Review on Collaborative Robot

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1. Existing Research and Development of Collaborative Robot

1.1 What is Collaborative Robot

Compared with traditional industrial robot, collaborative robot is a kind of robot that designed for work directly with human, which means they are not isolated from users' contact.

In 1996, J. Edward Colgate and Michael Peshkin published a patent named "cobots" (US Patent 5,952,796) started the history of collaborative robot, they are recognized as the first group of people who called this kind of robot as collaborative robot. There are four main different points between traditional robots and collaborative robot. First and the most important, collaborative robot removes isolation between people and robots in factories and laboratories. Secondly, it enables operation staffs to stay closer when robots are working cause most of them have the function to stop when detecting collision so it can be more convenient for these people to test the path and set working steps for robots, which improvement can help to increase the efficiency of production. Besides, some systems and library like ROS, OpenCV and many packages which can be used in ROS provided by people all around the world make the whole collaborative robot system works better [1], in this way, collaborative robot can be more intelligent than traditional industrial robots to some degree. Last but not least, the price of collaborative robot is lower than industrial robots to some degree, which means that many some companies can have the chance to build their own production line rather than renting machine from others.

Figure 1 Industrial Robot-KUKA

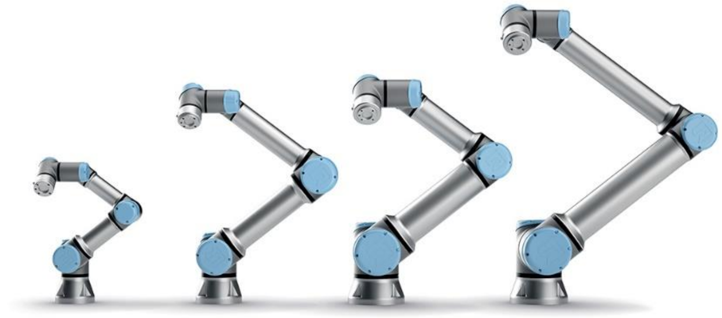

Figure 2 Universal Robot cobots

1.2 Existing Products

In terms of collaborative robot, you must highlight the cobots produced by the Universal Robots. It is the best collaborative robot that I have used. For collaborative robots come from different manufacturers with 6 degree of freedom. UR10 is the lightest but it can load 10 Kg at most, while FANUC CR 7iA can only take 7 Kg of goods even it is about twice as heavy as UR10. Pictures below shows some existing products.

Figure 3 AUBO Robotics

Figure 4 JAKA Robotics-CHINA

Figure 5 EPSON dual arm robot

1.3 Existing Research

There are three main directions of existing research. The first topic is structure and researchers are trying to make the bionic structures and joints more similar with human's arm. For example, the developers developed structures like hand.

Fgure 6 3-finger end effector from Robotiq

The second topic is about feeling the environment with many kinds of sensors and man-machine interaction. With sensors, the connection between humans and robots would be enhanced much more.
For example, using brain-computer interface to control robot. [2]

