The Faculty of Engineering

POPULAR SCIENTIFIC ABSTRACT

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[Easy Programming of Robotic 3D Surface and 3D Curve Processes]

In our current fast-moving world, where small-batch production is becoming increasingly popular, the set-up time when introducing new work pieces into robotic manufacturing processes also must become smaller and smaller. The traditional programming styles using a teach pendant and discrete data points are too slow and tedious, and require unnecessary long downtimes in the production cells while the robots are being programmed. In collaboration with two Danish manufacturing companies, Bang & Olufsen FACTORY 5 and VOLA, we will therefore, in this thesis, present an interface and pipeline, based on the concept of off-line programming for automatic robot program generation.

Contrary to existing off-line programming approaches, the pipeline and interface we present in this thesis are not tailored for a specific manufacturing application, but provide a common interface for general 3D curve and 3D surface processing. In the presented work, we import Computer-Aided Design (CAD) data in the form of STL files, which is the most common CAD format.

The extraction of necessary information from the STL files in the form of discrete corners, curves and surfaces is then outlined. We then present an approach for modeling the discrete curves with parametric continuous differentiable cubic non-uniform rational B-spline (NURBS) curves, for which we describe an approach of embedding the curves with an orientation, in the form of quaternions. The created NURBS curves function as our robot trajectories in the pipeline and can be extended to accommodate approaches and departures to and from the work piece.

We then present an approach for approximating the NURBS curves with linear and circular segments to be executed by standard robot controllers. Inverse kinematics is used to verify that the segments can be executed by a specified robot, along with collision checking of the paths in the work cell, before being made into robot programs and executed on actual robots.

For surfaces, we present a method for modeling the STL triangles with a parametric continuous differentiable Bezier triangle surface for the extracted discrete surfaces. Furthermore, we describe how we can deploy a sub-patch extraction scheme to extract parametric continuous differentiable NURBS curves from the Bezier triangle surfaces. These curves represent tool paths on the surface. The extracted NURBS curves for the surface processes, similar to those for curve processes, can then be used in the common interface to create robot programs.

We also present two approaches for correction of the NURBS curves that represent our robot trajectories, to handle the inaccuracies present in the real world, as these often results unusable programs from the off-line programming environments.

The presented pipeline and test interface are showcased in an edge grinding process of a work piece from Bang \& Olufsen and are currently used by a colleague for his research on surface polishing and brushing with VOLA. Examples of these created programs are included in the thesis.