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Programming and control for skill-based robots

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This paper considers programming and control of skill-based robots. Robot skills are used to integrate and synchronize robot actions and sensor data in a consistent way. Skill-based approach provides a framework for configurable robot systems, enabling quick setups and start-ups of applications. In the paper we will introduce skill programming and skill control concepts in more details, and how they relate to usage of models and sensors (see Figs 1 & 2).

Skills are based on proper parametrization, where a set of inputs will define the whole structure of a program. Skill parameters vary with different actions: they should define the actions for all the components in a robot system (including the robot, sensors and control systems). Skill parameters can be phase dependent locations/points, poses, object ID and so on. Skills can be hierarchic and at the lowest level, there are atomic actions representing device interfaces or API functions.

The control architecture (see Fig 2) is based on proprietary and open interfaces, the latter of which are based on ROS. Proprietary interfaces are implemented for connecting devices, i.e. sensors and robot and data interfaces with ROS. Key functional components include an Object Detector component and a variety of 3D Point Cloud acquisition components (or Point Cloud sources), based on 3D cameras (based on time-of-flight or triangulation) or cooperation of a set of motion provider components (robots, transfer axis and conveyors) together with 2D laser profiler sensor components. Crosswise usage of these are supported over ROS based interfaces for 3D Point Cloud sources and 2D profiles.

As a case example, all the skills required for task “grinding with localization” are introduced. It consists of lower-level skills such as global localization with 3D-depth sensor, precise (local) localization with 2D-profile scanner and straight seam grinding. Skills are independent from each other, which means that they can be more easily used in a different task. All the designed skills are programmed in an off-line programming tool called RoboDK and implemented in a robot cell composed of KUKA KR120 R2500 PRO industrial robot with grinding tools and all the necessary sensors. With the developed skills, re-programming the paths for other seams can be made with less effort and implemented faster. Results of the grinding can be seen in Fig 3.