WP2 Advanced Process Control and Predictive Maintenance

The objective of this work package is to develop knowledge, tools and concepts for automated high-performance manufacturing systems through focusing on advanced process control and intelligent predictive maintenance of production equipment.

Current activities in the work package are:

- **Real-time Interfaces to Robots**
- **Sensor-based Real-time Robot Control**

Real-time Interfaces to Robots

Most industrial robots ship with controllers that do not allow real-time control from an external control unit or PC. They have a fixed instruction set which can be used to program the robot, often including options for communication via a serial line or a TCP socket to receive control information and to communicate robot and controller states, for example when a programmed position is reached. This is sufficient for pick-and-place operations, but not for real-time control of these robots. With the advent of research into real-time interfaces of robots, some robot manufacturers have opened their controllers for real-time control on different levels. These are for example joint position and/or joint velocity control (Universal Robots, KUKA FRI), Cartesian position control (KUKA RSI) or torque control (KUKA FRI).

The project work aims at the layer between the commercial robot, either with an integrated real-time interface or selfmade interfaces, and the application layer, especially for robots using position or velocity-based interfaces. To control a robot from an application, an access stack has to be built, including filters and programs which ensure that the robot gets required position data before its internal deadline. In cooperation with a colleague, a framework has been developed to access different industrial robots and control them from PC applications.

Sensor-based Real-time Robot Control

This part of the project deals with sensor-based real-time control of robots. Examples are test cells where sensor data is used to control the robot instead of off-line programming of the robot trajectory, which is not possible for industrial processes like sewing where the robot has to interact in real-time with its environment. The aim is to build flexible and robust process control applications which are easy to reconfigure, for example when a new part type is introduced in the production cell. To control such processes sensors have to be used to observe process variables such as work piece positions and orientations, forces etc.

In the research sensors are used to control industrial robots in real-time. A main focus is the analysis of delays in the control loop and how they influence the behavior of the system. Another focus area is real-time process monitoring and control with unknown conditions, for example unknown work piece shapes or flexible materials.

A case in this research activity is an automated sewing cell that is mainly developed in a BIP project with Ekornes. The cell consists of two

industrial robots and a sewing machine. The goal is to build a system that is able to sew together different textile parts and to control this process in real-time. To achieve this, force sensors are mounted on the robots and an edge detection sensor is mounted in front of the sewing machine. Experiments verify the feasibility of such a control system and show the need of further research in the field of real-time handling of work pieces and processes with non-predictable behavior.