De-Mystifying Reduced-Order St. Venant-Kirchhoff Deformable Models

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The goal of this paper is to document each step taken in recreating the results of Real-Time Subspace Integration for St. Venant-Kirchhoff Deformable Models [1], so that others may use this as a guide to replicate his work.

1 Introduction

Introduce the idea of the paper.

2 Creating the Triangles

An explanation of how to create a triangle object.

2.1 Implementing StVK

This section isn't necessary if you are planning on implementing the cubic polynomial approach, but it's useful as a debugging tool.

2.2 Computing DF/Dx

An explanation of how to compute DF/Dx.

2.2.1 Vectorizing Tensors

An explanation of how to vectorize a tensor, bringing the order down by one.

3 Creating the Triangle Mesh

An explanation of how to create a larger triangle mesh out of triangles. It is useful if this is its own object.

4 Implementing the Euler-Lagrange Equation of Motion

An explanation of how to create a larger triangle mesh out of triangles. It is useful if this is its own object.

4.1 Implementing Internal Force

An explanation of how to implement internal force using the StVK set up. Can be skipped for now if you are planning on implementing the cubic polynomial approach, but useful for debugging.

4.2 Implementing the Tangent Stiffness Matrix

An explanation of how to implement the tangent stiffness matrix using the StVK set up. Can be skipped for now if you are planning on implementing the cubic polynomial approach, but useful for debugging.

4.3 Implementing the Mass Matrix

An explanation of how to implement the mass matrix.

4.4 Implementing the Damping Matrix

An explanation of how to implement the damping matrix.

4.5 Implementing the Newmark Integrator

An explanation of how to take a step in time.

5 An Overview of Tensors

A brief explanation of tensors, what they represent here, and how they are used. This will be necessary to understand before moving on to the precomputed coefficients section.

6 Generating Precomputed Coefficients

An explanation of how to create precomputed coefficients for the cubic polynomial approach for the unreduced problem.

6.1 Coefficients for the Tangent Stiffness Matrix

An explanation of how to derive the coefficients for the tangent stiffness matrix equation.

6.1.1 Constant Coefficient for the Tangent Stiffness Matrix

An explanation of how to derive the constant coefficient for the tangent stiffness matrix.

6.1.2 Quadratic Coefficient for the Tangent Stiffness Matrix

An explanation of how to derive the quadratic coefficient for the tangent stiffness matrix.

6.1.3 Creating the Global Tangent Stiffness Matrix Coefficients

An explanation of how to derive the global tangent stiffness matrix.

6.2 Coefficients for Internal Force

An explanation of how to derive the coefficients for the internal force equation.

6.2.1 Linear Coefficient for Internal Force

An explanation of how to derive the linear coefficient for internal force.

6.2.2 Cubic Coefficient for for Internal Force

An explanation of how to derive the cubic coefficient for internal force.

6.2.3 Creating the Global Internal Force Coefficients

An explanation of how to derive the global internal force.

7 Generating a Deformation Basis

An explanation of how to generate a deformation basis.

8 Reducing the Euler-Lagrange Equation of Motion

An explanation of how to push U through so that we can reduce the order of our calculations.

8.1 Reducing the Internal Force

An explanation of how to reduce the calculation of the internal forces, changing the coefficients of the polynomial.

8.2 Reducing the Global Tangent Stiffness Matrix

An explanation of how to reduce the calculation of the stiffness, changing the coefficients of the polynomial.

8.3 Reducing All Other Forces

An explanation of how to reduce all other forces.

9 Running the program

A brief explanation of how to run the program

10 Conclusions

End it by explaining how I hope this helps anyone who wants to try implementing this on their own. Explain how this can probably be optimized further by flattening all tensors.

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References

[1] Barbic, J., and James, D., 2005. "Real-time subspace integration for st. venant-kirchhoff deformable models". *ACM Trans. on Graphics,* **23**(3), Aug, pp. 982–990.