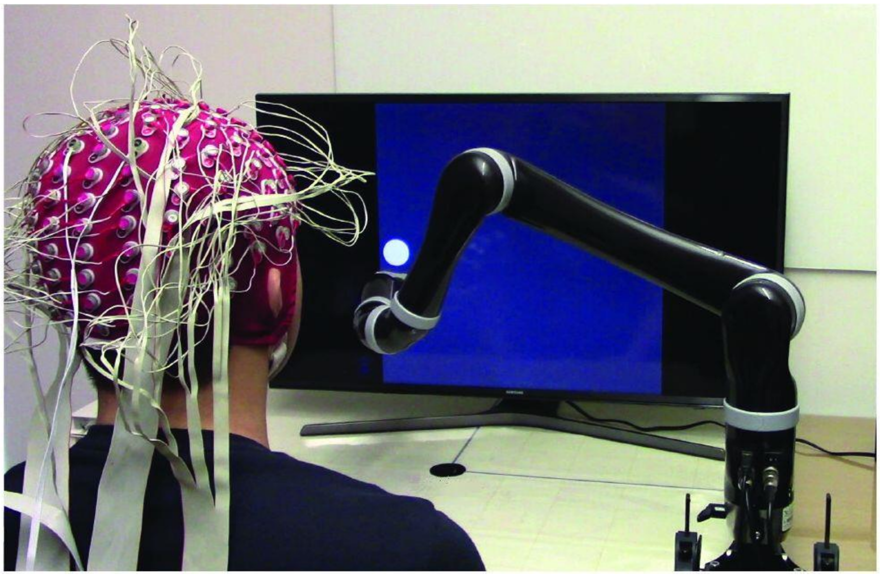

Figure 7 Control end effector on 2-D plane [2]

The third topic is about robot system and intelligent automation. For example, many developers are working to make 2 or more robots to work together without disturbing others. Figure 8 comes from https://www.knowin.com/kitchen-robot/index.html, accompany in China.

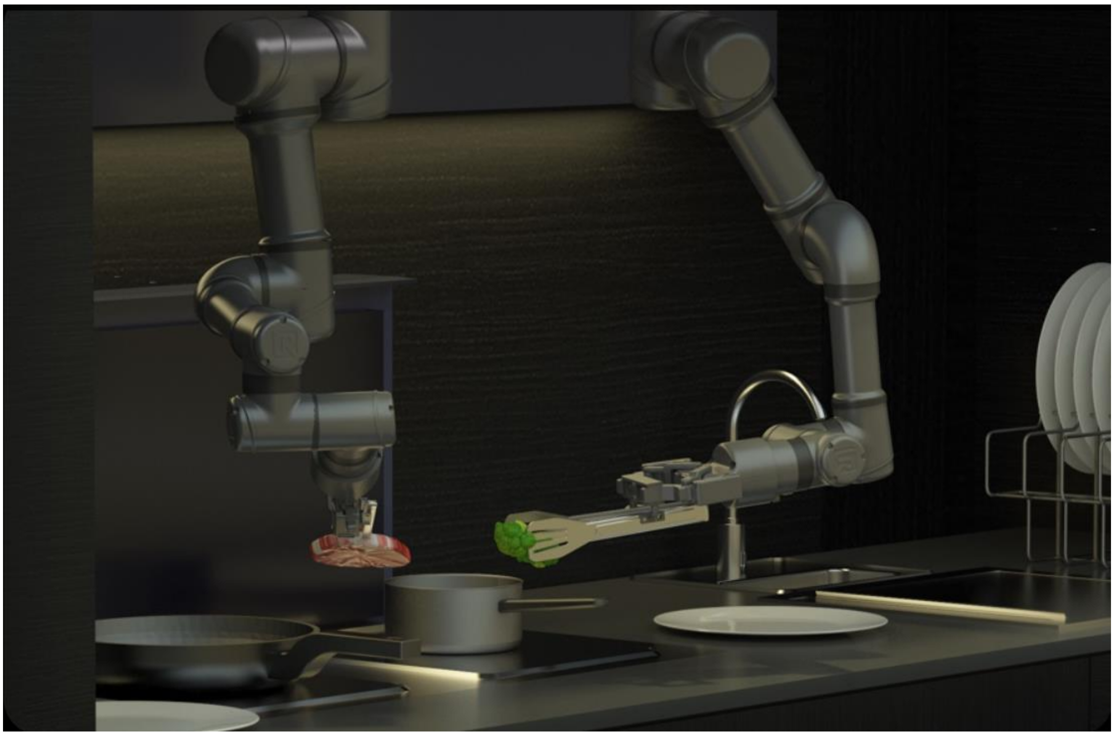

Figure 8 Two robots cooperatation

1.4 Potential of Cobot

First, Cobots means the closer cooperation which will boost work efficiency on assembly lines. Besides, because cobots are light and easy to be equipped, it can fit many kinds of work requirements rather than industrial robots. Also, it is useful outside the factories. For example, in 2020 Shanghai Industrial exposition, collaborative robot was used to massage.

