Statement of Purpose

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Working with computer graphics and simulations gives me immense sense of satisfaction. Hence I have always made careful choices throughout my career path to learn more about graphics even when the knowledge was hard to acquire at times. Since the first year of college I voluntarily started working as a programmer with the rendering team of a local game development company as an unpaid employee for more than a year for the sake of learning - an anecdote that certainly speaks for my self-motivation. Generally, I am interested in applying mathematical tools in computer graphics and thereby producing accurate images for correct visual interpretations. Apart from accuracy, real-time aspects of computer graphics are of paramount importance as they allow users to visualize data interactively and therefore I am also interested in GPU methods. At this point, upon finishing an exciting research based Masters degree, I am very keen about pursuing a Ph.D in the field of Computer Graphics and my areas of interest are Realistic Rendering, Fluid Simulations and Computational Photography.

Derivative Estimation on Regular Lattices: From the very get-go of my Masters degree I started doing research on graphics and my supervisor Dr. Torsten Möller introduced me to the intriguing world of non-standard sampling lattices like Body-Centric Cubic (BCC) lattice. BCC is the optimal sampling lattice for band-limited functions as it requires 30% less data to reconstruct a 3D image yielding the same quality, yet faster, compared to the commonly used Cartesian-Cubic (CC) lattice. On the other hand a robust method for estimating derivatives of different orders, which are required to solve Partial Differential Equations (PDE), was not known for such non-standard lattices and often these quantities would be approximated rather naïvely with little mathematical foundations. I picked up this open problem and formulated a generic framework, based on the 1D work of Möller *et al.* (1997), that works in arbitrary dimensions to approximate a given derivative up to a specified polynomial order with a given filter/stencil size and in all regular lattices. We demonstrated the framework in the light of improved shading qualities in volume rendering when gradients were estimated using our framework on both BCC and CC lattices. We published a paper on this work in the Transactions of Visualization and Computer Graphics (TVCG) titled "Toward High-Quality Gradient Estimation on Regular Lattices." My previous work experience (as indicated in my CV) on projects from game companies like Electronic Arts and Turbine prior to joining Masters proved to be invaluable for this research not only in terms of graphics but also in terms of designing and dealing with large code-bases as I implemented a very optimized volume Ray-Tracer from scratch with support for arbitrary lattices.

Edge-Aware Anisotropic Diffusion: The above work opens up the door to numerically solve PDEs on non-standard lattices with higher order stencils which I am interested to study further in my Ph.D. In the second year of my Masters, my co-supervisor Dr. Steven J. Ruuth introduced me to implicit surfaces and level-set methods that are extensively used in graphics simulations as discussed, for example, in the famous book of Stanley Osher and Ronald Fedkiw. This immediately made me wonder about how well these methods would perform on lattices other than CC. As a first attempt to implement a PDE on a BCC lattice I picked up the well known Perona and Malik's anisotropic diffusion. But tuning the diffusion parameter that is supposed to preserve "edges" in a scalar function, a property that has little to do with the underlying lattice, frustrated me very quickly and I wondered if the anisotropic diffusion itself could be re-modelled. We combined ideas from 2D image processing and took into account factors that only arise in 3D and re-modelled the diffusion equation where “edges” would be defined by the directional second derivative. This gave rise to a diffusion equation that is much less sensitive to parameters and is similar to Weighted Mean Curvature Motion yet critically different. Another paper was published on this work titled “Edge-Aware Anisotropic Diffusion for 3D Scalar Data,” in the proceedings of IEEE Visualization 2010. I gave a talk on this paper in the last IEEE VisWeek 2010 at Salt Lake City, Utah, USA. This paper was voted third in rank, among 84 IEEE Vis and IEEE InfoVis papers, in the VisImp competition, organized by Kitware Inc. It is believed that the most popular papers will be implemented in the widely used software Visualization Toolkit (VTK). However, in this paper we implemented our novel anisotropic diffusion in only CC lattice as we did not yet have a theoretical foundation on the stability of the evolution of the PDE in terms of the “time-stepping” Δt and hence there would be no normalized basis for comparison between CC and other non-standard lattices.

Current Work: Later we analyzed the stability of the above anisotropic diffusion theoretically using Courant-Friedrichs-Lewy (CFL) condition on arbitrary lattices and found that the theoretical analysis agrees with the empirical study we had done in our paper. With this analysis in hand combined with the previous work on derivative estimation we are ready to implement the above anisotropic diffusion on non-standard lattices like BCC. This also allows us to compare results with that of the CC lattice on a normalized basis and there is a good potential for a third journal paper.

Teaching: Teaching is an integral part of research as it hones the skills of presenting results in a way that others understand. I have been appointed Teaching Assistant (TA) several times during my undergraduate degree, specially in Mathematics and Digital Logic courses. During my Masters degree I have held a TA position twice for an undergraduate graphics course at Simon Fraser University titled “Introduction to Graphics” taught by Dr. Torsten Möller. I have also held three lectures of this course on Dr. Möller’s behalf when he was out of town. Apart from that I have also tutored several undergraduate students in Mathematics, C/C++, Matlab and graphics programming.

Conclusions: “The more I learn, the more I learn how little I know” - and that certainly makes me more curious to learn more. Moreover, my general knack for innovations and working on original research serve as key motivations to pursue a Ph.D in Computer Graphics and later adopt a research career in the field. It is hard to foretell what exact area I will end up working on but I am interested to work on the computational aspects of Computer Graphics including Realistic Rendering, Fluid Simulations, or Computational Photography. Speaking of Fluid Simulations and having evidences that better results are often obtained on non-standard lattices, I might be curious to study the techniques, lot of which were developed at Stanford, on these lattices. However, I am also open to work on other interesting computational aspects of Computer Graphics. Furthermore, Stanford Graphics Lab is a place of diversity with great faculties and students expanding research in many areas, including the ones of my interest, with excellent collaboration with the industry for a better access to real-world problems. Given my keen interest in graphics, complemented by my research background and work experience in the industry, I believe I can significantly contribute to the field during my Ph.D and beyond.