Full Graphics related Projects I have coded

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1   Solid deformation and simulation related:

Cage based deformation using ARAP energy or moving least square
Deform mesh based on coarse cage and use as-rigid-as-possible energy or moving least square method extending the paper *Image Deformation Using Moving Least Squares* [1] to 3D.

FEM simulation of solid using different constitutive models
Dynamics or quasi-static simulation of solid using finite element method and using different constitutive models such as linear elasticity, co-rotational linear elasticity, St. Venant-Kirchhoff model and Neohookean elasticity with tetrahedron mesh or hexahedron mesh. Some subspace acceleration method for FEM method has also been integrated in this framework, such as the paper *Real-Time Subspace Integration for St.Venant-Kirchhoff Deformable Models* [2].

Cloth or solid simulation using mass-spring model
Implement three versions of mass-spring based simulation: using classical Newton method, using local-global strategy based on the paper *Fast Simulation of Mass-Spring Systems* [3], using modified fast mass-spring based on the paper *A Chebyshev Semi-Iterative Approach for Accelerating Projective and Position-based Dynamics* [4] with a CUDA version Jacobi solver acceleration. Some mean curvature based shell bending energy has also been integrated in this framework, such as the paper *Discrete Shells* [5].

Numerical coarsening of FEM based solid simulation
Research for numerical coarsening acceleration solving of FEM based solid simulation with heterogeneous materials and non-linear constitutive laws on coarse grid. See our paper *Numerical Coarsening using Discontinuous Shape Functions* [6] published in the ACM Transactions on Graphics 2018 for the algorithm details. In this process, I implemented a basic FEM based solid simulation framework quickly first and then did the major two papers' comparison experiments almost by myself. And the first author Jiong Chen and I frequently communicated to analyze the experiment results and shared our observations to promote it.

2   Geometry processing related:

CatmullClark subdivision of surface mesh A course project.

Some discrete operator measuring curvature, normal on arbitrary triangle mesh
Junior graduate student training based on the paper *Discrete Differential-Geometry Operators for Triangulated 2-Manifolds* [7], knowing the cotangent form curvature operator and practice of halfedge structure, mesh curvature measure and mesh smoothing based on the mean curvature flow.

Surface mesh fairness using different energy
An implementation of the paper *An Intuitive Framework for Real-Time Freeform Modeling* [8], deforming mesh using different Laplace based energy: membrane surface energy, thin-plate surface, minimum variation surface energy with some fixed point constraints.

Heat flow based geodesic distance computation
An implementation of the paper *Geodesics in Heat:A New Approach to Computing Distance Based on Heat Flow* [9] which uses heat flow to compute the geodesic distance for per mesh vertex or per points cloud's point to the specified mesh vertex or point on point cloud. The algorithm core is just solving a Poisson's equation which is elegant and concise in maths! This project is just my hobby.

L1-based construction of polycube maps for mesh
An implementation of the core algorithm of the paper *L1-based Construction of Polycube Maps from Complex Shapes* [10] which uses an L1 Polycube deformation based method for hexahedralization and the algorithm is mainly solving an L1 norm optimization problem.

ARAP parameterization of triangle mesh
An implementation of the paper *A Local/Global Approach to Mesh Parameterization* [11].

3   Fluid simulation related:

Shallow water simulation with weakly two-way coupling with rigid body Practice.

Water simulation based on SPH method
An implementation of the earliest SPH based water simulation paper *Particle-Based Fluid Simulation for Interactive Applications* [12].

FLIP or PIC based water simulation with boundary correction
A simplified FlIP or PIC fluid solver with the boundary correction based on the paper *A Fast Variational Framework for Accurate Solid-Fluid Coupling* [13] without the implementation of its two way coupling part.

4 Deep learning related:

Image style transfer
Pretend to be Vincent using the paper *A Neural Algorithm of Artistic Style* [14]!

Handwriting number generation based Generative Adversarial Networks(GAN)
A simple implementation of the paper *Generative Adversarial Networks* [15] with just full connection layer on the handwriting number generation application.

Super-resolution of shallow water equation simulation based on GAN
Research for SWE simulation data's super-resolution using GAN. My master thesis proposes to achieve the SWE data super-resolution using GAN. By taking account of the temporal smoothness demand, rotation equivalence requirement, the possible negative value, this thesis proposes some modifications to the state of the art and obtains verified better results. See the *SWE report* for details.