Figure 9 Use cobot to massage

Besides, during this exposition, many customers looked for companies which can use cobot to replace humans in shops such as milk tea shops, canteens, and old people's home. Therefore, it can be assumed that the development of collaborative robot market would be better in the future because demand is increasing. Figure 10 is the predict from https://www.marketsandmarkets.com/.

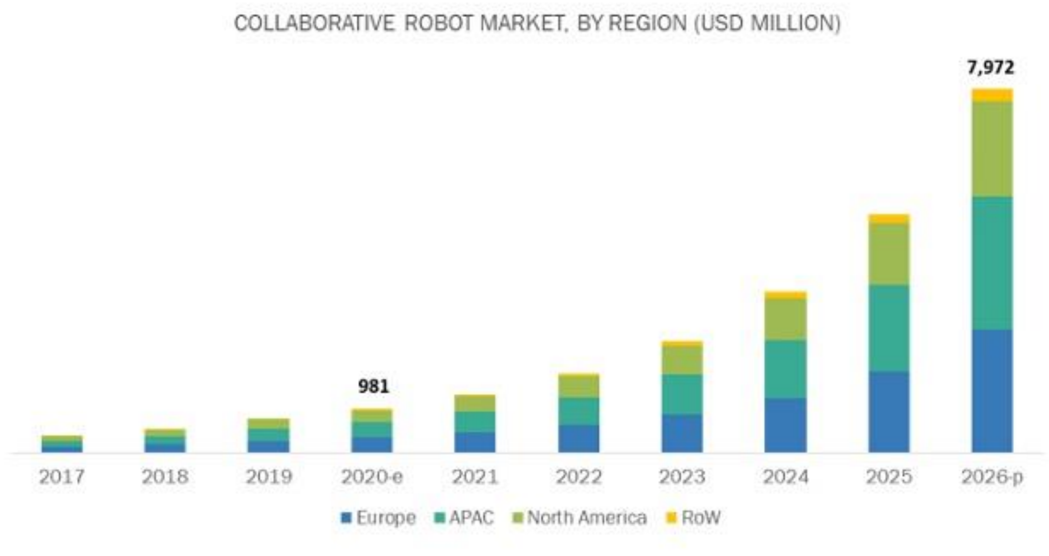

Figure 10 predict of cobot market

Also, with the development of Natural Language Processing and human-computer interaction, the collaborative robot can be more intelligent.[3]

2. Advantages and Disadvantages of Cobot

2.1 Advantages

Firstly, it is safe to be used. Taking a kind of cobot named innfos, it is very sensitive, and it would stop once detecting the collision with other people, and this technology is based on the detection of electric current and voltage.

Figure 11 Innfos Robot

Secondly, the cost of cobot is low, for most of cobots, the prices of them are below 40,000 SGD, some of then are even around 5,000 to 10,000 SGD. Therefore, it can be more cost-effective for factories or laboratories to buy cobots to do research.

Also, it is easy to use. Most of them are equipped with dashboard so users can set the path of cobot easily and it supports WIFI and drag and drop programming, figure 12 shows these good characteristics.

