Direct (and inverse) modeling of inflatables and other wrinkled thin shells

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Inflatables are structures made of flat planar membranes that are sealed or sewn to each other and that assume complex curved shapes once pressurized. Wrinkles tend to form at the locations of the seams, which makes the numerical simulation and, a fortiori, the inverse design, of such structures very challenging: not only does one need to finely discretize the mesh in order to accurately reproduce the geometry of these wrinkles, but one also has to deal with the numerical instabilities that arise in the system.

In this presentation, I will show that relying on tension field theory to convexity the constitutive material law of the membrane material allows us to correctly predict the global shape of the structure, even when we use coarsely discretized meshes. We can then use this convexified model in an interactive design tool that automatically adjusts the shape of the panels of the inflatable so as to create a structure of a desired shape [1].

In addition, we will see that we can subsequently recover the geometry of the missing wrinkles by parametrizing them by an amplitude and phase field that we solve for over the coarse base mesh. This approach allows us to recover complex wrinkle patterns with wavelength much smaller than the resolution of the base mesh while requiring much fewer degrees of freedom than required by traditional shell solvers [2].

References

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