5 Image based modeling related:

Single view or sparse multi-view based hair modeling
Research&Development for using a small number of images as input to reconstruct the 3D hair model to accelerate the process of hair asset production for artists. First, I surveyed 18 representative papers from 2012 to 2019 published at SIGGRAPH(Asia) or CVPR focusing on hair modeling and gave myself a clear feeling of its evolution. Then, according to these four aspects:(a).whether this algorithm is stable(some deep learning based methods are not stable for practical use),(b).whether the input of this algorithm matches the input from the current available hardware,(c).whether the output of this algorithm is physically available for simulation,(d).whether the data flow in this algorithm can be refined by artists flexibly, I select the combination of algorithms and make some modifications to make a tool for artists. The 2D feature extraction module, the hair model's data augmentation by clustering and recombination and hair model deformation based on image have been achieved. Now this project is still in progress. See the *hair report* for details.

Static hair/cloth retargeting
Research&Development for retargeting a hair/cloth model from one suited figure to another different figure. Very quick(in four days) to find and implement a solution of hair retargeting by ARAP energy based deformation and the artists give a good feedback of my work. After surveying some cloth retargeting papers in SIGGRAPH/CVPR, find a suitable solution for the artists. See the *retargeting report* for details.

6 Rendering related:

A naive path tracing solver A course project.

References

[1] Scott Schaefer, Travis McPhail, and Joe Warren. Image deformation using moving least squares. In *ACM transactions on graphics (TOG)*, volume 25, pages 533–540. ACM, 2006.

[2] Jernej Barbič and Doug L James. Real-time subspace integration for st. venant-kirchhoff deformable models. *ACM transactions on graphics (TOG)*, 24(3):982–990, 2005.

[3] Tiantian Liu, Adam W Bargteil, James F O'Brien, and Ladislav Kavan. Fast simulation of mass-spring systems. *ACM Transactions on Graphics (TOG)*, 32(6):214, 2013.

[4] Huamin Wang. A chebyshev semi-iterative approach for accelerating projective and position-based dynamics. *ACM Transactions on Graphics (TOG)*, 34(6):246, 2015.

[5] Eitan Grinspun, Anil N Hirani, Mathieu Desbrun, and Peter Schröder. Discrete shells. In *Proceedings of the 2003 ACM SIGGRAPH/Eurographics symposium on Computer animation*, pages 62–67. Eurographics Association, 2003.

[6] Jiong Chen, Hujun Bao, Tianyu Wang, Mathieu Desbrun, and Jin Huang. Numerical coarsening using discontinuous shape functions. *ACM Transactions on Graphics (TOG)*, 37(4):120, 2018.

[7] Mark Meyer, Mathieu Desbrun, Peter Schröder, and Alan H Barr. Discrete differential-geometry operators for triangulated 2-manifolds. In *Visualization and mathematics III*, pages 35–57. Springer, 2003.

[8] Mario Botsch and Leif Kobbelt. An intuitive framework for real-time freeform modeling. *ACM Transactions on Graphics (TOG)*, 23(3):630–634, 2004.

[9] Keenan Crane, Clarisse Weischedel, and Max Wardetzky. Geodesics in heat: A new approach to computing distance based on heat flow. *ACM Transactions on Graphics (TOG)*, 32(5):152, 2013.

[10] Jin Huang, Tengfei Jiang, Zeyun Shi, Yiying Tong, Hujun Bao, and Mathieu Desbrun. 1-based construction of polycube maps from complex shapes. *ACM Transactions on Graphics (TOG)*, 33(3):25, 2014.

[11] Ligang Liu, Lei Zhang, Yin Xu, Craig Gotsman, and Steven J Gortler. A local/global approach to mesh parameterization. In *Computer Graphics Forum*, volume 27, pages 1495–1504. Wiley Online Library, 2008.

[12] Matthias Müller, David Charypar, and Markus Gross. Particle-based fluid simulation for interactive applications. In *Proceedings of the 2003 ACM SIGGRAPH/Eurographics symposium on Computer animation*, pages 154–159. Eurographics Association, 2003.

[13] Christopher Batty, Florence Bertails, and Robert Bridson. A fast variational framework for accurate solid-fluid coupling. In *ACM Transactions on Graphics (TOG)*, volume 26, page 100. ACM, 2007.

[14] Leon A Gatys, Alexander S Ecker, and Matthias Bethge. A neural algorithm of artistic style. *arXiv preprint arXiv:1508.06576*, 2015.

[15] Alec Radford, Luke Metz, and Soumith Chintala. Unsupervised representation learning with deep convolutional generative adversarial networks. *arXiv preprint arXiv:1511.06434*, 2015.