Lecture Series ahead of the GCD25 Workshop

The lecture series ahead of the GCD25 Workshop on "Pressure Based Motion" consists of six lectures. In the following the Dates, Titles, Lecturers and Abstracts are given and how these lectures are linked to the aims and scope (Links to A&S) of the GCD25 Workshop.

1. Lecture

Date: Oct 8 at 10am (CET)
Title: Straight-, curved- and structural-folds
Lecturers: Klara Mundilova (EPFL) and Rupert Maleczek (Uni Innsbruck)

Abstract: In this talk, we introduce the fundamentals of curved- and straight-crease origami and highlight their multifaceted applications. We begin with a brief historical overview and an introduction to basic origami terminology, followed by an outline of the geometric description of these forms and references to computational design tools. Finally, we present examples of material realizations at different scales and discuss application-specific aspects such as hinge fabrication and actuation.

Links to A&S: This talk highlights the benefits and applications of foldable mechanisms, with a particular focus on curved- and straight-crease origami structures. It introduces basic terminology (such as crease patterns and rulings) and provides an overview of possible design approaches.

2. Lecture

Date: Oct 15 at 10am (CET)
Title: Types of flexion
Lecturer: Georg Nawratil (TU Wien)

Abstract: In this talk we present possible types of mobility of geometric structures, as the borderline between "rigidity" and "flexibility" is not as strict as it seems to be at the first glance. We provide some basic understanding of the intermediate levels ("shakiness" and "snapping") between these two poles, give geometric constructions and discuss their relation. Moreover, we demonstrate the different types on base of examples, which also highlight some curious properties; e.g. that polyhedra can flex continuously without breathing.

Links to A&S: This talk points out the difference between multi-stable structures, shaky and rigid-foldable ones, which helps to understand the design task of the GCD25 Workshop; i.e. the actuated spatial change of the structure can be a continuous motion, a snap or result from shakiness.

3. Lecture

Date: Oct 22 at 10am (CET)
Title: Direct design of flexible planar quad surfaces via control polylines
Lecturers: Kiumars Sharifmoghaddam (TU Wien) and Georg Nawratil (TU Wien)

Abstract: We give some basic geometric properties and construction principles of T-hedra, V-hedra (and their related surfaces, like anti-V-hedra) and P-hedra, as they are more or less the only known flexible planar quad surfaces, which can be generated in an exact geometric way and go beyond the rather abstract classification of (3×3) building blocks. Moreover they allow a design based on control polylines used by the tool "Scutes", whose functionality is demonstrated within the lecture.

Links to A&S: By a suitable choice of lengths of the line-segments of the control polylines the T-, V- and P-hedra can mimic semi-discrete surfaces with a rigid-ruling folding. Especially we will focus on T-hedra and special cases of V- and P-hedra, which can be realized with cylindrical air pouches.

4. Lecture

Date: Oct 29 at 10am (CET)
Title: From straight cylindrical air pouches to curved folding origami
Lecturers: Yiwei Zhang (TachiLab) and Tomohiro Tachi (TachiLab)

Abstract: During this talk, Tomohiro Tachi would first discuss some basic principles on rigid-ruling curved folding origami and the bridging of rigid panels with air pouches. After that, Yiwei Zhang will introduce the fabrication process of the air pouches including a demonstration. Then mentioning some works based on air pouches, especially the self-folding joints.

Links to A&S: This lecture acts as an inspiration for the theme of the workshop series from an aspect of pneumatics, showing how self-deploying motion is induced by a combination of air pouches and rigid origami patterns. Encouraging further studying on pneumatic structures from the base of geometry.

5. Lecture

Date: Nov 5 at 10am (CET)
Title: Inverse design of surface-based inflatables
Lecturer: Mark Pauly (EPFL)

Abstract: Surface-based inflatables are composed of two thin layers of nearly inextensible sheet material joined together along carefully selected fusing curves. During inflation, pressure forces separate the two sheets to maximize the enclosed volume. The fusing curves restrict this expansion, leading to a spatially varying in-plane contraction and hence metric frustration. The inflated structure settles into a 3D equilibrium that balances pressure forces with the internal elastic forces of the sheets.

We will discuss the geometric foundations and computational algorithms for analyzing and designing surface-based inflatable structures with arbitrary fusing patterns. Our approach employs numerical homogenization to characterize the behavior of parametric families of periodic inflatable patch geometries, which can then be combined to tessellate the sheet with smoothly varying patterns.

We explain how the homogenization algorithm is used to create a database of geometrically diverse fusing patterns spanning a wide range of material properties and deformation characteristics. This database is employed in an inverse design algorithm that solves for fusing curves to best approximate a given input target surface. Local patches are selected and blended to form a global network of curves based on a geometric flattening algorithm. These fusing curves are then further optimized to minimize the distance of the deployed structure to the target surface. We show that this approach offers greater flexibility to approximate given target geometries compared to previous work while significantly improving structural performance.

We will also introduce a Rhino/GH plugin that allows forward design of surface-based inflatables so that different deployed target shapes can be explored digitally.

Links to A&S: The geometric concepts and computational methods can be used to create inflatable sheets and explore design variations. By controlling stiffness, we can adjust the bending behavior for actuation.

6. Lecture

Date: Nov 19 at 10am (CET)
Title: Designing surface-based inflatables with analog methods
Lecturer: Duks Koschitz (Pratt Institute)

Abstract: This presentation will introduce applications and construction methods of surface-based inflatables. As described by Mark Pauly and his group these types of inflatables can be made by welding two thin layers of plastic sheet using specific curves. In order to control in-plane contraction one can use welding gadgets that produce specific three dimensional configurations.

The presented designs and projects cover a range of scales from small sketch models to prototypes to building-sized projects. Most are made by students in the context of semester long design studios. Some projects have been realized in collaboration with pneu.haus in Providence, RI.

The methods of working at small scales can be achieved with a relatively simple setup. The basic idea consists of welding two sheets of HDPE together with a hand tool with a heated tip, such as a soldering iron or leather iron. In order to prevent the plastic from sticking to the bottom or the tip of the tool, interlayers can be used.

Links to A&S: Based on the principles of spatially varying in-plane contractions caused by cylindrical configurations we can use a catalog of small sets of curves, called welding gadgets. The contractions can be controlled locally in order to realize a specific design. The workshop will allow participants to make sketch models and perhaps a table-sized model using soldering irons, HDPE sheets (2 mil) and printed or hand drawn patterns.