Statement of Purpose

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I am applying to the Computer Science Ph.D. program of Stanford University to conduct research in computer graphics and scientific computing. I aim to develop a deep understanding of the theory and application of these areas, and investigate the related fields of networking and large scale computing. This will allow me to bring about groundbreaking advances in the technology powered by computer graphics. I used my undergraduate career as a Computer Science and Electrical Engineering major at UC Berkeley to explore a breadth of research projects, teaching opportunities and academic interests. I found my niche in computer graphics, and the satisfaction of facing research challenges led to my conviction to pursue a Ph.D. I hope to obtain a future position as faculty at a research institution, and launch a startup company based on my graduate work.

Exposure to academic research through family ties and high school experiences piqued my curiosity. I took Professor Filippenko's highly rated Introduction to Astrophysics course as a freshman, was captivated by the engineering potential of this field, and finished as the top student in his 700-person course. The rapport I built up with Professor Filippenko over the course of the semester allowed me to demonstrate my interest, and he offered me a position in his research group to work on the technical challenges of detecting supernovae. I entered the team as a member of the automatic imaging telescope group managed by Weidong Li (who co-wrote one of my letters of recommendation with Professor Filippenko). My first contributions were in the form of data analysis and classification of the images flagged by our image processing software. I experienced the process of collecting and analyzing huge amounts of data, and the continuing effort demanded by research. By the end of my sophomore year I became one of the first undergraduates certified as a telescope operator at Lick Observatory. I expanded my involvement to include the collection of real-time data of supernovae through nightly observations and training new group members. My contribution to our group was recently acknowledged in the paper "Exceptionally Luminous Type II-L SN 2008es". I gained invaluable experience through this group, but came to the conclusion that my true interests lie closer to simulation and scientific computing.

During my sophomore year Yahoo opened a research lab affiliated with UC Berkeley, and I was recruited into a research internship to explore video distribution and interactivity after winning the Berkeley round of their programming competition. I started work on a project to support the synchronous social conversation between people watching videos in an online environment. This environment traditionally provides little communication between parties, and we wanted to investigate more worthwhile sharing experiences. I subsequently designed a system that enables co-presence among online viewers. By building on top of an open source video server, I focused my time on the game-changing aspects needed on the server side. I built a synchronized streaming service that muxes a single stream to multiple clients, and exported control of the video stream to all clients. I supported mixing streams in real time and pulling video from online sources such as Youtube and Hulu. I developed this server into a foundation for the rest of the research project, providing a 10x to 100x performance gain in video processing speed, as well as the necessary features to enable co-presence. I teamed up with a front end designer and built a multi-person online video room that provided text and video chat and control of playback to all parties in the room. Example use cases of this environment included showing certain segments of a video clip to other participants, and sharing the viewing experience with friends. Our system also consisted of an instant messaging client, "*Zync*", which is now integrated into Yahoo Messenger itself. We conducted a user study and analyzed usage patterns, and found strong emotions evoked by the co-presence we supported. The culmination of this effort was the publication of a SIGCHI 2008 paper I co-authored, and the integration of our technologies both into Yahoo Live and Yahoo Messenger. I was thrilled by the possibilities of computer-based media and I wanted to explore the computer graphics area.

I quickly discovered my passion for computer graphics through Berkeley's course in the field. Computer graphics perfectly combined my interests in simulation and image processing with digital media and content creation. The course, taught by Professor James O'Brien, allowed me to explore my interests through an open-ended final project. I combined my knowledge of signal processing, graphics and interactive media into a project that played a popular computer game through monitoring a video screen. I even applied my hobbies of music, physical computing and DIY electronics to this project. The ability of computer graphics to combine my interests in such a manner and my positive interaction with Professor O'Brien reaffirmed my decision to focus on this field. I furthermore gained invaluable industry experience during an internship at Pixar Animation Studios as a member of their next generation tools group. Software development in computer graphics left me wanting a deeper insight into the workings of the algorithms I was using. Seeing the subdivision work of Tony DeRose and the simulations of David Baraff and Andrew Witkin in person further convinced me to pursue research in computer graphics. Thus I contacted Professor James O'Brien about the possibility of conducting research with him. Not only did we find an exciting simulation project for me, I also became an undergraduate student instructor for his computer graphics course.

I am currently investigating numerical simulation under Professor O'Brien with the aim of exploiting the client-server environment of online games to produce stunning real-time simulations. I enrolled in an upper level linear algebra course and read papers on simulation by Baraff, Witkin and Fedkiw, and collision response algorithms by Bridson and Grinspun. I partnered with an undergraduate mechanical engineering student and we are constructing a simulation framework to conduct this research.

We started with an initial implementation of semi-implicit integration and a mesh modeled as a mass-spring system. Our first results showed almost realtime performance, but when we added collision detection our simulation often became unstable and performance was significantly degraded. We tested position and velocity modification and constraint-based approaches for collision reaction, and finally settled on a damping approach coupled with ellipse approximations of objects in our scene. This has little impact on performance, and the force-based approach receives all the benefits of a semi-implicit integrator. The current results of our simulation are online in my portfolio (njoubert.com). Our project has reached a mature enough state to start developing a client-server framework where techniques from mesh compression can be used to synchronize the simulation between a dedicated simulation server and a set of gaming clients. The latest in computer games are relying on simulation to bring a new level of interactivity to the environment, and I expect my experience in video synchronization to prove useful as I further develop this project with the aim of publishing a paper on avoiding latency while achieving synchronized simulations in online games. I am also excited to further my studies through a graduate course on physically based animation I am taking next semester.

I also immersed myself in the computer graphics field on a broader level by becoming a TA for Berkeley's computer graphics course. By TA-ing I developed a deep understanding of the fundamentals of the field while contributing to the quality of education of my peers. I first taught computer science as a tutor in Berkeley's self-paced center under Dr. Dan Garcia. Berkeley's self paced center is completely tutor-driven, so I worked one-on-one with students in exploring concepts, guiding them through their first big projects. I thoroughly enjoyed the experience of sharing in the education of my peers. I was rated as one of the top tutors at the self-paced center, and I started TA-ing for Berkeley's computer graphics class. I taught two discussion sections for which I produced worksheets and held marathon office hours that were attended by a third of the students in the class, with several students describing my efforts as indispensable to their understanding of the material. I finally received an average of 4.8 out of 5 for the quality of my teaching.

I find the nature of research deeply appealing. To me this is an ongoing endeavor where I can find creative solutions to technical challenges, leading to new possibilities for technology. Conducting independent research and sharing my knowledge through teaching are the highlights of my undergraduate career. I have no doubt that my future lies in a full time research position, contributing to the computer science field through application of my broad range of experiences. A Ph.D. from Stanford would allow me to achieve these goals by working with such leaders as Professor Fedkiw and Professor Hanrahan at this center of excellence. Stanford is a powerhouse in the computer graphics field, and I believe I have demonstrated my ability to contribute to the quality of this institution and strive for intellectual excellence. The Stanford faculty and students have made a tremendous impression on me during my frequent visits to the campus, and I am confident that this university provides the perfect opportunity to launch my research career.