Engineering Computations

ISSN: 0264-4401
Online from: 1984

Sensitivity analysis in optimized parametric curve fitting

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Citation: Oscar E Ruiz , Camilo Cortes , Diego A Acosta , Mauricio Aristizabal , (2015) "Sensitivity analysis in optimized parametric curve fitting", Engineering Computations, Vol. 32 Iss: 1, pp.37 - 61

DOI http://dx.doi.org/10.1108/EC-03-2013-0086

Abstract:

Purpose
– Curve fitting from unordered noisy point samples is needed for surface reconstruction in many applications. In the literature, several approaches have been proposed to solve this problem. However, previous works lack formal characterization of the curve fitting problem and assessment on the effect of several parameters (i.e. scalars that remain constant in the optimization problem), such as control points number (*m*), curve degree (*b*), knot vector composition (*U*), norm degree (*k*), and point sample size (*r*) on the optimized curve reconstruction measured by a penalty function (*f*). The paper aims to discuss these issues.

Design/methodology/approach
– A numerical sensitivity analysis of the effect of *m*, *b*, *k* and *r* on *f* and a characterization of the fitting procedure from the mathematical viewpoint are performed. Also, the spectral (frequency) analysis of the derivative of the angle of the fitted curve with respect to u as a means to detect spurious curls and peaks is explored.

Findings
– It is more effective to find optimum values for *m* than *k* or *b* in order to obtain good results because the topological faithfulness of the resulting curve strongly depends on *m*. Furthermore, when an exaggerate number of control points is used the resulting curve presents spurious curls and peaks. The authors were able to detect the presence of such spurious features with spectral analysis. Also, the authors found that the method for curve fitting is robust to significant decimation of the point sample.

Research limitations/implications

– The authors have addressed important voids of previous works in this field. The authors determined, among the curve fitting parameters *m*, *b* and *k*, which of them influenced the most the results and how. Also, the authors performed a characterization of the curve fitting problem from the optimization perspective. And finally, the authors devised a method to detect spurious features in the fitting curve.

Practical implications

– This paper provides a methodology to select the important tuning parameters in a formal manner.

Originality/value

– Up to the best of the knowledge, no previous work has been conducted in the formal mathematical evaluation of the sensitivity of the goodness of the curve fit with respect to different possible tuning parameters (curve degree, number of control points, norm degree, etc.).

Keywords: Sensitivity analysis, Minimization, Noisy point sample, Parametric curve fitting, Reverse engineering

Publisher: Emerald Group Publishing Limited

Why is it important?

In many reverse engineering applications, the primary data is a point sample. However, a mathematical smooth representation is needed to express a shape and to execute downstream applications.

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