Christian Wortmann
Algorithmische Analyse von rohrförmigen Flächen für das Reverse Engineering

Abstract

This dissertation presents a method for planning the manufacturing of pipes from straight cylinders. On the one hand, this allows for feasibility studies by simulation and analysis of the strain on the cylinder during the manufacturing process. This is done before a pipe is created. On the other hand, planning may be used as input for manufacturing machines used by the industry.

A possible approach is to start with the result, i.e. the desired pipe, to get the initial situation, i.e. the cylinder. This is done by reverse engineering the manufacturing operations. Here the following problems can be determined:

- Integration of pipes, i.e. the approximation of the pipe by a tube. A tube is a deformed and bent cylinder.
- Approximation of spatial curves by circular splines i.e. a G^1 continuous curve which is a consecutive combination of arcs and lines.

This dissertation starts with a mathematical definition of pipes and the needed theoretical basis, for example the definition of part-pipes. Based on this, the pipe-tube-approximation problem is formulated as a multicriterial optimization problem which is orientated at the elastic contours of the image processing.

Two solutions are presented for the optimization problem. The first one uses dynamic programming, the second one is an adaptive segmentation which is a well known approximation method of curves by polygons. The advantage of the adaptive segmentation is the low run-time. The disadvantage is that a success is not guaranteed, in contrast to dynamic programming. Some methods for basic geometrical operations are presented, which are required to achieve an efficient implementation.

Both optimization methods are analyzed. On the one hand, theoretical conditions are presented to guarantee the success of adaptive segmentation. On the other hand, analysis is based on experimental evaluation. It will be shown that both methods yield good results for pipes used in the industry. However, neither provide fully automatic solutions for the practical domain of application. Suggestions are made to handle this complex problem.

The definition of a “U-spline-curve” is presented to describe the curve approximation. The aim of a U-spline-curve is to contain as few segments as possible. Therefore, two heuristics are presented. The first one uses adaptive segmentation which is based on the curvature of the curve. The second one is based on a well known algorithm which creates an arc-spline-curve with a minimal number of segments. It will be shown that both methods yield equal results when applied to pipes used in the industry.