3DSSC (3D Smart Sense and Control)

Deliverable D3.1

Final Demonstration

3D Smart Sensing and Flexible Task Programming for On-Line Trajectory Adaptation in Fast Surface Treatment

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1 Experimental System

As it is also described in the bimonthly reports, the final phases of the project are developed and carried out on an industrial robot (KUKA KR16). The following figures demonstrate the developed experimental setup.

Figure 1: Experimental setup using KUKA KR16.

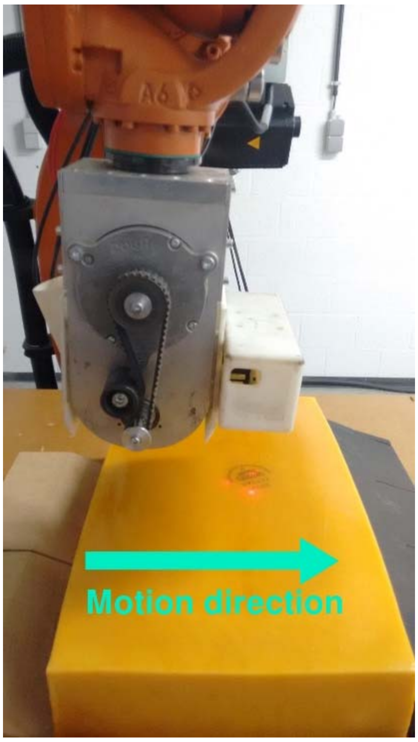

Figure 2: Experimental setup using KUKA KR16

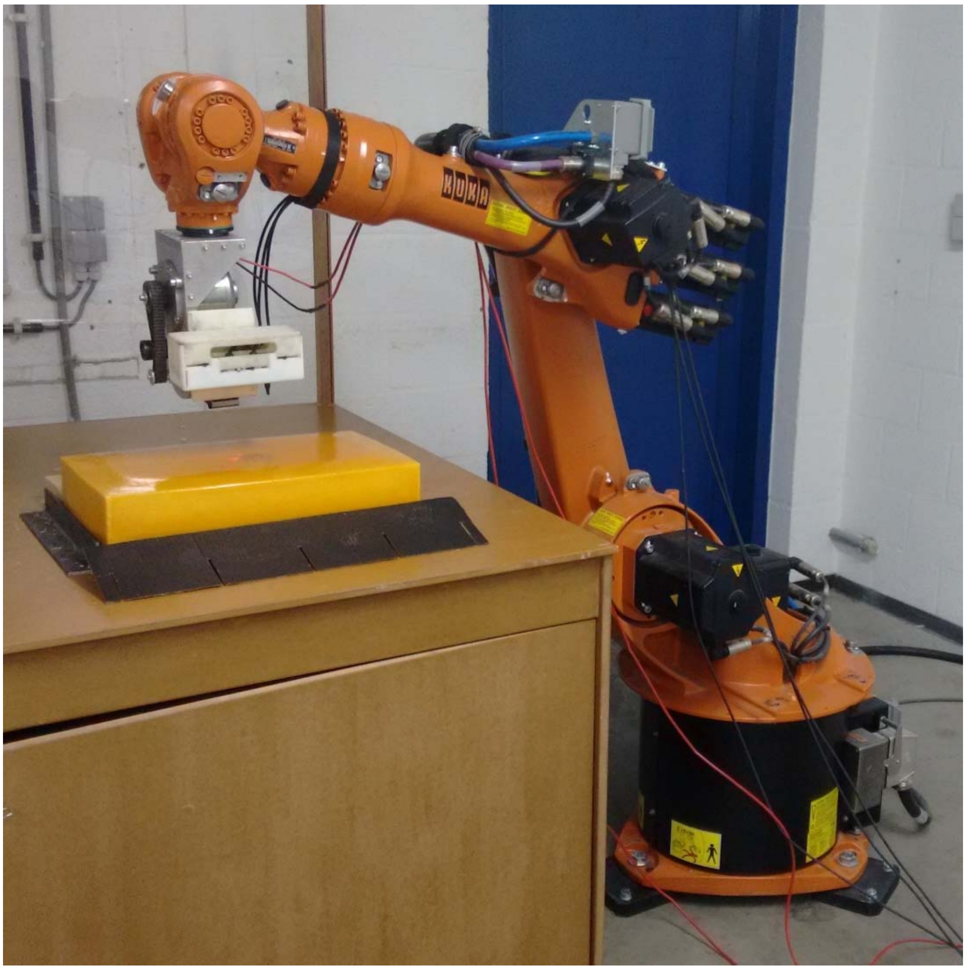

Figure 3: Experimental setup using KUKA KR16

In addition, the robot is also visualized and simulated as it is shown in the image below.

