CS 685 Paper Reading Assignment

Paper Title : **Point Based Animation of Elastic, Plastic and Melting Objects**

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Brief Overview : This paper presents a method for modeling and animating a wide spectrum of volumetric objects, with material properties anywhere in the range from stiff elastic to highly plastic. Both the volume and the surface representation are point based. The physical model used in this paper is derived from continuum mechanics, which allows the specification of common material properties such as Young's Modulus and Poisson's Ratio. In each step, the paper computes the spatial derivatives of the discrete displacement field using a Moving Least Squares (MLS) procedure. From these derivatives it obtains strains, stresses and elastic forces at each simulated point. It also demonstrates how to solve the equations of motion based on these forces, with both explicit and implicit integration schemes. In addition, this paper proposes techniques for modeling and animating a point-sampled surface that dynamically adapts to deformations of the underlying volumetric model.

Lets us look at some of the merits and demerits of the techniques used in this paper:

Merits

- The model proposed works with materials of any stiffness – stiff elastic to highly plastic.
- The paper is based on the **physical model of Elasticity,** thus the results are quite accurate and has a strong theory to support.
- This paper uses points as primitives. Therefore any kind of physical deformations are possible, as opposed to models using mesh connectivity. Here, there is no need for **Mesh Restructuring**.
- It works for high as well as low resolutions. We can get high resolution results if the code is ran offline and low resolution results if we are interested in seeing the output real time.
- Optimal Hashing scheme used for storing neighborhood information happens in linear time, **O(n)**, where **n** is the number of points in the model.

- Singular Value De-composition is used for avoiding problems with singularities in calculations.
- System remains unconditionally stable as it uses **implicit time integration**.
- Paper uses multiple surface representations which is good for high quality rendering and also handles arbitrary topological changes quite well.
- Resampling and Zombies used in the technique preserve the details during extreme topological changes, which is extremely important.
- It has a option of volume conservation to be applied to the model during any deformations, but does not include melting. This comes in quite handy when we want the model to behave a bit different from what the underlying physical model might produce.

Demerits

- The paper takes into account only tensile stress and strain.
- The algorithm defined here does not work for volume stress and strain and tangential stress and strain. Thus, the technique won't work for gases and liquids which possess **bulk modulus of elasticity**.
- If sampling of points is coarse, then singularity problems arise in the calculations of spatial derivatives of the displacement vector.
- Using implicit time integration scheme for making system stable is computationally more expensive and high on memory consumption.
- During plastic deformations, changes in the reference shape used may cause large stresses and strains to develop causing simulation to crash.
- In case of melting and flowing algorithms, volume conservation is not guaranteed.
- Field function used for implicit surface representation, defines an algebraic surface. Point sampling of such surfaces creates problems at silhouette edges since the main body of the surface does not have any high frequencies to alias.
- The kernel function used while initialization has its parameter **h** set to **h = 3r**. Nothing has been mentioned to support this assignment.
- It uses user defined thresholds while resampling and user has to go through some trial and error steps before getting the new resampled resolution right.
- High quality rendering is not possible real time. Thus, there is always a trade-off between quality and time.
- MLS method used works well if each point in model has at least 3 neighbors at non-degenerate locations, thus the approach works only for volumes but not for 2D layers or 1D strings of points.
- Close points always interact and hence for fracture simulations, the model will have be extended.
- The model does not handle sharp features and extreme fractures.