On Validating a Physically-Based Deformable Surface Model

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Abstract. Preliminary results on the analysis of a physically-based model are presented.

Over the past two decades several approaches to modeling flexible and soft surfaces, such as cloth, rubber, piece of paper, and a metal plate, have been proposed in order to enhance the realism of the computer-synthesized scenes. The model for which the parameters have geometric semantics is the one proposed by Terzopoulos et al.[4]. Their model relates the Lagrangian motion equation to the metric and curvature tensors of the deforming surface. Once the metric tensors measure the variation of the area of the deforming surface and the curvature tensors give us the amount that a surface bends while it is deforming, we believe that this model may be of great importance for intuitive specification of desired deformations.

A series of experiments on this model have been carried out by our research group. In [3] the authors reported that they had difficulty obtaining the perceptual effect of a deforming surface which has resistance against bending. They suspected that it was due to the failure in satisfying the differential geometry compatibility conditions (the inherent relations between the metric and curvature tensors). However, even after including these conditions in the original model, unrealistic deforming behaviors concerning with bending may be yielded. This motivates us to further investigate the mathematical foundations of this model.

Up to now, we have identified two approximations in the model that may distort the results of the simulation: (1) the approximation of the normal vector $\vec{\mathbf{n}}$, and (2) the approximation of the potential energy.

To avoid complexities in computing cross product in a system of partial differential equations, Terzopoulos et al. suggested an approximation for $\vec{\mathbf{n}}$. From our analysis this approximation is very poor, since the direction of $\vec{\mathbf{n}}$ is not preserved, which may result in residual force in unexpected directions. We derived an exact expression for the term involving $\vec{\mathbf{n}}$, without resorting to additional numerical complexities. Figure 1 illustrates the results we obtained with this new approximation in the simulation of a sheet of paper with a force orthogonally applied at its midpoint.

However, forces applied at an arbitrary point $\mathcal{P}$ other than the midpoint may result in internal moments about $\mathcal{P}$ and may cause the "wrapping effect". Our preliminary study leads us to conjecture that it is due to the failure in including the total moment of all the forces about $\mathcal{P}$ in a rational way. This is the subject of our further work. We plan to propose an alternative deformation model on the basis of the Theory of an elastic Cosserat Surface[1, 2], which permits us to model more realistic deformations in a more intuitive way.

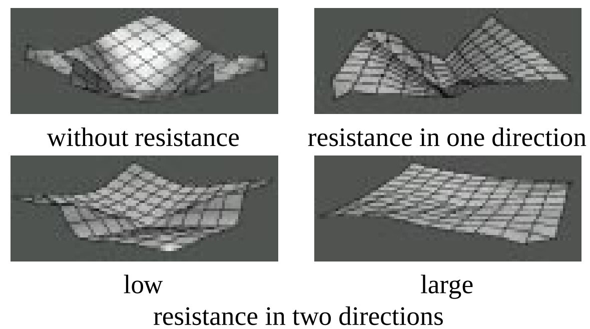

Figure 1: Resistance to the curving.

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References

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