Virtual Collaborative Cells Modeling for UR3 and UR5 Robots in Gazebo Simulator

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Abstract

This paper presents virtual models of collaborative cells for two industrial collaborative robots UR3 and UR5 in the Gazebo simulator. Typically, the UR3 and UR5 robots are used by enterprises for packaging, assembly and sorting. Modeling and virtual experiments are an important stage in production processes planning, which involves joint human-robot work. Such models allow to plan safe human-robot interactions within a joint workspace and, if required, to rearrange the workspace. Our models of collaborative cells were adapted to several typical cases of joint human-robot operation scenarios and could be used in engineering design and testing for human-robot interaction in the field of production processes.

Keywords: Gazebo simulator, ROS, Collaborative industrial robot, Collaborative robot cell

1 Introduction

Simulation studies are often used for modeling the human-robot interaction in different processes[1][2][3], including the manufacturing processes involving collaborative robots[4][5][6]. Simulation models help to secure the safety of the human-robot interactions[7]. In particular, simulations are used for avoiding collisions in human-robot interactions[8][9]. Virtual models are also required for efficient and secure algorithm testing of collaborative robots before incorporating the robots in a real-world environment[10][11].

Nowadays, there are numerous simulation software available for simulating human robot interactions such as[12][13][14]. The selection of a software for evaluating human operator interactions with robots depends not only on the effectiveness of the modeling, but also on other elements like the software's accessibility and usability.

In this work, virtual collaborative cells for two industrial collaborative robots UR3 and UR5[15] using the open-source environment Gazebo[16] are developed for simulating industrial tasks. Gazebo is used to develop a variety of robotic systems since it can be integrated with the Robotic Operating System (ROS)[17][18].

UR3 and UR5 developed by the Universal Robots are used by large, medium-sized and small-scale industries. Development and testing of collaborative interaction of UR3 and UR5 robots with human operators are made easier using simulation studies before the implementation of these robots in industrial environments.

2 Typical use cases for collaborative industrial robots UR3 and UR5

During the last 10 years, a lot of research has been reported on the studies and implementation of collaborative robots in various industrial sectors[19][20]. As part of our research, we analyzed more than 100 cases of collaborative interaction of UR family robots with humans as part of the manufacturing process[15]. As a result, various applications of UR3 and UR5 robots and workspace prerequisites for incorporating the robots are identified.

We have identified the following common types of cases in which UR3 and UR5 robots are involved: collaborative assembly or processing, packaging and sorting. The most common cases of human-robot interaction work include transfer of objects from robot to person or vice versa and working on a common process simultaneously. The transfer of the part can be carried out either by shifting the part to a certain location or using a conveyor.

We have identified two options for arranging the collaborative workspaces. Workspaces of human operator and robot are located in adjacent zones in the first option. In the second option, the human operator and a robot work in a common area. In the second case, the workspace is difficult to distinguish.

Three cases of human robot workspace simulation models are developed in this work. A person sitting and standing in one location are considered as the first and second cases respectively. The third case involves the movement of a person to different locations inside the workspace of the robot.

A collaborative work area in which a robot and a human do a common job can also be integrated into a common space in various ways. A small area of a shared workspace with other people, in a shared office or office with conditional boundaries Part of a production workshop with other people and robots or a separate room can also be considered a collaborative environment. It should be noted that UR3 and UR5 robots are successfully used in small-sized rooms.

3 Modeling the virtual collaborative cell in Gazebo simulator

The following common traits of a virtual collaborative cell are identified based on the investigation of various applications of UR3 and UR5 robots. Cell sizes, type of the robot, workspace sizes, location of the working area relative to the cell, location of the robot relative to the work area, the position and trajectory of a person relative to the work area are important for the development of a collaborative work. These characteristics are considered during the development of simulation models of work cells in the Gazebo environment.

Simulation models of virtual collaborative cells in the Gazebo environment, taking into consideration the main characteristics of the collaborative robotic cell are developed. By updating the above-mentioned characteristics, this model can be used for a wide variety of applications. Cells that satisfy the requirements of a certain assignment can be produced with the use of this model. This model can be adapted to various constraints changing the key characteristics of the workspace. With the help of this model, cells that meet the conditions of a particular task can be generated. In addition to the robot itself, an animated model of a person standing or sitting at the workplace is created inside the cell. The user can control the motion of the person inside the cell.

