A Library of Skills and Behaviors for Smart Mobile Assistant Robots in Automotive Assembly Lines

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Introduction

In the automotive industry, market demands tend to require more variants of products while life cycles become shorter. This means an increasing complexity in automotive assembly lines. Therefore, flexible assistant systems will be needed in the future to optimally support human workers. Assistant robots will not follow fixed, repetitive sequences anymore, but logical behaviors based on the interpretation of different sensors. To manage the complexity of such robotic systems, skill-based programming is a common approach [1]. A library of skills for human-robot collaboration is developed and behaviors are introduced as additional module in a skill framework that allows intuitive programming of smart robots.

Methodology

An extension of common skill frameworks by a set of behaviors for direct human-robot interaction is proposed (Fig 1). This extension is required, since primitives in skills are executed in sequence and only one skill is performed at a time. But while executing a skill, the robot still needs to monitor its environment and react instantaneous to movements of the worker [2]. Therefore behaviors are introduced as a set of functions and profiles that run continuous on the robot, parallel to the execution of primitives.

Furthermore, existing workplaces, where people are working in teams, are analyzed in order to build a library of skills needed by robots collaborating with humans. Categories of manual work as provided by MTM-UAS (Measured Time Methods – Universal Analysis System) are taken as base for the skill library [3].

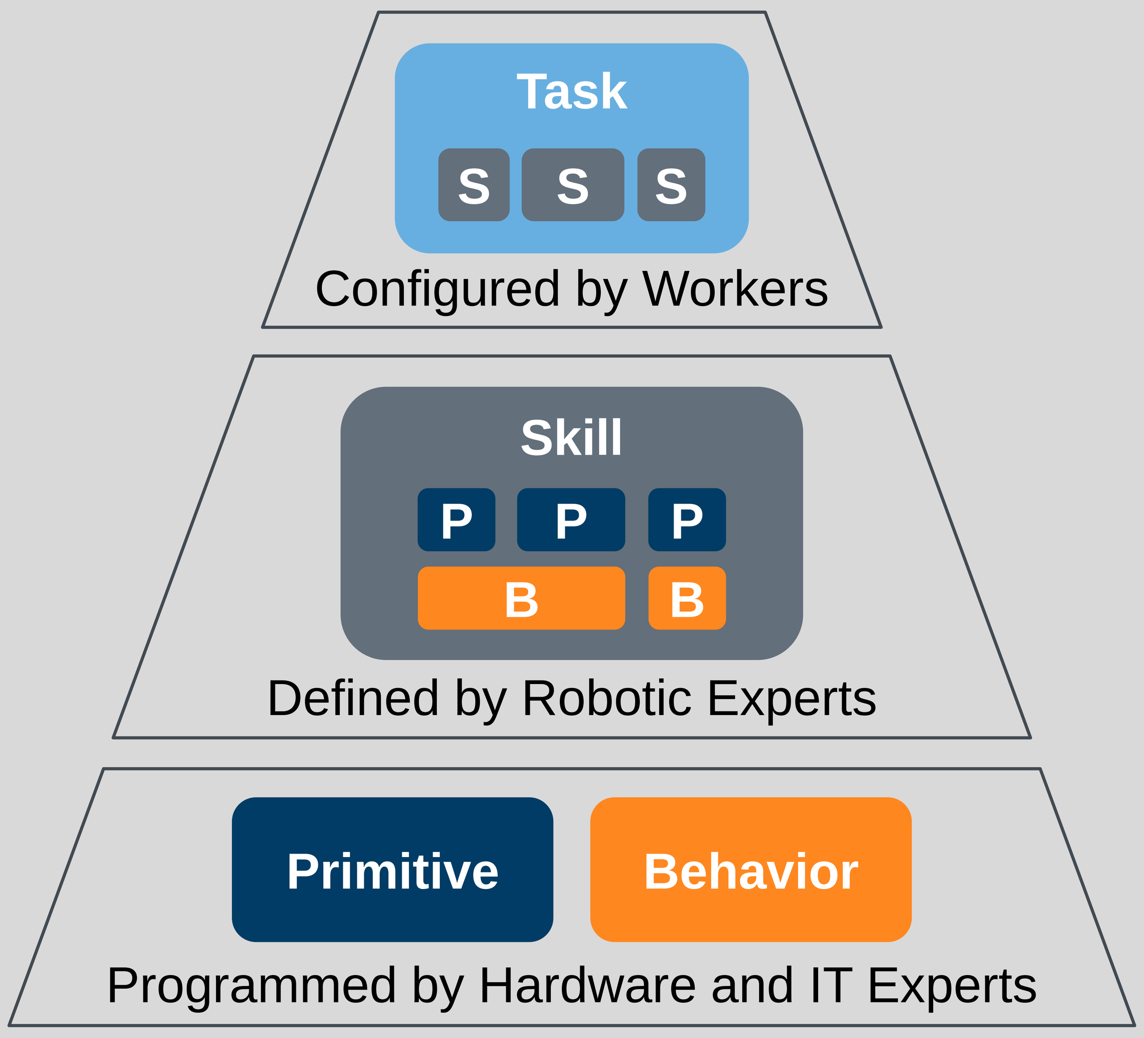

Fig 1: Skill framework organized in three layers of Abstraction, adapted from [4].

Results

In total,13 elementary skills are identified that are necessary to perform the majority of tasks in automotive assembly lines. From the categories of MTM, 7 skills are adapted: The skills *Pick, Place, Move (along a predefined path), Navigate (walk or drive to another location), Wait, Handle/Apply Tool,* and *Trigger* are known from standardized work descriptions and have also been used for programming conventional robots. This group of conventional skills is extended by 6 skills adapted from the analysis of interaction in human teams and mainly refers to the sensitivity of the robot: The skills *Position*, *Hold*, *Align*, *Apply Force*, and *Apply Force along Path* are integrated in the library enable the use of sensitive functions and forces, which are often needed in assembly tasks (e.g. mounting of parts with tight tolerances). Other, more sophisticated skills can be represented as combinations of the elementary skills.

