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# Bijective Finite Element Method

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## ABSTRACT

In a time-dependent non-linear elastic physical simulation a body is heavily deformed due to internal and external forces. The body is usually discretized by means of a mesh, and large deformations may lead to meshes with degenerate elements. Such degenerate elements might become flipped and have negative volume, which is unphysical, hence causing the simulation to stop. We propose a novel approach based on bijective maps which guarantees that the mesh does not degenerate. The main idea is to bijectively warp the mesh between two successive time steps. By doing so, we ensure that the elements will not flip and hence the simulation remains physical. In order to warp the mesh we employ the method proposed by Schneider et al.[1] which creates bijective maps between a source and a target polygon as composite mean value mappings.

We extend the mapping not only to the vertices of the mesh but to the entire volume of the element, which also includes the edges, because otherwise the elements may flip due of the linearity of the edges. Since this leads to curved elements, we redefine all differential operators and propose a new way to exploit standard non-conforming domain decomposition techniques such as the L2-projection to transfer quantities from one deformed mesh to another.

## REFERENCES

[1] Schneider T., Hormann K, and Floater M. S. Bijective composite mean value mappings. *Comput. Graph. Forum.* 32:137–146 (2013).