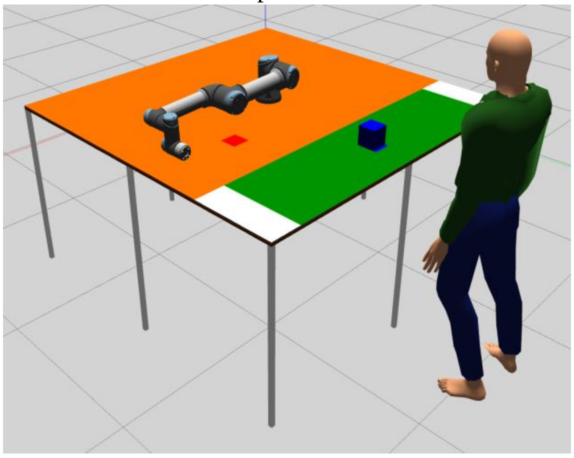

Fig. 1. The virtual model of collaborative workcell with the standing person and UR5 robot

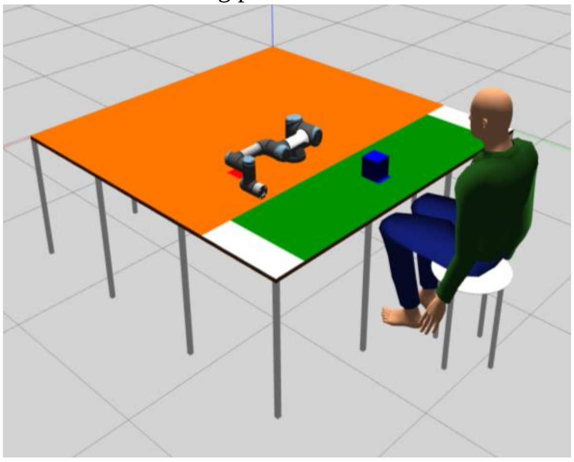

Fig. 2. The virtual model of collaborative workcell with the sitting person and UR3 robot

Fig. 1, Fig. 2, and Fig. 3 show various virtual collaborative cells constructed in Gazebo for simulating different workcell environments. Fig. 1 shows a person standing next to a table on which a UR5 robot is fixed. Fig. 2 shows a person sitting next to a table on which a UR3 robot is fixed. In Fig. 3 the integration of two collaborative workcells with UR3 and UR5 robots into the office space model is presented.

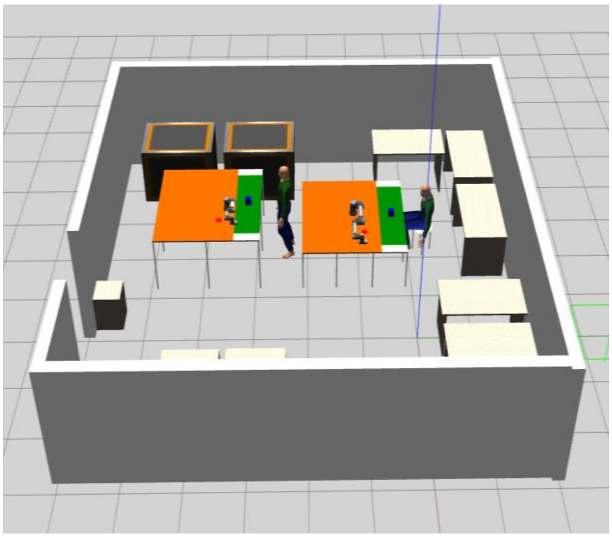

Fig. 3. The integration of two collaborative workcells with UR robots into the office space model

4 Conclusions and future work

Different applications of UR3 and UR5 robots are studied for determining the common characteristics of collaborative robots used in industrial applications along with human operators. UR3 and UR5 robots collaborate with human operators to complete tasks including assembly, packing, and sorting operations. In the Gazebo environment, a generic model is created which enables users to easily create virtual collaborative cells for UR3 and UR5 robots. These cells can be used to design and test different algorithms for the collaborative robots for robot-human interaction. The created virtual model can be expanded to different applications by including other types of manipulators and systems. The motion of human operators can also be planned for future works.

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