The integration of behaviors in the defined skills and their combination with the execution of primitives enables the robot to perform skills in human-robot collaboration (Fig 2). Simple behaviors are for example different *Speed Modes*. If the robot provides force control, additional behaviors are the *Compliant Mode* or the *Collision Detection.* Behaviors are mainly dependent of the robot's sensors and the capability to interpret its environment. The set of behaviors is therefore extended the more sensors and functionalities are provided by the robot.

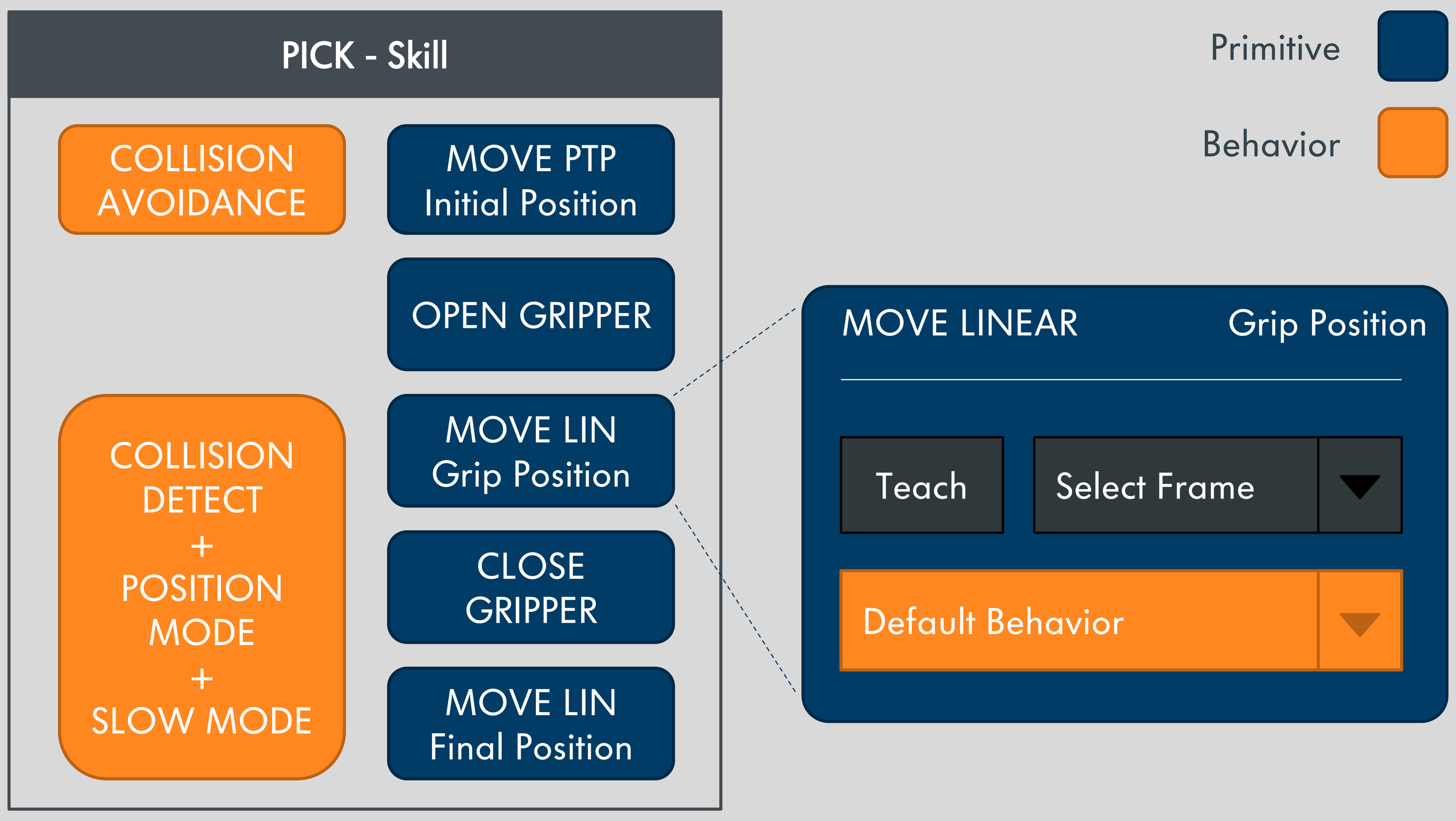

Fig 2: Definition of a pick-skill using primitives and behaviors.

Conclusion

A library of 13 skills has been introduced for the easy configuration of robotic assistant systems in automotive assembly lines. The need of new frameworks that allow the integration of behaviors and more detailed development of Skills is shown. Also skills for other Industries have to be developed in future work.

References

[1] A. Bjorkelund et al. On the integration of skilled robot motions for productivity in manufacturing. *IEEE International Symposium on Assembly and Manufacturing*. 2011.
[2] J. De Gea Fernández et al. iMRK: Demonstrator for Intelligent and Intuitive Human–Robot Collaboration in Industrial Manufacturing. *Springer Nature SharedIt, KI - Künstliche Intelligenz. 2017.*
[3] J. Teiwes et al. Identifying the Potential of Human-Robot Collaboration in Automotive Assembly Lines using Standard Work Description. *IEEE Int. Conf. on Automation and Computing*. 2016.
[4] M. R. Pedersen, et al. Robot skills for manufacturing: From concept to industrial deployment. *Robotics and Computer-Integrated Manufacturing*. 2015.

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