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Human-Robot Collaboration Demonstrator Combining Speech Recognition and Haptic Control

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Abstract

In recent years human-robot collaboration has been an important topic in manufacturing industries. By introducing robots into the same working cell as humans, the advantages of both humans and robots can be utilized. A robot can handle heavy lifting, repetitive and high accuracy tasks while a human can handle tasks that require the flexibility of humans. If a worker is to collaborate with a robot it is important to have an intuitive way of communicating with the robot. Currently, the way of interacting with a robot is through a teaching pendant, where the robot is controlled using buttons or a joystick. However, speech and touch are two communication methods natural to humans, where speech recognition and haptic control technologies can be used to interpret these communication methods. These technologies have been heavily researched in several research areas, including human-robot interaction. However, research of combining these two technologies to achieve a more natural communication in industrial human-robot collaboration is limited. A demonstrator has thus been developed which includes both speech recognition and haptic control technologies to control a collaborative robot from Universal Robots. This demonstrator will function as an experimental platform to further research on how the speech recognition and haptic control can be used in human-robot collaboration. The demonstrator has proven that the two technologies can be integrated with a collaborative industrial robot, where the human and the robot collaborate to assemble a simple car model. The demonstrator has been used in public appearances and a pilot study, which have contributed in further improvements of the demonstrator. Further research will focus on making the communication more intuitive for the human and the demonstrator will be used as the platform for continued research.

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Keywords: Human-robot collaboration; Speech recognition; Haptic control

1. Introduction

The fourth industrial revolution, Industry 4.0, is a top priority for many research institutes, universities and companies [1], because this ultimately shapes the future within the industry. In this revolution human-machine collaboration is one important aspect, and therein Human-Robot Collaboration (HRC). HRC means that a robot and a human work closely together to solve a task related to for example assembling or quality control. By HRC, the unique strengths of a human (such as flexibility and intelligence) can be combined with the unique strengths of a robot (such as strength and the ability to exactly repeat the same a movement an infinite number of times).

Most of the existing industrial robots all over the world require safety fences, because it is not safe to walk close to these robots. However, some of the major industrial robots suppliers, such as ABB and KUKA, have developed new collaborative robots that can be used without a safety fence and thereby make HRC possible. Another supplier is Universal Robots, officially founded in 2005, which focuses on bringing lightweight, flexible industrial robots to the global market. Universal Robots has today three variants of collaborative robots, UR3, UR5, and UR10. HRC is the next step in the development of robots as seen with the prediction of Industry 4.0 and the new collaborative robots.

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The common way of interacting with industrial robots is with a teaching pendant. A teaching pendant is a tool connected to the robot which can be used to move and program the robot. However, the teaching pendants way of moving the robot is with either a joystick or buttons, which is both difficult and time consuming for someone not familiar with the controls. The new collaborative robots offer another way to interact with the robot, namely through guidance by hand. This simplifies the way a human can move a robot but is in most cases not enough to achieve an intuitive interaction. To realize a more intuitive way of interacting with the robot, this work attempts to combine haptic control with speech recognition.

There are plenty of research within speech recognition, including some of the largest companies in the world, Google, Apple, and Microsoft. Haptic control have also been thoroughly researched, and there are several focused on robotics, e.g., [2, 3]. However, research on the combination of the two technologies to achieve a more intuitive industrial HRC is limited.

2. Human-Robot Collaboration demonstrator

The research in focus is the combination of speech recognition and haptic control to create an intuitive HRC. A design and creation approach [4] is suitable for this research, because a physical artifact is necessary to evaluate the technologies. Therefore, a demonstrator was planned, because a demonstrator can be used for multiple purposes [5], within and outside the scientific domain. The demonstrator serves as platform for prototyping, and for disseminating the concepts to potential users.

The main requirements considered when designing the demonstrator were: (1) it needs to be safe for humans to use, (2) it should be mobile to move around, (3) the task to carry out in collaboration between the human and the robot should be simple yet relevant, and (4) it should involve both haptic control and speech recognition. In the following subchapters, the implementation of the demonstrator is described in further detail.

2.1. Setup of the demonstrator

The following setup was used, as shown in Fig. 1, to meet the requirements of the demonstrator:

- UR3 robot (a) and controller (b) from Universal Robots.
- Flexible 85mm 2 finger tool (c) from Robotiq
- Sennheiser ME 3 EW microphone with Steinberg UR12 USB audio interface (d)
- Computer (e) installed with Microsoft Speech API 11 and EasyModbusTCP, connected to the microphone and the robot controller
- A movable wagon, containing components (a-e)
- A TV as the graphical user interface, mounted on a movable stand

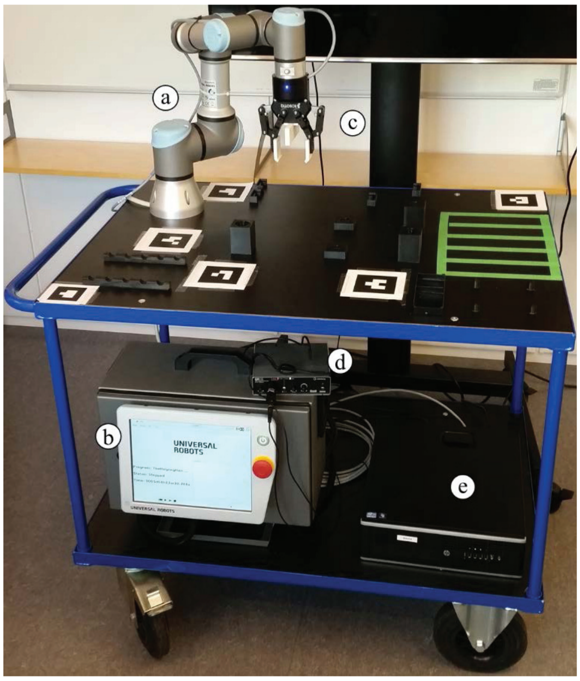

Fig. 1. HRC demonstrator setup, (a) robot, (b) robot controller, (c) robot tool, (d) microphone and USB audio interface, (e) computer. All components placed on a movable wagon.

The UR3 robot was selected because it is certified for working in collaboration with a human, in combination with being one of the cheapest robots for HRC on the market. It is a six axis light weight articulated robot that can lift up to 3 kg. It has joint-by-joint haptic control, called freedrive mode. The freedrive mode uses the impedance/back-drive control which allows a human to move the robot by hand.

The 85mm 2finger tool from Robotiq was selected because it is highly flexible, where the fingers can open 85mm wide and close at 0mm. This tool can also control the speed and force with which it grips an object. In the demonstrator the speed of the tool has been reduced, limiting the possibilities of someone getting stuck.

The computer is the central system controlling what will be displayed on the graphical user-interface, listening to commands by the human and controlling the robot execution. The speech recognition system combines Microsoft Speech API 11, Sennheiser ME 3 EW microphone and Steinberg UR12 USB audio interface. Microsoft Speech API 11 is not cloud based, which is an advantage because depending on the location, Internet access might be unavailable. The Steinberg UR12 USB audio interface connects the microphone to the computer, and this was necessary because the Sennheiser microphone plug is not compatible directly with the computer.

The robot execution is controlled from the computer, through EasyModbusTCP, which acts as a Modbus server. Several signals are defined in the Modbus server, which are: reset, start, next, open, close, and handshake. The handshake signal is used to ensure a good communication between the robot and the computer. The other signals are used for different commands controlling the execution of the robot.