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On a human and dual-arm robot task planning method

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Abstract

This paper proposes a method for task planning in a hybrid assembly cell which includes both Humans and Robots (HR). A model is structured addressing in a unified manner both humans and robots as the cell's resources. The sequence of the HR tasks is structured in three levels. The evaluation of the alternative HR task plans is based on multi-criteria, such as average resource utilization, mean flowtime, ergonomics etc. The proposed method is implemented into a graphical software tool and is applied to an automotive case study, comprising a dual arm robot and a human operator.

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Keywords: Human;Robot;Planning.

1. Introduction

The Human-Robot (HR) cooperation in hybrid production lines enables the reduction in production cost, the improvement of product quality and the addressing of ergonomic issues [1]. The HR task planning aims to improve the efficiency of manufacturing and assembly processes, in order for high levels of adaptability and robustness to be achieved [2]. The multi-arm robotic systems, cooperating with humans in a production environment[3, 4], allows for space saving in the shop floor, the simplification of the gripping devices and the reduction or even replacement of the fixtures required for complex parts.

An extended review of hybrid assembly lines, design approaches and simulation models is presented in [5, 6, 7]. The problem of modelling human assembly tasks and their scheduling was presented in [7, 8], while research efforts have been done also in HR task planning [8, 9, 10, 11, 12, 13].

This study presents a task planning method, where humans and robots share tasks according to their capabilities. Difficult assembly tasks require dexterity and flexible handling, traditionally connected to human-like capabilities. Tasks that require repeatability, heavy load lifting and accuracy are mainly assigned to the robots. The introduction of a multi-arm system allows easier automation of these tasks and the reduced complexity in the hybrid production cell. The proposed approach is described in section 2, while section 3 summarizes the automotive industry case study where the method is applied. Results, conclusions and future work follow.

2. Approach

A generalized model is proposed for the hybrid cell representation including both humans and robots as resources simultaneously (Fig. 1 a). As regards the human operators, each individual human is considered as a resource, while in the case of the single arm robots, each arm is consider as a resource as well. As regards the dual arm robot system, each single arm constituting the dual-arm robot is considered as a unique resource that can be assigned to a task. At the lowest level, the grippers and tools that are used by the individual resources are considered as part of them.

The model of the HR workload represents the total work that will be executed in the hybrid production cell (Fig. 1 b). In this context, the workload can be considered as a production plan. The workload consists of different processes, of which each one is broken down into tasks. A similar approach to the HR workload decomposition has been followed in [3].

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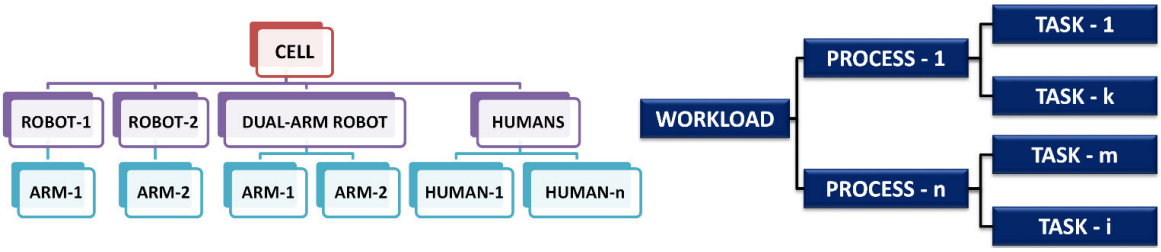

Fig. 1. a) Hybrid cell model; b) Workload model.

Taking as input the tasks and the resources, what follows is the question as to which resource will execute a particular task. The model of the tasks and the resources is required, as well as the pre and post conditions between the tasks for ensuring the correct sequence of tasks to be considered. The alternatives are determined based on the suitable resources per task. The resources suitability is decided upon the payload, the capability of handling flexible equipment and parts, the number of arms that is required for a task etc. The alternative task plans are then generated.

Multiple criteria are considered for evaluating the alternatives. Each criterion is described with a relationship, depending on the application. A total score is calculated for each alternative. The alternative with the highest score is selected as a solution. A Gantt chart with tasks is generated. The re-planning of the existing tasks is possible. The described approach has been implemented software-wise with the help also of a Graphical User Interface (GUI), allowing the planning and re-planning of HR tasks.

3. Case study

The proposed method was applied to a hybrid assembly cell (Fig. 2) for the assembly of a vehicle dashboard, in the automotive industry. The cell consists of a dual arm robot and a human (Fig. 2). For this work [2], some tasks can be carried out by a human and some others by the dual arm robot. The loading and assembly area (Fig. 2) are used for the picking up and the placement of the traverse (weight~12 kg).

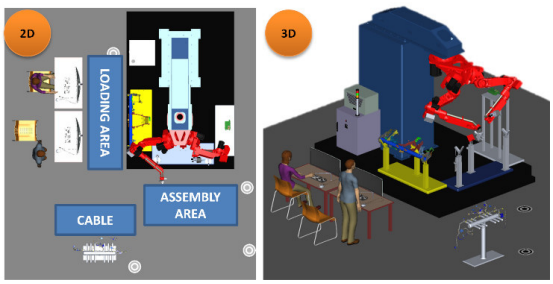

Fig. 2. Dashboard hybrid assembly cell layout.

The fuse box is the next part to be assembled in its final position, in the traverse slot, with the help of three screws for stability reasons. The cable pack is the last part to be installed and is quite flexible. This work is a typical case for combined HR cooperation. The hybrid cell model (Fig. 3) and the workload model (Fig. 4) are used as an input to the decision making framework. The work load includes four processes, namely the placement of traverse, the placement of the computer body as well as the cable pack preparation and installation.

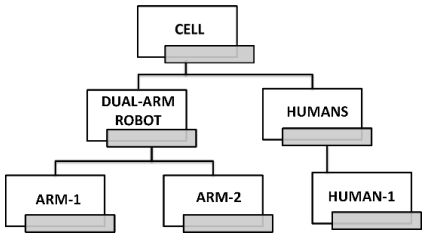

Fig. 3. Dashboard hybrid assembly model.

These processes comprise a number of tasks and a number of suitable resources per task (Fig. 5). The suitability of the resources for a task is decided taking into account the weight of the parts compared to the payload capabilities of the resources. Additionally, the flexibility of the parts is taken into account compared to the resource handling capabilities.

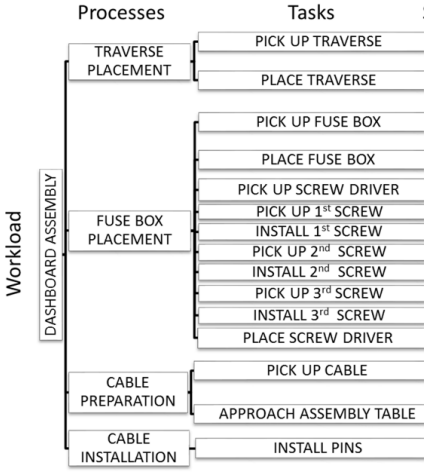

Fig. 4. Dashboard workload model.

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