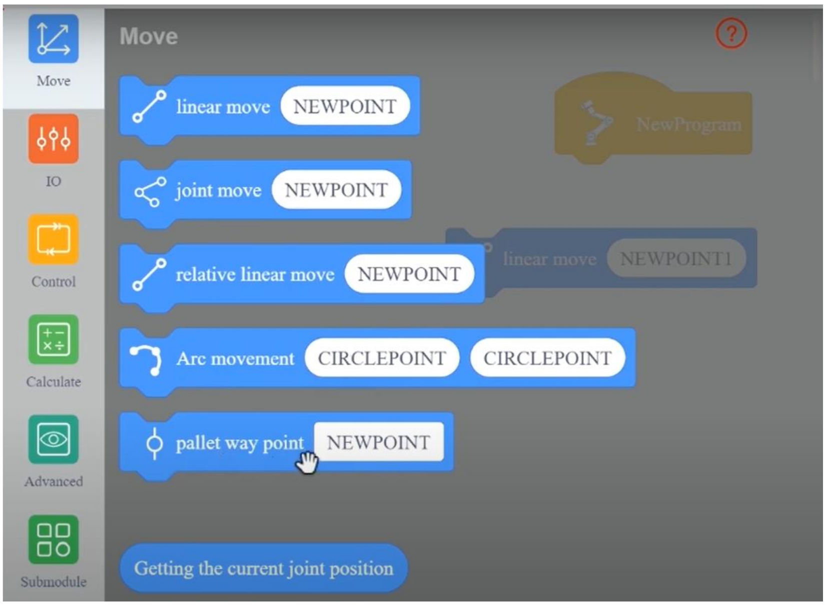

Figure 12 drag and drop programming of JAKA Robot

Last, collaborative robots are easy to connect with computers such as PC, Jetson Nano and raspberry pi, with these computers, finding better solutions for path and collision avoid are easier for robots. Besides, a couple of tools like ROS and OpenCV can be integrated with collaborative robots, so, users can have more ways to use or simulate. Figure 13 and 14 are my past work with ROS.

Figure 13 Using a joystick to control UR3

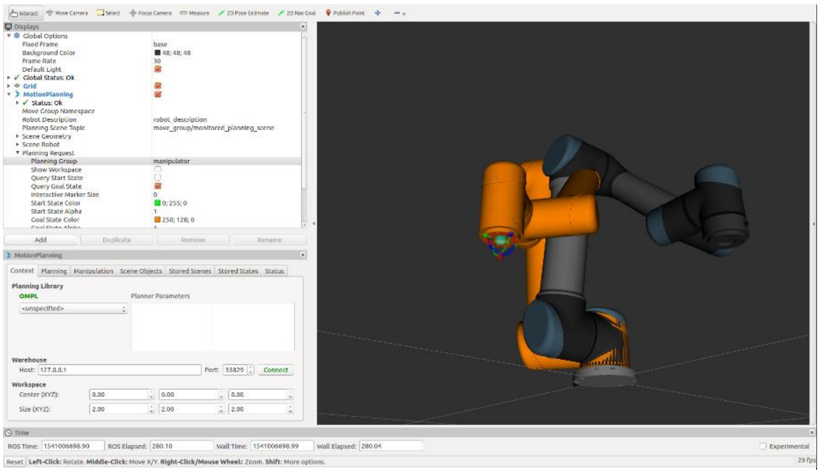

Figure 14.1 UR in Rviz

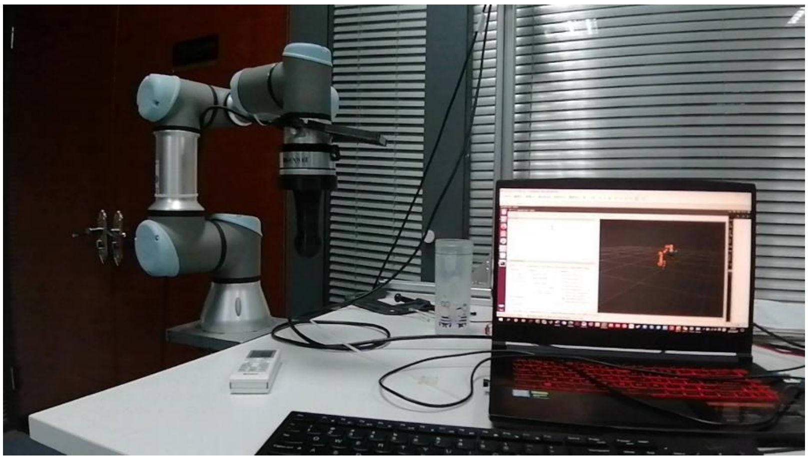

Figure 14.2 Control UR by Rviz and torque transducer

Here, ROS is a kind of tool to make robots work better, and this robot operation system is supported by many robot users all around the world, Therefore, I believe cobot has huge potential in the future because it is supported by many smart people.

