

Vision-based Robot Arm Grasping in Medical region

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Abstract. This paper proposes a vision-based robot arm grasping system for automatically sorting various and complicated medicines and helping take care of patients, etc in medical area. This system could successfully identify and locate the target objects in a complex and messy environment. To achieve accurately location, the system uses several cameras to recognition and estimation. The cameras cover various kinds, visual, laser, and mechanical sensors are all included. The computer will process the data and send instructions to robot arms for grasping. The experiment shows that the vision algorithm will efficiently help to sort medicines and other works. The robotic arms are fully covered by leather which makes it more safe and the internal lube and anti-slip pads on the gripper make it more flexible and smooth when grasping objects. During the COVID-19 pandemic, the robotic arm adjusted from industries to hospital so that it plays an important role in Nucleic acid testing, drug classification, disinfection. Moreover, it could help not only nurses to monitor the patients' health but also patients to take better care of themselves.

Keywords: Computer vision system, Robot arm, Medicine, Automation.

1. Introduction

With the development of science and technology, manufacturing from the original pure manual to now automated production lines, human beings begin to pursue more efficient completion of repetitive tasks. Recently, robotic arms have been gaining increasingly more popularity in both the automated factories and other environments closer to people's livelihood such as homes, hospitals and delivery station.

Given the issue of ageing population and shortage of medical and nursing staff in many countries, this naturally leads to attempts to use robotics and automation addressing this problem [1, 2]. For example, China will enter a deeply aging society in 2022, with the elderly population accounting for 14%. Then around 2060, the proportion of aging will up to 35 percent, which means that in 2060, one out of every three Chinese people will be over 65 years old [3]. This will lead to a huge shortage of healthcare workers and result in a doubling of the cost of care.

Furthermore, poor working conditions due to the pressure and overtime cause a lot of people don't want to work in healthcare anymore. For example, about 8% to 38% of healthcare employees have suffered physical violence in their careers [4]. It is possibly that there will be a staff shortage of more than 500000 healthcare employees in Europe by the year of 2030 [5].

Since the outbreak began in 2019, the COVID-19 crisis has given an increase in robots applicable to the health care sector. The robotic arms are one of them. However, most of them are not able to grips objects. For example, the UVD robots are popular in disinfection filed which could navigate to and disinfect the whole room [6]. But it can't do more delicate tasks, like cleaning up the mess in dead corners of a room. The high flexibility of robot arms effectively alleviates this problem [7].

This paper, through the aspects of the framework, working principle and practical application of the robot arm grasp, tells the convenience brought by the automatic robot arm to the society, especially in the medical filed during the epidemic of novel corona virus. What's more, put forward some feasible plans for the development prospect of the robot arms.

2. Framework and Operation

2.1. System Components

The robotic arm grasping system is developed based on four main components: several RGB-D cameras, a UR5 robotic arm and a robotic 85 gripper and Data processing center, as shown in Fig1.

- RGB-D cameras are used to recognize, estimate the location and pose of the targets and send the data to data processing center.
- The UR5 robotic arm has 6 degrees of freedom, with 300mm working radius and 360 working degree for shoulder pan, shoulder lift and wrists.
- The robotic 85 gripper has 85 cm inner distance between two fingers, which could easily grab objects.
- The data processing center is to evaluate the data, give the coordinates of the transformed object to the robotic arms and command to grab.

