INTUITIVE PROGRAMMING

Application of Industrial Robot Systems in Small Businesses
Challenge: Industrial Robots for Small Businesses

Due to their complexity and the corresponding programming effort, industrial robots are currently not used to their full potential, especially in small and medium-sized enterprises (SME).

The requirements of such companies are typically driven by lot size one or small lot production and short product cycles; this necessitates frequent adaptation of programs.

Robot programs written in manufacturer-specific languages are esoteric and often only comprehensible by the original programmer; a reference to the actual task is not often possible.

Alternative programming environments that are integrated with CAD solutions enable an easy definition of robot paths based on CAD data. However, the explicit specification of the intended tasks are not supported.
A possible solution for SMEs is provided with the introduction of alternative programming concepts based on current research, that enable a domain-specific process and task definition in a language familiar to an end-user.

For example, a welding expert would like to have the possibility to specify a weld seam in an easy and graphical fashion, including a specification of required parameters like temperature. For an assembly operation, the specification of geometric constraints between objects, as in CAD programs, is significantly easier to comprehend than the teaching of individual positions and orientations. The picture on the right shows an example from an assembly specification for aluminum parts, that can be directly used for the definition of the executable program. An expert can specify the assembly with geometric constraints between parts and instruct the task in this domain-specific language.

Essential for execution is the link between this definition and the available tools, as well as their grasp pose and fixation to the robot. Programming is intuitive when not all details have to be specified and open issues can be solved intelligently by the system. For this purpose, the system must be equipped with appropriate domain-specific knowledge and common-sense knowledge. Human workers naturally possess this kind of knowledge and due to this, they can easily determine whether a part is on the table and within the working area of the robot.

In order to understand this, the system must incorporate knowledge about the positions and sizes of individual objects as well as the kinematics of the robot. A task from a specific domain must be described semantically (content and context) in a similar fashion in order to support underspecified tasks. For in-
stance, a welding task requires a different tool than an assembly task.

This can be specified explicitly for the system by using semantic modeling. With the availability of semantic information, certain inputs can be tested automatically and the cognitive system can provide support to the programmer while writing the program specification.

In order to define the task in a more suitable language, the end user is provided with an intuitive interface. Such a domain-specific user interface can be used to specify an assembly process and its individual tasks. The task specification directly maps to the execution of the process/program on a specific robot system.
Further steps toward a natural interaction concept and a natural learning between a domain expert and a robot system are possible. Input and output modalities for intuitive programming are not restricted to sequential input and graphical or web-based interfaces, but can be extended to include further sensors such as camera-based object recognition, flexible gesture recognition, or additional output channels such as visual feedback through projection on a table’s work area (augmented reality). The integration of multiple input channels enables a more robust processing of input signals.
Human-Robot Cooperation
Semantic Modeling of Processes
Multimodal Input/Output Concepts
Augmented Reality
Interaction Management
Domain-Specific User Interfaces
User Studies
Dialog Management
Kinematics, Dynamics, and Trajectory Calculation
Real-Time Control of Robot Systems
Collision Avoidance and Path Planning
Software Engineering for Robotics
Service Portfolio

Professional training for small businesses regarding current developments in programming of industrial robots

Customized workshops about topics regarding the use of industrial robots in small businesses

Support in selection and operation of robot software solutions

Design and implementation of innovative software solutions for robot control

Scientific evaluation and benchmarking of robot software and service solutions

Initiation and realization of research and transfer projects in Bavaria, Germany, and Europe