Geometry and Algorithms for Archtecture and Design

Summer School and Symposium at DTU 15-19 June 2015

Programme

Monday 15 June: Workshop 08:30-17:00

Building 358 Room 006

Alla Sheffer (UBC): *Parameterizations of triangle meshes.* Topics include methods for least squares conformal parameterizations and stretch metrics. Exercises using GEL geometry processing framework.
Lunch: 12:00-13:00 in Building 101 Canteen.

Tuesday 16 June: Workshop 08:30-17:00

Building 358 Room 006

Johannes Wallner (TU Graz): *Ruled Surfaces and Developable Surfaces.* An overview of the geometric properties of ruled surfaces and developable surfaces and their practical uses, especially for freeform architecture. We discuss the following topics:

- geometric properties of ruled surfaces
- developable surfaces as a special case of ruled surfaces
- representation and definition of developables
- modeling with ruled surfaces, with a focus on building construction
- developables and discrete differential geometry
- developables in auxiliary structures associated with surfaces
- modeling with developables, with a focus on building construction
- the Eiffel Tower pavillons as a high-profile example
- new developments in algorithms

Lunch: 12:00-13:00 in Building 101 Canteen.

Wednesday 17 June: Symposium

Building 101 Room S09

08:30-09:00 Coffee and pastries.

09:00-09:45 Johannes Wallner (TU Graz): *Geometric modeling of developables and curved-folding objects* We present a new approach to geometric modeling with developable surfaces and the design of curved-creased origami. We represent developables as splines and express the nonlinear conditions relating to developability and curved folds as quadratic equations. This allows us to utilize a constraint solver which may be described as energy-guided projection onto the constraint manifold, and which is fast enough for interactive modeling. This is joint work with Chengcheng Tang, Pengbo Bo, and Helmut Pottmann.

10:00-10:45 Stefan Sechelmann (TU Berlin): *VaryLab Discrete surface optimization*: We introduce VaryLab, a software developed at Berlin Institute of Technology by members of the geometry group. It is designed to be an extensible and modular tool for experiments with discrete surfaces in mathematics and applications in industrial geometry. We explain the capabilities and features targeted at designers and architects. We use recent examples to illustrate its potential, e.g., conformal remeshing, periodic hexagonal patterns. Attendees will be given a token for the online beta phase of the software available at www.varylab.com.

11:00-11:45 Angelos Mantzaflaris (RICAM): *Self-supporting structures and form-finding by means of isogeometric analysis*: We explore NURBS-based geometric descriptions and isogeometric analysis in the design of self-supporting masonry surfaces. The mechanical behaviour of the surface is simulated by isogeometric analysis, acting on the B-spline description of the surface. Starting from given input model or boundary data we obtain smooth, equilibrated structures using only a fraction of the nodes required in standard mesh-based descriptions and thrust network analysis. This has a salubrious influence in all the stages of the computation, including the usually costly optimization phase which is needed for ensuring that the stress tensor is divergence-free. The resulting surface models possess high order smoothness without any additional effort, and can have general topology by adopting a multi-patch representation. We present several test cases that demonstrate that the method is robust, efficient and suitable for architectural design. This is work in progress together with Yang Xia, Bert Juettler and Wenping Wang.

12:00-13:00 Lunch in Building 101 Canteen.

13:15-14:00 Konrad Polthier (FU Berlin): *TBA*

14:00-14:30 Coffee.

14:30-15:15 Niels Aage (DTU): *Topology optimization as a form-finding tool* Topology optimization can be described as a family of numerical methods aimed at finding optimal structural layouts and material distributions. The methods are all based on solving optimization problems constrained by partial differential equations, and the classic example problem is to find the stiffest structural layout that utilizes a prescribed amount of material while fulfilling the elasticity equations. Since its introduction in the late 1980's, the procedure has become a crucial design tool in industries dealing with auto mobiles, aerospace, optical fibers and nano structures to name just a few. Recently, the method has started to receive an increasing attention from architectural and industrial designers who wants to use the method as a form-finding tool. In this presentation, the focus will be on the mathematics of the methods and how design problems from different branches of physics can be used to generate new and interesting shapes. Special attention will be on how to make the methods interactive and thus accessible to non-academics (see www.topopt.dtu.dk for more).

15:30-16:15 Alla Sheffer (UBC): *Sketching 3D: creating 3D models from 2D design sketches.*

18:00: Dinner at Fortunen restaurant.
(Address: Ved Fortunen 33, Kgs. Lyngby 2800).

Thursday 18 June: Workshop 08:30-17:00

Building 358 Room 006

Konrad Polthier (FU Berlin): *Tessellations.*

Lunch: 12:00-13:00 in Building 101 Canteen.

Friday 19 June: Industry Day

Building 101 Room S10

8:30-9:00 Coffee and pastries.

9:00-9:45 Asbjørn Søndergaard (Odico APS): *Geometry and robotic construction*: Following a decade of intense developments, robotics are currently emerging in technologies of construction. With the outlook of inducing a fundamental shift in the global construction industry, disrupting not only economics, but providing also a vast arrays of new architectural design possibilities, the new field of architectural robotics promises a significant reshaping of the cities of the future. This talk will introduce the historical development and outline the new frontier in robotic construction, in which new advanced technologies are being introduced at full scale building realization. This context provides a new importance to architectural geometry and mathematics, which serve as key for bridging between digital design and manufacturing.

10:00-10:30 Jacob Drachmann and Stefan Brandt (CN3): *Digital Construction current challenges and breakthroughs*: Abstract: CN3 delivers digital production data for the construction industry and construction suppliers. We transform digital design models into constructible production models and therefore need to handle different geometries and data formats. To establish the link between design and construction a certain level of geometrical knowledge needs to be leveraged into the digital models. Complex geometries often need to be rationalized in order to establish an effective and repetitive production method, and an effective translation and flow of data between different software needs to be established. The presentation gives practical examples of the challenges we encounter in geometrical modelling and the translation in to the constructible production model.

11:00-11:45 Morten Lund (GXN): *Coding Architecture.* As architectural designs get more complex and the requirement for documentation increases, architects look more and more to computational tools to drive the design process, post-rationalization and manufacturing, with profound implications on the architecture. The presentation gives an overview of the research and design done by GXN in this field and tries to show a direction on how architects will use computational tools in the future.

12:00-13:00 Lunch in Building 101 Canteen.

13:00-13:45 Björn Johnsson (AutoDesk): *Computer Geometry in Computer-aided Manufacturing* I will present an introduction to computer-aided manufacturing, CAM, and how computer geometry is used in computer-aided manufacturing. I will also present a specific problem, planar subdivision, listing some work-cases that it can be used for. I will present the requirements that those give, how they are not met by standard literature algorithms, and what we do to handle those cases.

14:00-16:00 Mathieu Huard (Evolute): *Research and Consulting in Architectural Geometry.* Evolute was founded as a spin-off from Vienna University of Technology to provide expertise regarding projects featuring complex geometry. I will introduce some of the theoretical work Evolute has been involved with in the fields of architectural geometry and optimization, then showing how those results were used in project consulting. The presentation will be followed by a demonstration of Evolute's software solutions.