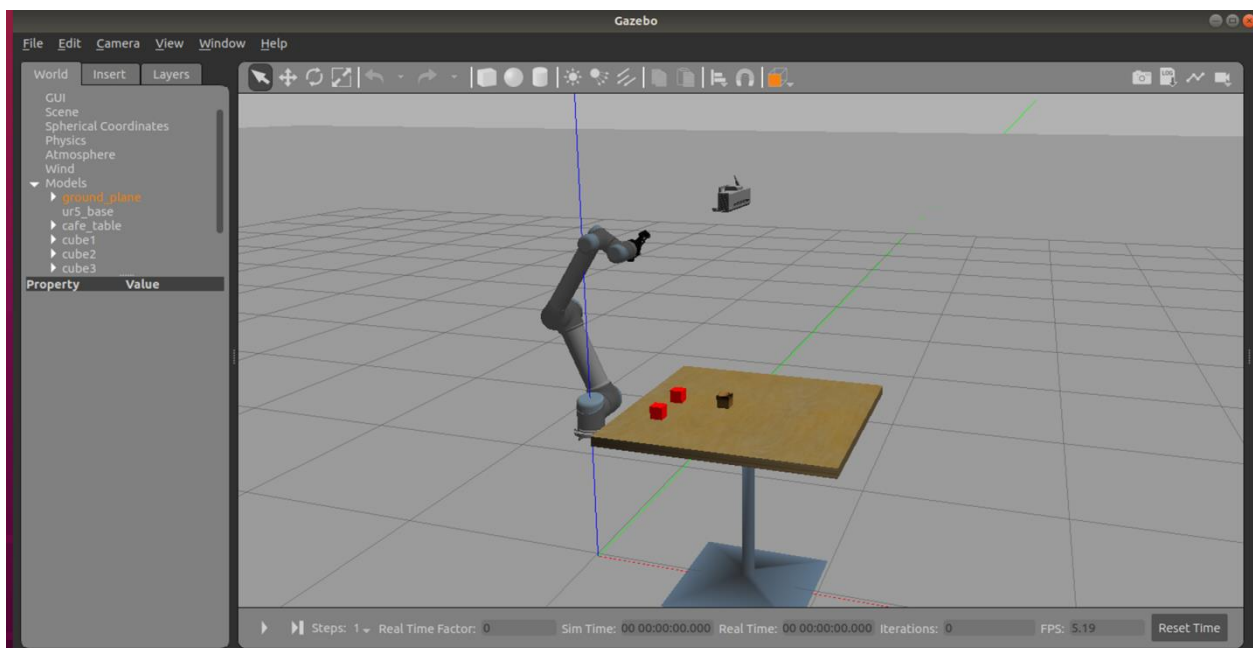


Figure 1. The robotic arm grasping system

2.2. General Framework

The general ideas of this system are to collect the object position's data from the RGB-D cameras. Then the data processing center could convert pixel coordinates into 3-D coordinates by Open-CV. After the 3-D coordinates are obtained, conducting motion planning of the robotic arm through an open source platform called Moveit and Actionlib. Then, sending orders to robotic arms to realize the motions of picking up. At the end of each loop, the final position of the end-effector will be examined to prepare for the next motion.

2.3. Computer Vision

Camera calibration and transformation is one of the most important things to locate [8]. First, a calibration stick is needed to calculate the ratio of the pixel unit coordinates and meter unit coordinate. Then, changing the camera frame into the world frame and add the constant another coordinate. After determining the coordinates of the objects, a rotation matrix will be set to eliminate the angle between the two frames.

After the camera calibration and transformation, design a computer vision algorithm by the python Open-CV repository- CV2 [9]. Among this project, filters and color mask are two main functions. As for filters, with the purpose of gripping the cube block, it is necessary to ensure that the top surface area of the objects can be calculated accurately. However, due to the influence of camera angle, the top

surface area might be a range. For the Color mask, using online tools to convert the RGB color values to HSV values. Then it is easier to deliver the data.

Following the above steps, locating the objects in the world frame by RGB cameras and passing back the end-effector position to the arm could be realized.

2.4. Grasping Motion

Grasping motion is conducted by the robotic arm and the gripper while using motion planning to integrate all previous work together. Firstly, through calling the computer-cartesian-path function in the robot_commander library to conduct the Cartesian path planning. Set Cartesian waypoints and control the manipulator moving with them could avoid collisions while improve the efficiency. Trajectory can be tracked by creating a linked list of waypoints for the end-effector until to the final position. Secondly, geographical information and robot pose presettings should be obtained before matrix conversion. Geographical information can be obtained from computer vision algorithms. Initial position setup can be achieved by the Moveit setup assistant which is used for setting configuration and SRDF file. To simplify the grasping operation, the rotation of the gripper is ignored due to the motion of the manipulator is perpendicular to the target objects. After the initial positions are set, the robotic arm can move along the preset Cartesian path by following the Cartesian waypoints.

