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Spatial Control of High Speed Robot Arms using a Tilted Camera

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Usual programs of industrial robot arms require accurate knowledge of the world. But there are potential applications in which the position and orientation – and sometimes even the shape – of the workpiece are subject to big uncertainties. Then a universal sensor is essential, which on the one hand supports high accuracy requests typically less than a millimeter, and on the other hand allows control at high speed e.g. 1 m/s. In addition, for industrial use a cost-effective hardware is desired.

In our paper we show that a standard CCIR camera mounted on a robot with an appropriate control architecture meets these demands. We present a method to control robot paths, sensed in real-time from lines or edges which are parallel to the desired motion. Time delays owing to processor load or to a usually low image rate are tolerable as long as the instant of exposure is known.

This is possible since we use a predictive architecture which separates positional control from the sensing of the desired path. Positional control might be improved using a dedicated control system published earlier, for which the sensed part of the desired path is represented by the poses at different sampling steps. Alternatively any positional controller will do, then maybe with a small degradation of path acuracy.

The sensed desired path is updated at 50 Hz using a robot mounted camera which measures the lines nearby. The image points of a line are represented by a polynomial in the image space. One or two of such lines are used to compute a polynomial representation of the desired path in the working space. This implies that some a priori information is used. If only one line is used, the distance of the line is required. If two lines are used the distance is sensed from the spacing between them. Our approach considers a camera that is mounted lateral to the tool center point and tilted with respect to the task frame. This complicates the equations.

Nevertheless we are able to modify the location and shape of a robot path online in 2 dofs. We show experiments using a KUKA KR6/1 robot with spatial paths and varying orientation. Remaining control errors are below 1 mm at a nominal speed of 0.7 m/s. In order to guarantee low costs, image processing, computation of the desired path, and dynamical control are executed using only the standard hardware of an industrial robot controller, in our case the KUKA KRC1. This way we demonstrate practical applicability of cameras for accurate control of high speed motion.

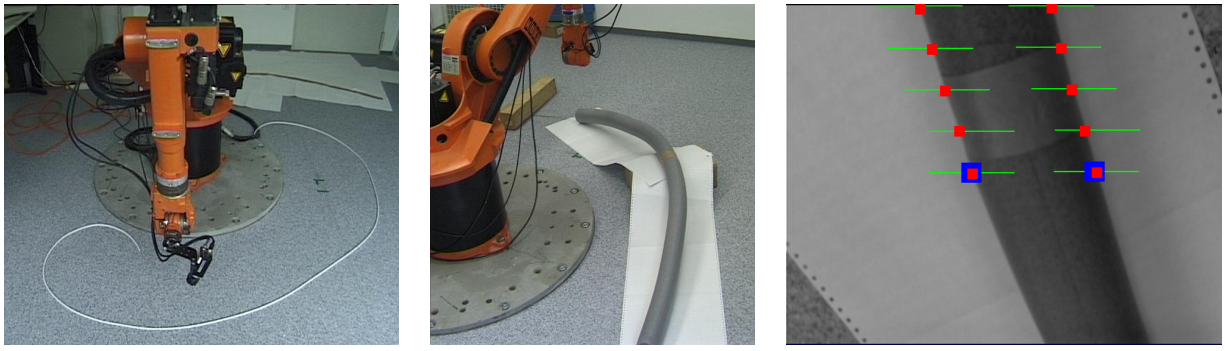

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Figure 1: Sample tasks with natural and artificial background and view from the robot mounted camera