A Skill-based Robot Co-worker for Industrial Maintenance Tasks

Paul J. Koch a, Marike K. van Amstel a, Patrycja Dębska a, Moritz A. Thormann a,
Adrian J. Tetzlaff a, Simon Bøgh b and Dimitrios Chrysostomou b*

aDept. of Mechanical and Manufacturing Engineering, Aalborg University, Fibigerstræde 16, Aalborg Øst, DK-9220, Denmark
bRobotics & Automation Group, Dept. of Mechanical and Manufacturing Engineering, Aalborg University, Fibigerstræde 16, Aalborg Øst, DK-9220, Denmark

Abstract

This paper investigates the concept of a sensor based robot co-worker working in flexible industrial environments together with and alongside human operators. In this particular work, a realisation of a robot co-worker scenario is developed in order to demonstrate the implementation of a robot co-worker from the starting point of an autonomous industrial mobile manipulator. The cobot is applied on the industrially relevant task of screwing by the use of a skill-based approach. The technical work on the human-robot interface and the screwing skill is described.

Keywords: Collaborative Robot; Skill-based Programing; Maintenance Task; Screwing Operation; Intelligent Manufacturing; Industry 4.0.

1. Introduction

The field of production is continuously developing and seeking new means and strategies for faster, more affordable, and flexible automation. Over the last years, the fourth industrial revolution has been responsible for...
introducing novel ideas and establishing concepts that shape the smart factory of the future [1]. One of the pillars for flexible automation in the Industry 4.0 era is the integration of the collaborative robots. The concept of collaborative robots introduces new fields of application for industrial robots and allows them to work in close proximity with humans.

1.1. The field of collaborative Robots

The field of collaborative robots has been widely investigated, however, it has yet to be exclusively defined what type of robot can be specified as a collaborative one. Even with a multitude of products currently available [2, 3] and after the completion of many research projects [4, 5], the definition of a collaborative robot remains unclear.

According to SICK Sensor Intelligence the interaction between human and robot can be classified as one of three. "Coexistence" is the lowest level of interaction, where the human and the robot work together to carry out a process but does not share the workspace and work pieces are transferred between the workspaces. The second level is "cooperation"; the workspace is shared but is rarely used or entered concurrently and the robot and the human are not executing operations in the workspace simultaneously. The last and highest level is "collaboration", in which the workspace is shared and both parties can carry out operations simultaneously [6].

The authors of this paper accept as the most precise the definitions provided by the German Institute of Occupational Safety [7] and the Technical Specification ISO/TS 15066:2016 [8]. According to the former, cobots are defined as: "Collaborative industrial robots are complex machines which work hand in hand with human beings. In a shared work process, they support and relieve the human operator". Furthermore, the Technical Specification states that a collaborative robot per definition shares a workspace. This requires an industrial manipulator, which is able to work safely and without endangering or injuring the human operator. Robots designed for this purpose, utilise force/torque feedback in their joints in order to stop their operation when collision occurs and they are often designed with rounded edges to minimise damage in case of potential collision. Typical examples of such design and technical considerations are the UR3 and LBR iiwa7 R800 from Universal robots and KUKA respectively.

However, the definition above is not an exclusive definition, and in earlier works cobots have been classified differently [9, 10]. Using the classification by SICK this work strives to develop a system for safe human-robot collaboration. Safe interaction between a human and a robot derives from the need for more efficient, flexible and productive industrial cells, as well as for reduction of heavy workload and occupational stress for the human operator. This can be achieved by simplifying the execution of the robot’s tasks in the manufacturing industry, under human guidance [11].

1.2. Human-Robot Interaction

As an ideal case one should consider the case where a human and a robot are working continuously and coherently on one or more work pieces. The human operator is working alongside the robot sharing the workspace as well as the necessary operations while both seemingly intuitively recognise and adapt to the movements and operations of each other enabling mutual support. This collaboration would be of great value for improvement of manual labour that is difficult, unhealthy or disadvantageous to automate entirely.

In order to enable such advanced collaboration between a human and a cobot two technical aspects are essential. The first being sensor inputs enabling the robot to recognise and adapt to the presence of the human, and the second being a human robot interface enabling easy communication between the two parties. In relation to sensor inputs, the presence of force/torque sensors alone in the manipulator is inadequate. Other types of sensors such as depth/distance sensors and thermal cameras able to monitor the working environment are necessary. The second aspect can be addressed using means such as sound, visual instructions, voice control, or an intuitive graphical user interface (GUI). The latter is considered in this work as one of the key technologies in relation to collaborative robots. Also, the need of an intuitive human-robot interface is emphasised by the fact that cobots most likely will be applied in working areas of shop floor workers with none or sparse insight into how such robots operate.

Researchers have already been investigating ways to enable robot novice shop floor workers to handle and program robots. In literature, several examples of “learning from demonstration” approaches for programming can be found [12, 13, 14]. Additionally, similar method is used in the teaching phase in the Skill-Based System
دریافت فوری متن کامل مقاله

امکان دانلود نسخه تمام متن مقالات انگلیسی
امکان دانلود نسخه ترجمه شده مقالات
پذیرش سفارش ترجمه تخصصی
امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
امکان دانلود رایگان ۲ صفحه اول هر مقاله
امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
دانلود فوری مقاله پس از پرداخت آنلاین
پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات