Methods for the design & operation of human robot collaborative workplaces

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Abstract— This paper reports the deployment of a unified system for the design of hybrid assembly cells and the execution of Human Robot Collaborative (HRC) tasks in them. In the design phase, the HRC workplace layout optimization combined with task allocation techniques may be the springboard for the effective operation of such production systems. In the execution phase, novel communication and interaction techniques are applied for the effective execution of the production process. The analyzed system has been deployed in an automotive case study.

I. INTRODUCTION

The prompt setup and reconfiguration of production cells is needed to include new products and handle dynamic changes at the shop floor. The hybrid production paradigm, where humans and robots coexist and cooperate is a promising concept that combines human skills with robot performance [1]. The design of HRC cells currently asks for considerable time and a team of engineers, robot specialists, designers, system integrators etc. Although, the facility layout problem for robotic systems has been widely investigated ([2],[3]), most methods do not consider the task planning. On the other hand, multiple decision-making frameworks for task planning have been reported ([4], [5]), but most of them focus on isolated machine or manual assembly systems. HRC tasks require means for human operators to safely interact with robots [6]. HR Interaction can be perceived as the exchange of information between these entities and mechanisms for the coordination of production activities are also required [7].

II. APPROACH

The approach of this work includes two phases:

A. Design Phase: Layout & Task Planning in HRC cells

The proposed approach involves the automatic workcell layout generation and task allocation to resources. Multiple user criteria are used to derive alternative solutions for both problems. A unified model for active and passive resources, allowing teams of humans and robots to undertake cooperative tasks is applied. The integration with a 3D simulation tool enables the evaluation of the criteria and the visualization of the result allowing the user to validate it.

B. Execution Phase: Execution controller for HRC cells

Upon the physical set up of the designed cell, a service based controller is used to orchestrate and monitor the execution of the generated task allocation. An Augmented Reality application coupled with a smartwatch interface and the robot controller under a ROS framework allow the human operator to be included in the execution loop, increasing his safety awareness.

III. CASE STUDIES

A. Automotive Case 1: Rear wheel group assembly

The proposed framework has been applied to a robotic cell, with a high payload robot (COMAU NJ130) that loads a 25kg vehicle axle on a fixture and cooperatively handles an 11-kg rear wheel group. The operator adjusts the parts’ position and performs assembly of the wheels and cables.

B. Automotive Case 2: Damper assembly

The same method is extended towards new assembly paradigms [8] that involve multiple mobile resources able to perform multiple operations (handling, screwing etc.) for the pre-assembly and compression of a vehicle damper.

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REFERENCES


