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3D Bin Picking with an innovative powder filled gripper and a torque controlled collaborative robot

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Abstract

A new and innovative powder filled gripper concept will be introduced to a process to pick parts out of a box without the use of a camera system which guides the robot to the part. The gripper is a combination of an inflatable skin, and a powder inside. In the unjammed condition, the powder is soft and can adjust to the geometry of the part which will be handled. By applying a vacuum to the inflatable skin, the powder gets jammed and transforms to a solid shaped form in which the gripper was brought before applying the vacuum. This physical principle is used to pick parts. The flexible skin of the gripper adjusts to all kinds of shapes, and therefore, can be used to realize 3D bin picking. With the help of a force controlled robot, the gripper can be pushed with a consistent force on flexible positions depending of the filling level of the box. A Kuka LBR iiwa with joint torque sensors in all of its seven axis' was used to achieve a constant contact pressure. This is the basic criteria to achieve a robust picking process.

Keywords: Powder filled gripper, vacuum, 3D bin picking, force controlled robot, joint torque sensors

Introduction

Robot based bin picking is a rising topic in the field of fully automated assembly. Traditional feeding methods like bowl feeders and presenting parts to the assembly robot in a tray drive up costs in automation projects. The more unique components there are in an assembly, the more feeding systems are needed to present the parts in proper orientation for the assembly robot. Very often, the costs for feeding systems exceed the costs for robots in an assembly project. Therefore, new concepts are needed to increase the economic efficiency of assembly cells. One of these concepts is bin picking. The idea is to present a box filled with components to the robot and the robot picks the parts out of the box.

State of the art

Common bin picking systems described in the literature, use a high performance camera system which guides the robot to a part in the box. Both, the position and the orientation of the parts needs to be guided by the camera [1] [2]. Despite 3D bin picking being a popular research topic for years, it hasn't been developed in practice. There are many issues which stop companies from using this technology. On the one side, 3D objects have different appearances, illumination, and occlusion when seen from different viewpoints [3]. Many more issues occur in practice, depending on the geometry, the surface, and the material of the parts which should be handled. These problems often lead to unreliable image recognition which, in turn, lead to unsuccessful picking results.

Powder filled vacuum gripper

In this article, a gripper with an inflatable skin filled with powder is being used to pick the parts out of the box. No camera is needed. The function of the gripper is quite simple. In the unstressed condition, the powder in the gripper is soft and enables the possibility to adjust to any contour of the part which has to be picked. Once the gripper forms around the part, a vacuum generator creates a vacuum in the inside of the inflatable skin. The applied vacuum forces the powder inside the inflatable skin to become solid. A combination of form, fit, traction, and adhesion, is causal that the part sticks at the gripper [4]. For the inflatable skin, many known materials, such as a balloon and latex bag, were tested. It turned out that the finger of a rubber glove gives a very good compromise between resistance and adjustability.

Coffee powder was used for the filling, as it is light, and gets very soft in the un-jammed condition [4]. The part used was a gear with sharp edges which should be handled with the gripper. The sharp edges of the gear require a high wear resistance and a high puncturing of the skin.

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Bin Picking with a sensitive robot

In the test, a box filled with gears was emptied by a sensitive robot with a powder filled gripper. A Kuka LBR iiwa 7 R800 robot was selected as an adequate robot. It can handle a payload of 7 kg and is equipped with joint torque sensors in all seven of its axis.

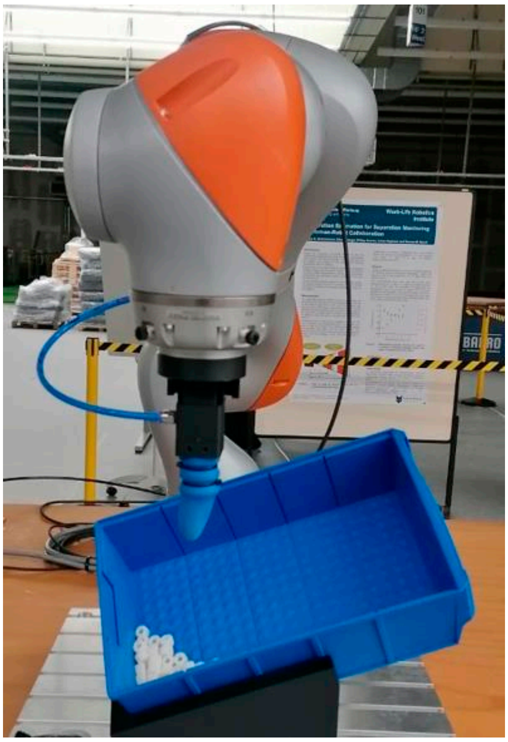

Figure 1: Kuka iiwa LBR 7 R800 robot with a powder filled gripper

These joint torque sensors enable to operate the robot force controlled. The accuracy of those sensors in each axis is 2% of the max torque [5]. The high performance controller also enables force and torque controlled movements in all of its seven axis, as well as along and around the Cartesian axis. It can measure the weight and the center of gravity of its end of arm tool automatically. The use of joint torque sensors provides the opportunity to make the end of arm tool flexible in the required axis. Additionally, it provides the opportunity to simulate a spring with the robot arm and move the robot arm until a specified force is applied on the end of arm tool. The robot is collaborative because of its lightweight design and its joint torque sensors. Also, the gripper doesn`t have any moving parts which means it can be seen as collaborative. Before pushing the gripper on the gears, the gripper gets applied with a positive pressure of 0.2 bar to ensure a soft powder. If the pressure is less than 0.2 bar the gripper doesn`t lose the coffee powder properly. If the pressure is increased above 0.2 bar the gripper inflates. The possibility to move the end of arm tool until a specified force is met on the end of arm tool is used to empty the boxes filled with gears. In a series of tests, it was determined that the optimal force, with which the gripper has to be pressed on the gears in the box, is 40 N. The robot was programmed to move in Z-direction until it measures a counter force of 40 N. It then stops the movement. Once this occurs, the powder filled gripper is applied around one or more gears in this area. Then the vacuum gets applied on the gripper and the parts stick on the gripper. These parts can then be placed in a centering fixture or on a plate where the next robot can pick the part. The force control is important since the filling level in the box changes. This feature enables to compensate the changing pick up height.

To avoid areas without parts in the box it should be placed tilted (see figure 1). In case a situation occurs which leads to a couple of unsuccessful gripping, knocking on the box changes the order of the gears in the box and allows further picking.

Conclusion and Outlook

In this work, a new concept for bin picking has been successfully demonstrated. A force controlled robot with a powder filled gripper does make sense when an automation has more than one component to be picked out of the box. As a next step, the lifetime of the gripper needs to be validated. To orientate the gears in a specified orientation an alignment station could be created.

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