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Fast B-Spline 2D Curve Fitting for unorganized Noisy Datasets Authors: N El-Hayek ${ }^{1,2}$, O Gibaru ${ }^{1}$, M Damak ${ }^{1,3}$, H Nouira ${ }^{2}$, ${ }^{\text {N Anwer }}{ }^{4}$ and E. Nyiri ${ }^{1}$ 1- Arts et Métiers ParisTech, Laboratory of Information Sciences and Systems (LSIS), 8 Blvd Louis XIV, 59046 Lille, France 2- Laboratoire Commun de Métrologie (LCM), 1 r. Gaston Boissier, 75015 Paris, France
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## Context

1. Optical and Tactile Metrology for Absolute Form Characterization (EURAMET project IND10)
2. Fast polynomial spline curve reconstruction from very large unstructured datasets

## Objective

 Curve reconstruction of freeform shapes, specifically turbine blades, from data with unknown topologyObjective function

$$
\min _{t_{1}, t_{2}, \ldots t_{m}} \sum_{j}\left(\left(\mathrm{M} T_{m}\right)_{j}-\delta_{j}\right)^{2}
$$

$M$ is the subdivision matrix (1)
$T=\left\{t_{1}, t_{2}, \ldots, t_{m}\right\}$ is the control points translations vector

## Discrete B-Spline Convection scheme


$\checkmark$ NO initial parameterization
$\checkmark$ NO differential calculations
$\checkmark$ NO sampling requirements
$\checkmark$ Invariance of final control polygon geometry
to initial position and orientation

## Methodology Coincide new B-Spline curve at iteration (i+1) with data points by minimizing the distances

(1) Subdivision relation

$$
q_{j}^{(i)}=\mathrm{M} C_{m}^{(i)}
$$

(2) Convection equation

$$
C_{m}^{(i+1)}=C_{m}^{(i)}+T_{m}^{(i)}
$$

(3) Solution equation
$q_{j}^{(i+1)}=\mathrm{M}\left(C_{m}^{(i)}+T_{m}^{(i)}\right)$
(i): iteration i
p: Point set
q: Piecewise linear B-Spline curve
c: Control points
d: Distances
ع: Distance vectors
$t$ : translation vectors

Experimental results Invariance to point-set orientation $\varepsilon=$ mean of residual errors


10 final control points:
$\varepsilon \approx 0.0024 \mathrm{~mm}, 140$ iterations


8 final control points: $\varepsilon \approx 0.00088 \mathrm{~mm}, 140$ iterations


10 final control points:
$\varepsilon \approx 0.0017 \mathrm{~mm}, 140$ iterations


8 final control points: $\varepsilon \approx 0.0023 \mathrm{~mm}, 140$ iterations


11 final control points: $\varepsilon \approx 0.00091 \mathrm{~mm}, 140$ iterations

## Conclusions

* The B-Spline convection algorithm is founded on discrete computations.
* The algorithm is robust regarding the relative initial position of both the B-Spline and the data.
* The algorithm is tested on several shapes and returns residual errors below threshold if not too small.
* The initial number of control points must be minimal.
* The algorithm can be subject to time complexity improvement.
* Precision is not yet controllably achievable.
[1] Speer T., M. Kuppe, and J. Hoschek. Global reparametrization for curve approximation, in Computer Aided Geometric Design, 1998
[2] Wang W., H. Pottmann, and Y. Liu. Fitting BSpline Curves to Point Clouds by Curvature-Based Squared Distance Minimization, in ACM Tansactions on Graphics, 2006. 3] Zheng W., P. Bo, Y. Liu, and W. Wang. Fast Bspline curve fitting by L-BFGS, in Computer Aided Geometric Design, 2012.


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