3. Disadvantages and Challenges

3.1 Only Stop after Collision

For some kinds of collaborative robot, they only stop after the collision happened, however, the collision may already lead to harm to humans, parts. Therefore, how to make it stop before collision can be a challenge.

3.2 Sensors

To make full use of machine learning and computer vision, RGB-D sensors like Kinect V2, RealSense series are used to combine with robots. However, the equality from cameras is not always perfect to be used because many kinds of factors, and the effective range sometimes limits the usage and performance of some object detection algorithms [4] and pick-place algorithms. Therefore, the performance of sensors such as lidar and camera would affect the development of collaborative robot. Besides, the bad performance of sensors can lead to serious result in medical treatment. [5]

Figure 15 RealSense D435 and Kinect V2

3.3 Capacity

Although collaborative robot can work under many circumstances, the work envelop of it is small compare with traditional industrial robots or Special purpose robots. For example, the UR16e collaborative robot can only reach 900mm around it, which is not a big range for some demands. Sometimes, because of the shapes of things to be carried, the real effective would decrease.

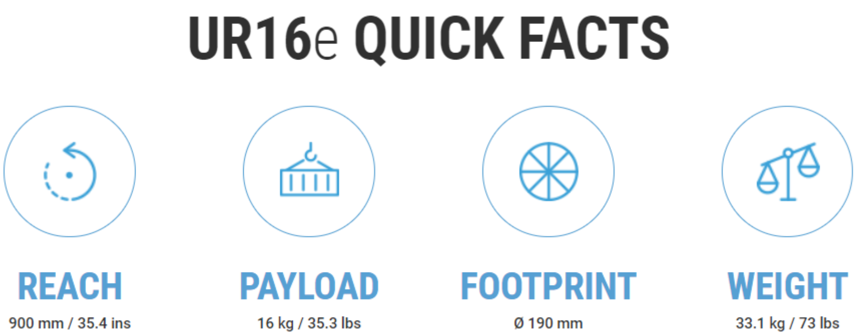

Figure 16 Facts of UR16e

3.4 My Solution for These disadvantages

For Collision problem, I suppose that three ways can be applied. First solution comes from machine learning. Users can detect the movement of robots by using more sensors and stop robots before the Collision. This demands users to set a good algorithm to decide when to stop, and I guess a kind of reinforcement learning algorithm may have this power by reward mechanism.

Second way is using some special sensors which can let robots put on like a cloth, so these sensors can help to detect collision signal and return some control information.[6]

Third solution needs the help from ROS. Before the running of robots, uses can set a permitted workspace and pose for robots, in this way, it may help to stop some collision. For example, if we know the cobot will take something and go around some things, we can set the size and shape with XML or URDF file, then, with the help of Rviz and some other ROS packages, cobot can avoid some collision. Also, the ROS Industrial has been introduced in recent years, which can help to make cobot easier to be used in many areas.

Figure 17 ROS Industrial

For the equality of sensors and capacity, I think that is the problem for mechanical engineers and Optical engineer.

4.What I Get and My Interest in Robotics

4.1 What I Get

After this review, I have a better understanding of the history of collaborative robot and its potential in the future. Also, I know the details of famous collaborative robot in the market. To be honest, I think the collaborative robot will be a good area to do some research and this kind of product will be very useful in areas such as service for the aged [7] and remote manipulation in dangerous environment.

4.1 My idea

From my perspective, I believe that collaborative robot will more and more important in the future, but the main challenge is not from the mechanical structure and precision, it comes from the algorithms like how to make many robots work together without collision or how to use image processing technology and machine learning to make the robot smarter. Besides, with the development of society, automation work and free of free up labor market will be the main topic in the next decades.

Therefore, the robot area combined with state-to-art computer science technologies will be very attractive to me.

Reference

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