Research results in a nutshell

Modeling general topology free-form surfaces in 3D (OTKA #124727, 2017-2023)

1. Multi-sided parametric surfaces

The focus of our work was to create various new, parametric, multi-sided surface representations. Our efforts have been directed towards Generalized Bézier and B-spline patches. We have already published surfacing schemes over convex polygons, which were later extended to handle domains with concave angles. The main contribution in 2019-21 was to formulate patches over domains with curved boundaries, moreover, these patches were capable to handle internal hole loops, as well. New methods were elaborated for domain generation, parameterization and internal shape control. We consider this as an important step forward in multi-sided surface modelling. We have also developed a special editing technique for constrained modification, that retains G1 continuity. These new representations can be primarily applied in curve network based design and for vertex blending and hole filling in CAD systems.

Publications:**7**,8,9,10,11,13,14,16,17,**20**,**22**,**23**,27,28,29,31,32,**33**,34,**36**

2. Implicit surface modelling

An interesting area of research involved modeling complex geometries by implicit equations. We have investigated the mathematics of a former implicit representation (I-patches), and enhanced this scheme. Our work with implicit multi-sided surfaces included applications of polyhedral design and vertex blending. Then research efforts were directed towards approximating triangular meshes by I-patches (approximating data points on a mesh and refining a related curvenet structure until a tolerance criterion is satisfied). Finally, a new scheme of corner I-patches was developed.

Publications: 18,**19**,21,24,25,**26**,31,35

3. Trimmed surface modelling and constrained fitting

An important problem in our research project was to approximate general topology surface regions by trimmed tensor product patches, such as, NURBS. This is a difficult problem, as approximations must be accurate, properly aligned with the geometry of the shape and cannot wiggle beyond the surface boundaries. We have elaborated a new technique based on labeling, constrained parameterization and 3D mesh extensions that produces well-controlled and predictable surfaces with even curvature distribution.

An important area of approximating meshes is constrained fitting; a couple of disjoint point clouds need to be approximated by a couple of surfaces, while various engineering constraints - smoothness, perpendicularity, parallelism, concentricity, symmetry - are satisfied. Heavy numerical methods and so-called auxiliary elements were applied to solve this problem. Novel results emerged for applying this technology to constrain free-form curves and surfaces.

Publications: **4**,5,6, **12**,**15**,

4. Proximity curves and surfaces

We have developed a new representation called P-Bézier curve. In fact, not a single curve is defined, but a family of curves, where a proximity parameter determines the distance between the shape being edited and its control polygon. Tensor product generalization to P-Bézier surfaces, and an extension to P-Bspline curves and surfaces have been accomplished, as well. We thoroughly investigated these constructions, in particular, the design aspects and the approximation properties.

Publications: **1**,2,3,30,

Summary of the publications:

Refereed journal papers with impact factor:

[**1,4,7,12,15,19,20,22,23,26, 33,35,36**]

International conferences: [6,11,17,21, 32]

Domestic conferences:[3,5,9,13,25,27,29]

University conferences:[2,8,10,14,16,18,24, 28, 30, 31, 34]

Dissertations:

Vaitkus Márton: Generating Smooth Surfaces from Discrete Pointsets (Defended: 2021)

Kovács István: Curves and surfaces determined by geometric constraints (Defended: 2022)

Sipos Ágoston: Implicit surface patches in 3D geometric modelling (Defense: Fall 2023)