Invited Talk

Discrete Geometric Structures for Architecture

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Abstract

The emergence of freeform structures in contemporary architecture raises numerous challenging research problems, most of which are related to the actual fabrication and are a rich source of research topics in geometry and geometric computing. The talk will provide an overview of recent progress in this field, with a particular focus on discrete geometric structures. Most of these result from practical requirements on segmenting a freeform shape into planar panels and on the physical realization of supporting beams and nodes.

A study of quadrilateral meshes with planar faces reveals beautiful relations to discrete differential geometry. In particular, we discuss meshes which discretize the network of principal curvature lines. Conical meshes are among these meshes; they possess conical offset meshes at a constant face/face distance, which in turn leads to a supporting beam layout with so-called torsion free nodes. This work can be generalized to a variety of multilayer structures and laid the ground for an adapted curvature theory for these meshes. There are also efforts on segmenting surfaces into planar hexagonal panels. Though these are less constrained than planar quadrilateral panels, this problem is still waiting for an elegant solution.

Inspired by freeform designs in architecture which involve circles and spheres, we present a new kind of triangle mesh whose faces' in-circles form a packing, i.e., the in-circles of two triangles with a common edge have the same contact point on that edge. These "circle packing (CP) meshes" exhibit an aesthetic balance of shape and size of their faces. They are closely tied to sphere packings on surfaces and to various remarkable structures and patterns which are of interest in art, architecture, and design. CP meshes constitute a new link between architectural freeform design and computational conformal geometry.

Recently, certain timber structures motivated us to study discrete patterns of geodesics on surfaces. This topic is closely related to the classical geometry of webs. There are numerous open problems in the geometry of webs, in particular when one asks for webs formed by special types of curves, as preferred in applications such as architecture.

Categories & Subject Descriptors: [Computer Graphics]: Computational Geometry and Object Modeling—Geometric algorithms, languages, and systems; I.3.5 [Computer Graphics]: Computational Geometry and Object Modeling—Curve, surface, solid, and object representations

General Terms: Algorithms, Design.

Bio

The speaker is the director of the Geometric Modeling and Scientific Visualization Center at KAUST, Saudi Arabia. He received his PhD in Mathematics from Vienna University of Technology. His research focus is on Applied Geometry and Geometric Computing.

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