Personal History Statement for Berkeley M.S. in Computer Science

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My journey starts from an interest in game development, then computer graphics, then physical simulation, and then finally control of physical simulations.

After my first course in computer programming at UofT, I decided to explore my life long interest in games through game development. I made a physics-based puzzle game using Unity for a semester-long student game-making competition hosted by UofT's Game Design and Development Club (GDDC), where my game placed 3rd overall. While it was a great experience, I wanted to learn how to make games from scratch without Unity.

I became more interested in game engines rather than games themselves, and it was between my first and second year at UofT where I made a few demo games with custom engines built with C++ and OpenGL. Learning graphics programming with OpenGL was really fun for me because I could visually see the results of my computer code. This led me to make small visualizations of various mathematical and scientific concepts I was learning about during my second year at UofT.

To further pursue my interest in graphics after 2nd year, I joined Professor David Levin at UofT's Dynamic Graphics Project (DGP) lab for a summer research internship. That was when I was introduced to modern methods for physical simulation, specifically the material point method (MPM) which had been gaining lots of popularity in the graphics community since it was used to simulate snow in Disney's Frozen.

My graphics journey was put on pause for a bit when I started my third year of Engineering Science at UofT, where I majored in Electrical and Computer Engineering and eventually took a year-long internship at Microsemi, an FPGA company. During that time, I really missed researching physical simulation. This led me to an internship at Rocscience Inc during the summer before my final year at UofT. Here I worked on optimization for slope stability analysis, which is an important safety assessment test in the field of civil engineering.

In my final year of Engineering Science at UofT, I worked with professor David Levin again to complete an undergraduate thesis on amorphous character control. This was done using back propagation through time on a differentiable MPM simulator to optimize a control sequence for a topologically morphing character. This expanded on my previous summer research on MPM, now being applied to a new application. MPM has a natural ability to handle topological change due to being a particle method as opposed to a mesh-based method, making it a perfect simulation method for amorphous character control. I derived an MPM specific control parameter through deformation gradients, which can be considered as the MPM equivalent to rest-state parameterization, a method previously used for mesh based elastic character control. There were also many interesting choices for loss function design I discovered which allowed for different types of animation such as shape morphing and color morphing.

I presented part of my thesis work at MOTOGRAPH 2019, a Montreal/Toronto/Waterloo student conference, with some very pleasing animations of shapes morphing their topologies through internal forces. I believe this was a strong demonstration of my research ability, and that it was a huge contributing factor to my Masters in Computer Science offer at UofT with a conditional offer to continue to a PhD.

My plan was to do another summer internship at Rocscience before beginning graduate school at UofT. However, my graduation year was the same year the Covid-19 pandemic started. I made the difficult decision to pause my academic career and continue gaining professional experience at Rocscience during the pandemic, while also being more financially stable in an uncertain time.

At Rocscience, I led the development of the physics engine for RocFall3, a new software for large scale 3D rockfall trajectory computation designed to analyze and assess the safety of slopes near civilian areas and infrastructure. Examples of slopes this software is used to analyze include mining pits, roadside mountains, and mountains next to villages and cities. To design and build RocFall3, I reviewed literature as far back as the 1990s up to the present day on rigid body dynamics, simultaneous impact, constraint based contact mechanics, and fast continuous collision detection of mesh-based geometries. In addition, I dealt with many challenges unique to rockfall simulation such as large multi-material irregular terrain, tumbling rocks with high angular velocity, and extra importance placed on energy conservation.

Eager to get back into computer graphics research, I attended the SIGGRAPH 2022 conference in Vancouver, Canada. The state of the art in reinforcement learning for character control in physical simulations was amazing to witness, and it made me decide that now is the right time to continue my previous research in amorphous character control.

Now I have gained multiple years of professional experience applying physical simulation to real world engineering problems. I believe I am much more prepared for graduate school and academic research than I was years ago during the peak of Covid-19 when I had to make the difficult decision to work instead of study.