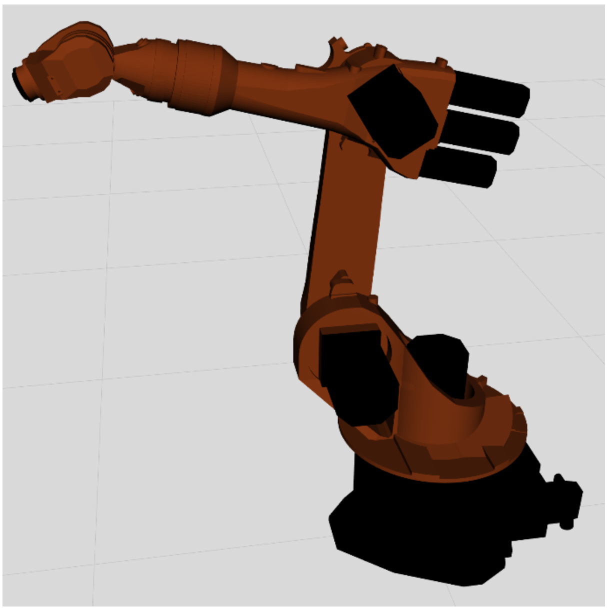

Figure 4: Visualization of KUK1 KR16 robot in simulation environment

The developments on an industrial robot and the implementation of the control strategy using the state-of-the art task specification language (eTasL [1]) make this project unique in its kind.

Furthermore: 1) we were able to select the robot with the appropriate specifications (payload and reach), 2) we were able to select the robot with a fast and high quality interface with our control computer, 3) we have good connections with the robot manufacturer to assist us with the interfacing, and 4) the developer of the task specification environment, eTasL, was a member of our team. Therefore, developing the experimental results in a robotics innovation facility (RIF) in this project was not necessary (this is also mentioned in the RIF report deliverable)

2 Coating removal

The coating of a cheese block is removed using the developed methodology. A multimedia report is available at the following location: https://sway.com/qlE13OUl5YaVpc3v , where the robot removes three strips of the top surface of a cheese block. A small view of this task is shown below:

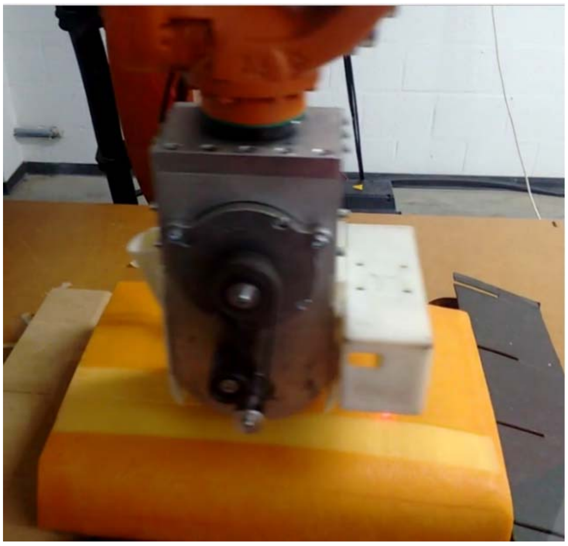

Figure 5: The robot motion on the cheese block while removing the coating.

The presented video shows the robot removing one [mm] of the top surface of a cheese block. During the milling process, the robot moves with an average velocity of 200 [mm/sec] in three [sec]. Since the laser sensors need to be ahead of the robot while moving on the surface (to provide a real-time model of the surface), de-coating the next strip requires the robot to travel back to the beginning of the block (40 [mm] next to the previous strip). In the presented video, the return trajectory is performed in five [sec] with one [sec] delay on each side of the block for safety reasons

3 Project Objectives

The first objective of this project is related to the experiment and scenario where a common industrial robot with a real-time PC interface is equipped with smart 3D sensing to perform a new task. The developed prototype was then expected to perform not more than 30% slower than a skilled worker. An operator using a plane tool can remove the coating in around 90[sec]. The presented results of the developed test setup suggest an operation of around 120[sec] for the robot which is around 30% slower than an operator. We would like to emphasize that there is still room for improving the planing speed.

Another important aspect of automation of this task is higher accuracy of de-coating the cheese block. When an operator uses a plane to de-coat the block, the amount of cheese loss is around 6%. Using the technology developed in the 3DSSC experiment, the loss is around 3-4%.

Another objective of this project is the focus on research where the benefits of a system architecture, control software and the Orocos RTT real-time software are shown. eTasL converts the task specification and control strategy to a straightforward operation where different performance specifications are reliably translated to an optimization problem and rapidly solved. eTasL provides a rather simple syntax to define constraints with different priorities and weights.

Even though, this first prototype is not up to an industrial standard yet, the methodology is reliable enough to be extended to a fully automatic system meeting the requirements of the food industry.

Next steps (beyond the scope of the 3DSSC experiment)

We are currently working on evolving this technology by increasing the milling speed and improving the control/ estimation algorithm. We are in negotation with 2 potential customers.

References

[1] E. Aertbeliën, J. De Schutter, eTaSL/eTC: A constraint-based Task Specification Language and Robot Controller using Expression Graphs, proceedings of the 2014 IEEE/RSJ International Conference on Intelligent Robots and Systems, Chicago, 2014.