot manipulator is four axis manipulator structure, as shown in Figure 1, the operation precision can reach 0.2mm, using three sets of stepper motor driver, with two angle sensors, provides a more complete functional user agreement. Through this protocol, it can be controlled by a serial or Bluetooth communication with a computer. It can perform complex actions and tasks such as writing, carving, grabbing, 3D printing and so on.

The Dobot 3D print accessories are easy to install, and the accessories include the extruder, the hot end, the motor wire and material. The control of the Dobot manipulator is by DobotStudio software, which has a built-in 3D printing slicing software Repetier-Host.

The 3D printing operation of Dobot is very convenient. The USB interface can be used to connect the manipulator to the computer and switch to the 3D printing function. The parameters of the printer can be set when it is first used. Before printing, test the extruder work to make sure it is normal. Then, import the model, set the slice parameters and slice to start printing. The finished product, such as Figure 2, has a clear texture and smooth surface.

Its 3D printing uses a generic STL format, and the imported model can be designed and converted into STL documents by 3D modelling software.

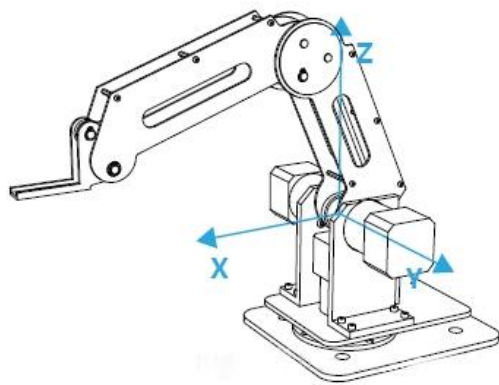


Figure 1. The Structure of Dobot manipulator.



Figure 2. The finished product of Dobot manipulator.

2.2. Using Python to control the motion of the manipulator

The movement of mechanical arm is very important. The manipulator is associated with 3D printing equipment, and the device operates on the mechanical arm, which requires high performance for the mechanical arm. The motion precision of the Dobot manipulator can reach 0.2mm, and the program controls the direction of motion. In this paper, the program is written and used in Python language, because it has great readability.

Python Demo is provided in the user file of Dobot, with two files of DobotControl.py and DobotDllType.py. DobotDllType.py is the Python API file of Dobot. It has encapsulation of Dobot's dynamic link library, which includes functions such as manipulator's control of point to point, joint movement and so on. It can be called directly when programming Python program. DobotControl.py is a specific implementation file. The Dobot dynamic link library is put into the running directory of Python, or the path of Dobot dynamic link library is added to the system environment variable, programming in Python can control the movement of the manipulator.

Based on the existing operation program in Python Demo, the programs of basic 2D graphics such as line, circle, rectangle, triangle and star are encapsulated for software preparation for collaborative printing. Each two-dimensional graphics program can set the position and size of the graph, and at the same time, if the different initial points and end points are set up, it can also achieve partial trajectory

movement of two-dimensional graphics. So, it can realize the combination of complex and irregular graphics.

2.3. Combining Python control to realize the printing of structural parts

When printing 3D model, it needs to cut the 3D digital model into two-dimensional graphic information, print 2D graphics and stack 2D graphics to get the complete 3D graphics. The thickness of the split sheet is determined by the properties of the printed material and the specification of the printer^[1]. 3D printing used layered processing and superposition to complete the 3D solid printing.

According the motion accuracy of the manipulator, the manipulator is set up to increase the 0.2mm in the direction of the Z axis after each layer is finished. The number of layers of the print is determined by the number of slice which is by introducing the 3D model into the DobotStudio to slice. Then the most important step is to plan the path to improve the printing efficiency and printing accuracy.

The first step of each layer is print the outline. Based on the ant colony algorithm^[2], we plan the path to get the shorter one and record the start and end of the outline for programming. And the most important thing is to fill in the scan. For the relatively small area, we can use the contour scanning method^[3] to form the centre of the heart. For large area, the graphics need to be separated at first, and each part can be implemented by parallel scanning algorithm, as shown in Figure 3.

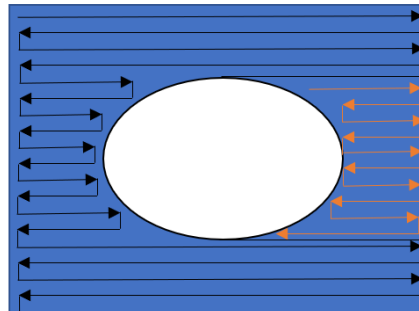


Figure 3. The finished product of Dobot manipulator.

When parallel scanning is used, a larger error will be produced if the scanning distance is same^[4]. To solve this problem, BIAN^[5] proposed an adaptive spacing algorithm. WURIKAIXI and so on^[4] studied the influence of the scanning distance on the precision of molding, which provided the basis for selecting the appropriate scanning distance and optimized the adaptive algorithm.

3. Multi manipulator cooperative 3D printing

To meet the requirements of mission complexity and operation intelligence, collaborative operation of manipulator is one of the key technologies to popularize and apply mechanical arm technology in industrial environment^[6, 7].

The synergies of multiple manipulator are divided into two categories: loose coordinated and tight coordinated^[8, 9]. Loose coordination refers to the synergy of a multiple manipulator at some point position, and its dynamic analysis is the same as a single arm mechanism, such as robotic arm for assembly. In the condition of loose coordination, the two robots perform their respective tasks in the same workspace. The tight coordination is to maintain a specific position or change according to a certain rule, and to coordinate the motion along the predetermined trajectory. Such as double arm carrying a common object, the two arms form a closed chain system.

This paper studies the cooperative 3D printing with multi manipulator by tight coordination. According to the base two-dimensional figure of the target structure, the location of the starting print point and the initial position of the manipulator are determined, and the printer parameters of each manipulator are set to the same value. The print task needs to be assigned before determining the starting print point. The rotation angle of the base of the entire Dobot manipulator is 270 degrees, and the maximum radius of the arm is 320mm, and when the height changes, it will be reduced to 310mm. According to the printing range of the manipulator, the target structure can be preliminarily divided, and

the size of the area should be less than 3/4 of the circle with a radius of 310mm. The general large structure parts are symmetrically distributed, and it is the most convenient and reasonable to use symmetry to carry out the preliminary division of the structure. The division of unsymmetrical structure should consider the structural features and the stress distribution to ensure the firmness of the structural parts. After allocating the printing task of each manipulator and finishing the development of the Dobot manipulator, the printing of the whole large structural part can be controlled and realized by Python.

4. Summary

The problem that is easy to meet when multi manipulator is co printed is the collision between the manipulator. For Dobot manipulator, if it wasn't developed, the collision problem of manipulator will happen, because the path planning in software cannot be changed and controlled. If we install sensors on the mechanical arm, we can solve the collision problem, but the hardware is too complex. Additional materials may also affect the accuracy of the movement of the manipulator. Although the python program control robot has complicated operation and large amount of programming, its logic of thinking is relatively simple. It can also artificially avoid the collision of manipulator and save the cost of hardware at the same time, which is a feasible solution.

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