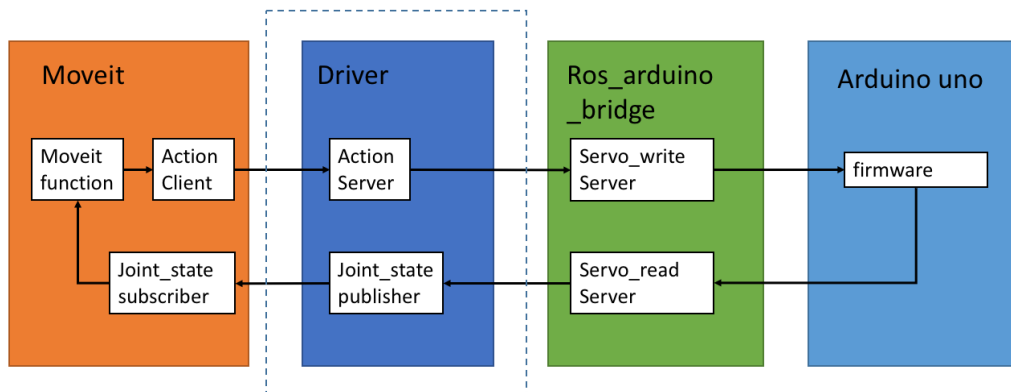


Figure 2. Moveit communication principle

Move_Group is the core part of moveit, which can integrate various independent components of the robot to provide users with a series of action instructions and services. Similar to an integrator, it does not have rich functions in itself. It mainly integrates various function packages and plug-ins. Receive the point cloud information uploaded by the robot in the form of message or service. In moveit, the motion planning algorithm is completed by the motion planner, which is installed as a plug-in and can be loaded through the ROS interface. Moveit communication principle as shown in Fig2. There are many motion planning algorithms, and each motion planner is a plug-in of moveit. The planning scene can create a specific working environment for the robot and add some obstacles. Kinematics algorithm is the core of all kinds of robot arm algorithms, especially the inverse kinematics algorithm, which changes the terminal pose into joint angle. Flexible Collision Library feature pack. Collision detection is the most time-consuming operation in motion planning, which often takes about 90% of the time. In order to reduce the amount of computation, the open motion planning library is an open source motion planning library, a C++ library for motion planning, which contains many cutting-edge algorithms in the field of motion planning. Provides a motion trail. Given a robot structure, a target, and an environment, OMPL will provide you with a trajectory containing M arrays, each of which has a length of N, that is, a complete joint position. Move the joints along this track in turn to finally move the terminal to the target.

3. Medical Application

In the face of COVID-19 pandemic, automated robotic arm could assist care professionals in these extenuating circumstances [10, 11]. There are lots of routines robotic arm can do, such as collecting

Nucleic acid test sample from different wards and bringing them to the pick-up point at the reception. What's more, the robotic arms could entertain patients by robotic arm dance and take care of them, such as delivery of some daily supplies and helping with medicine retrieval. What's more, robotic arms could help to call the nurse by knocking on the door, opening it. Staff can control them using phone or other electronics to do more complex works. For example, if the robotic arm is deployed in a home of a disabled person, it could make the owner more independent by assisting with his daily life like taking an apple, opening a bottle. Even more, he could manually control the arm to peel an apple, regulate air conditioning and so on.

4. Summary

The robotic arm is considered a brand new one in the medical field. From the above introduction about the framework and operation of the robotic arm. It is obviously that its code and design has been optimized to address the limitation of similar arms and ensure the requirements of health care institutions, as well as home care. The robotic arm is covered by artificial leather which could limit forces and speed, and has advanced navigation and behaviour algorithms.

Algorithms in the robotic arms are divided into many parts which means it can be easily improved by researchers and developers depending on their field of expertise.

For the hardware of the manipulator, leather covered makes the arm softer and less likely to hurt others by accident, while the overall design with fur also makes it look more warm and kind. Moreover, internal lube and anti-slip pads on the gripper make it more flexible and smooth in the grip of things.

With the capabilities of both assisting and interacting with people, it has been proven during multiple deployments in health care institutions and had positive feedback regarding functionality as well as acceptance by patients, residents and medical staff. What differentiates the robotic arms from other arms are the manipulation capabilities of the large arm and gripper which allows opening doors, grasping, bringing routines and handling homework.

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