Knot Optimization for B–Spline Curve Approximation

Claudius Schmitt and Hans Neuner (Austria)

Key words: Deformation measurement; Engineering survey; Laser scanning; freeform curve; B-Spline curve; TLS profile approximation; free knots

SUMMARY

Surface based sensors, like terrestrial laser scanner, needs new surface based analysing methods. Instead of the classic point based geodetic evaluation approaches the surface based approximation of 3D point is one of the main issues making the huge amount of information suitable and taking benefits from the redundancy. This can be done by point cloud approximating with freeform curves and surfaces to get parameterized curves/surfaces for further evaluation steps, like the shape information for structural analysis of existing physical objects. In the past it was shown that the freeform shapes significantly improves the approximation quality, instead of approximation with geometric primitives. As contactless surveying metrology the terrestrial laser scanner was deployed to measure a concrete freeform dome built by the civil engineers at the Vienna University of technology with a new formwork technic. To test our approximation method one profile of the panoramic scan from the inside of the dome was used. Continuous parameterized shapes are necessary for the structural analysis. A freeform curve, especially the B-Splines curves, produces such shapes with respect to local behavior of the points. In the past the first parameter set, the control points of the B-Spline, were the only unknowns of the B-Spline approximation. Instead to the second parameter set, the knots, part of the basis functions of the B-Splines, which are determined at fix positions. With fixed knots, the approximation functions ended up in a linear system, but intuitively restrict the B-Spline curve in its flexibility following the profile points. Hence the residuals of the B-Splines approximation contain still systematic effects. However estimating the control points and the position of the knots at the same time succeeds in full flexibility of the B-Splines and optimizes the approximation. The prior mentioned linear equations change to a highly nonlinear system with the aim of minimizing the squared distance between the curve and the profile points. To enhance the convergent behavior, in our case, constraints and adequate starting values are necessary. The constraints are derived from Schoenberg-Whitney theorems. The starting values for the knots are chosen with the bottom up method, beginning by the minimum number of knots and adding one knot at each iteration step at particular curve sections until the convergent criterion has reached. The decision to an insertion section as well as the position of the knot inside is made with the aid of the section residuals. The starting values of the control point are computed from the linear system. The improvements are shown by comparing the results, between the B-Spline approximation without the control points as unknowns, like the models in the past, and the approximation method with the control points and the knots as unknowns.