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Representative Model of a Collaborative Workstation

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Introduction

A model of a robotic workstation will be presented where an operator and an industrial robot are expected to collaborate to carry out manufacturing operations such as assembly tasks. Such workstations are also referred to as Collaborative workstations. The model is the result of an analysis of two laboratory workstations what was developed to demonstrate safety strategies for collaborative workstations.

The two laboratory workstations are:

1. Hand-guided assembly of a Flywheel Housing Cover and

2. Collaborative assembly of Under-body panels. A distinguishing feature of these demonstrators is the use of large or traditional industrial robots that have significant reach and payload capacity relative to robots developed and marketed as Collaborative Robots.

The presented model has similarities to that described by Hales. Hales noted that physical, procedural and personnel are three aspects that must be addressed when planning an assembly cell. The presented model aims to describe a collaborative workstation in terms of workspaces, tasks, and interaction. These three constituents can be considered by system designers when planning and designing a collaborative workstation.

Model of a Collaborative Workstation

A model could be understood as a representation of a system using general rules and concepts [1-7]. A model that describes a collaborative workstation Figure 1 can be represented in terms of Workspaces, Tasks and Interaction. The model is based on the notion that there are two resources the operator and an industrial robot to which tasks can be delegated to fulfill the function of a collaborative workstation (Figure1) [8].

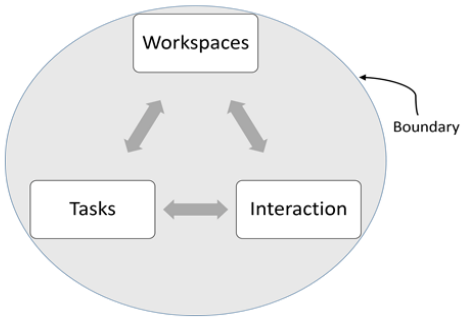

Figure 1. An illustration of the three elements of a collaborative workstation, which are workspaces, tasks and interaction.

Workspaces

Workspaces are physical spaces allocated to install machinery and/or perform tasks. The physical workspaces can be conceptualized as collaborative, operator, and robot workspaces. It can be noted that these three workspaces together form the limits of machinery which is the first step in carrying out risk assessment according to ISO 12100 [9].

A Collaborative Workspace is a common workspace for the operator and the robot to perform the allocated tasks during production [10]. A Robot Workspace can be understood as the spatial limit for the robot to carry out delegated tasks and are safeguarded appropriately. Within this workspace, the robot can be programmed to move at speeds significantly faster to meet production demands. An Operator Workspace is allocated to the operator to safely carryout operator specific tasks. Within this workspace, the Operators can monitor the robotic system and have access to functions related to the system (e.g., emergency stop, HMI).

Tasks

The assembly task can be broadly distinguished as collaborative, operator, and robot tasks. It is valuable to highlight that tasks delegated to a robot, regardless of the intended spatial location, are a set of preprogrammed instructions. Similarly, operator tasks are predefined and carried out by an operator. The operator and the robot tasks are those delegated to the operator and the robot, respectively. They are explicitly defined to be carried out within the operator and the robot workspaces. The robot and operator tasks designed to be carried out at the collaborative workspace are the collaborative tasks. The term collaborative task is introduced for clarity in discussing interaction and safety. In certain applications such as hand-guided operations, collaborative tasks may require that the two resources (Operator and robot) synchronize to complete collaborative tasks. Synchronized behavior is not a necessary condition as collaborative tasks can also be defined in a way that the operator and the robot are not at the collaborative workspace at the same time.

Interaction

Interaction refers to the act of communication between two participants that intended to collaborate. In human-robot interaction, this is enabled by interface technologies such as displays, gesture and voice control, buttons, and lamps etc. Interaction between two resources (Operator and robotic system) are needed when the tasks are designed that require them to move from their respective workspace to the collaborative workspace.

In practice, modes of operation can be defined, such as collaborative mode that requires operator or the robot to move their respective workspaces to the collaborative workspace and vice versa [11]. A change in state

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from normal operation to collaborative mode needs to be communicated effectively. A lack of awareness of a change in state has been recognized as a safety issue by ISO 10218-2 [12]. That noted and change point between autonomous operation and collaborative operation is a particularly critical part of a collaborative application. It shall be designed in a way that the robot cannot endanger personnel when changing from the autonomous operation to the collaborative operation and back to the autonomous operation.

Final remarks

A conceptual model was presented with Workspaces, Tasks and Interaction as constituents that represent a collaborative workstation. The practical purpose of this model is to support system developers in identifying and configuring a functioning collaborative system. That is, it can support designers by acting as a reference that forms the basis for activities such as: 1. plan and motivate design requirements for robotic systems; 2. identify and mitigate potential hazards; and 3. Specify safeguarding measures that meet regulatory requirements.

Conclusion

A logical set of workspaces (operator, robot and collaborative workspaces) can guide designers to define tasks to the two resources, i.e., the operator and the robot. The tasks are specified in a manner that takes into account the essential characteristics of the two resources and can be organized to achieve the goal of the workstation. The interactive element encourages system designers to develop the sequence of tasks, supported by feedback devices, that easily enables the operator to synchronize with the robotic system, thereby achieving production goals efficiently and safely.

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