DEPLOYING GRIDSHELLS MADE EASY

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INTRODUCTION

Making structures light is an important goal for architects and engineers. One approach to light structures are gridshells. There is a special class within the family of gridshells, where members are so slender, that they bend. These “elastic gridshells” utilize the elastic potential of their members produce beautifully curved structures and can still be surprisingly stiff. Building them is not easy: In the design stage, the physical behaviour has to be simulated to know how it actually will look. During construction, many members need to be arranged, requiring scaffolding, falsework, cranes or other equipment [1]. We present a new type of elastic gridshell, that tackles these issues. It can be assembled flat on site and pulled into shape. During its deployment, members rotate around the joint and bend. Our design method is composed of several steps, where algorithms simplify the job and optimize for user goals.

EXPERIMENTS/FUNDAMENTAL OF THE PROBLEM/EXAMINATIONS

The design of a gridshell is usually based on a surface, that should be approximated. To develop an initial concept of arranging the members, geometry comes into play. Since we deal with a surface and want to place rods (idealized by their center lines) on the surface, we use geodesic curves to do so. Geodesic curves are a special curves on surfaces, that have nice properties for our specific problem. Randomly picking geodesics and joining them at their intersections with rotational joints produces curved 3d structures. Since not all surfaces can be made flat without tearing (in fact only developable surfaces can be), networks geodesics generally can not be flattened either.

To come up with a network of geodesics that reflects the nature of the surface, we have developed a method, that slightly adjusts the locations of the member’s intersections and makes the grid flattenable (see Fig.1). Pulling apart the closer of the two corners of the grid makes the structure buckle out of plane again. It basically acts as a one degree of freedom system (see the result of pulling in Fig.2). To simulate the deployed network of rods, we define and minimize elastic energies as in state of the art simulations [2] [3]. To calibrate the parameters of our simulation we compare our it against point cloud scans of claped rods. Observing from the results one can see that constraining the structure to

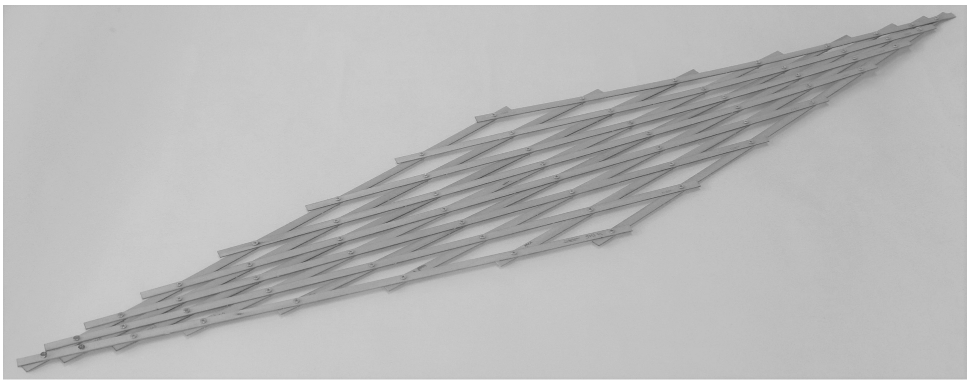

Figure 1: Example of a grid in planar state

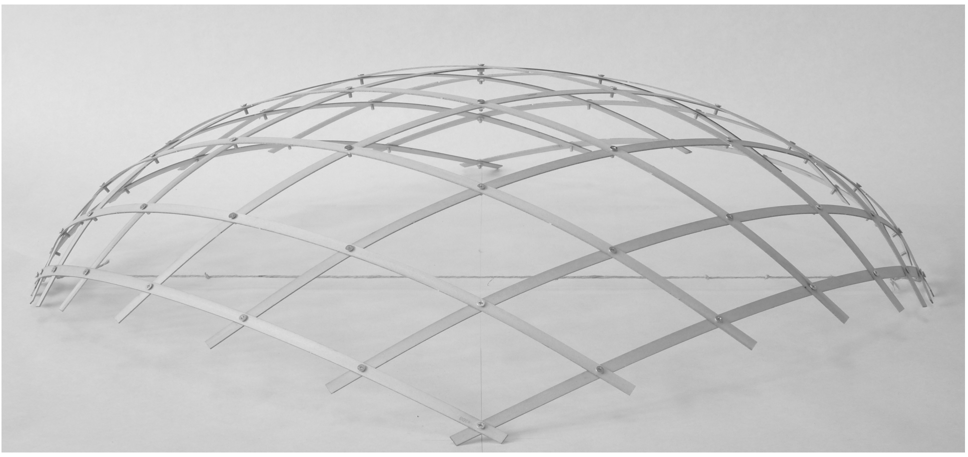

Figure 2: Grid of Fig.1 in deployed state

be flattenable comes with a price: in the deployed state, the structure does not approximate the design surface as well as without this constraint. We minimize this defect in a subsequent shape optimization algorithm. In this algorithm, we slightly adjust the placement of the geodesics and re-evaluate the design to approximate the design surface better, keeping the constraint of planarity upright.

RESULTS AND DISCUSSION

With our method we can compute 1-DoF structures, that are initially flat and can easily be pulled into shape, resulting in curved structures, that approximate a given design surface. Because of their planarity in the initial state, they are easy to assemble. Enforcing planarity however, can result in deviations of the shape of the deployed structures and the design shape. A subsequent optimization step can reduce the deviations, but not fully prevent them. Observing from the different design surfaces we tested, we can see that some kinds of surfaces are better suited for our method than others. By now we can not specify details of what makes a surface suited despite avoiding high curvature, this will be one of the scopes of our future work. [5]

CONCLUSION

We present a method, that supports the design and construction of elastic gridshells. Starting from a free form surface, a designer can use our method to create a flattenable gridshell, that can be easily deployed without any additional measures than pulling two corners apart.

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