Statement of Purpose

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Education

I grew up in a college campus in India. I have always been interested in Mathematics and making things. My introduction to computer science started following a week long workshop in 8^{th} grade, where I was introduced to C programing. That one could build powerful solutions to problems immediately resonated with me. My interest led me to explore more and to compete for the National Informatics Olympiad in my 9th grade. Subsequently I represented India thrice in the International Informatics Olympiad and got medals twice. The training sessions and our instructors in the training camp introduced me to the wonderful world of algorithms and data structures.

Unsurprisingly, when I started college, I was drawn towards theoretical Computer Science. I had the opportunity to take several upper level and graduate courses in this domain starting right from my freshman year, which boosted my interest. Through the years at MIT, I have actively pursued some exciting research topics. My primary research exposure has been in the fields of Sublinear algorithms under the guidance of Ronitt Rubinfeld, and computational geometry under Erik Demaine.

I have also sought out many teaching related activities in MIT which have been a satisfying experience for me. I have been a TA for the second level undergraduate algorithms course (6.046) three times, starting from my sophomore year. I also organized and taught a month long independent algorithms crash course for MIT students. I completely conceived and organized a programming, simulation and robotics workshop for high school students in my hometown in India, as a joint venture between MIT and IIT Kharagpur (Indian Institute of Technology).

I am interested in a career in academia that will allow me to pursue my interests in research and teaching. Pursuing a PhD will enable me to delve more intensely in research in theoretical computer science, and prepare me for my academic career.

Research

During my time at MIT, I have conducted research in a number of different topics in Theoretical Computer Science, including Sublinear algorithms, local algorithms, computational geometry and origami theory, and distributed algorithms.

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Sublinear Algorithms

My first exposure to research was through a graduate course I attended in my freshman year titled "Randomness and Computation". Our instructor was Ronitt Rubinfeld, and being the only undergraduate student in a small class, I got to know her quite well. I was invited to join in group meetings with her PhD students, who were working on property testing on graphs. Having considered $\mathcal{O}(n)$ to be the gold standard of complexity all my life, I was very excited to learn more about sublinear algorithms.

Counting Subgraphs. Our work (published in Algorithmica [1]) was focused on estimating the number of star subgraphs in a given graph. We introduced a new model in graph property testing, that allowed for a random edge to be sampled. Most prior research had only considered random vertex, and random neighbor queries. However, the ability to sample an uniformly random edge is very natural, since it is equivalent to sampling a random element from an adjacency list representation of a graph. We were able to show that this model is more powerful than the old vertex sampling models, by improving the bounds presented in [2].

Local Access Implementations. More recently, I have started working on a new research project (also under Ronitt's tutelage). in the field of *local-access implementations* of huge random objects. This is a relatively new area, pioneered in [3, 4], and further developed in [5, 6]. This model considers huge random objects such as exponentially sized random graphs. Classically, such objects are fully generated, before being studied. However, in the context of algorithms with sub-linear query complexity, it seems wasteful to generate the entire random object. Local-access implementations aim to provide oracle access to these random objects, without having a large pre-processing overhead.

We have obtained some new and interesting results in this area – particularly for undirected random graphs with independent edge probabilities. We provide the first implementations of a RANDOM-NEIGHBOR query, which would allow efficient implementation of random walk based algorithms. Our implementation is also the first to support dense graphs, and unlike many past results, we can generate the entire graph without introducing inconsistencies. Specifically, we show that our algorithm can be used to efficiently implement Erdos-Renyi graphs, and the Stochastic Block Model. We also design generators for graphs in Kleinberg's small world model, where edge probabilities depend on a 2-dimensional distance metric.

Currently, I am working on several other classes of random objects. In the realm of graph theory, I have been considering implementations of Geometric and Hyperbolic Random Graphs. We also have some partial results for locally generating uniformly random domino tilings, and obtaining uniform samples from Dyck languages.

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Computational Geometry

Over the past year, I have also worked on several problems in origami and computational geometry with Erik Demaine.

Origami. One of the results from this class was a result on common unfoldings. Our paper[7], published in CCCG, outlines the construction of a development, that can fold into twelve different convex polyhedra (the list is now slightly longer), in five different combinatorial classes. Most of the past results in the field [8, 9, 10, 11, 12] only result in a small number of unfoldings. Additionally, our construction presents the first non-trivial *uncountable family* of unfoldings.

Ialso worked on the origami construction of extruded surfaces. Here, I developd a construction for arbitrary extruded orthogonal graphs, with $\mathcal{O}(2+\varepsilon)$ optimal paper usage, under some suitable assumptions. We also formulated a technique for constructing arbitrary extruded polygons, where convex polygons can be made with $\mathcal{O}(1+1/n)$ optimal paper usage.

Compare to past results

Auxetic Linkages. One of my ongoing projects is on the design of 2-dimensional auxetic linkages. Specifically, I am interested in inhomogeneous bistable auxetic linkages. Bistable auxetic linkages that have exactly two possible configurations, and it is not possible to continuously deform them into each other. Generally, the final state of the linkage will have a larger area.

Existing literature focuses on periodic linkages that have homogenous expansion properties. I am investigating an aperiodic linkage that has varying amounts of expansion in different locations. This implies that the final state is non-Euclidean, and I have constructed some physical models, that start out from a flat sheet, and unfold into a 3-dimensional surface.

Pictures

Teaching

I enjoy teaching, and very much appreciate its importance for being academically active and doing research. In addition to solidifying my own understanding of the material, teaching a topic is also a wonderful exercise in communication. After all, the most novel of ideas is useless unless you can communicate it effectively.

Teaching Assistant My first experience teaching a class was in sophomore year, when I was a TA for the second level undergraduate algorithms course. This also happened to be the semester when the course was being recorded for MIT Open Courseware. So, the videos of my recitation were going to be recorded, and posted on the OCW website (recitations $\{2, 6, 8, 9\}$ available online).

This was my also first teaching experience, and I found that I thoroughly enjoyed the process of preparing material, and teaching a class. I have since been a TA for this class three times, and every offering has contributed to further my understanding of the material.

Independent Teaching I have also undertaken several independent teaching related activities. During my Junior year, I designed, and taught a month-long algorithms course at MIT, with 40 students. Last summer (2017), I started a workshop for high school students in my hometown in India. During this three-week intensive workshop, the participants learned C programming, basic simulations, and completed a hands-on robotics project.

Conclusion

I look forward to continuing my research as a PhD student. I hope to continue to work on the topics that I have already started working on, but I will also be looking out for new interesting problems in related areas. I am excited to formulate new ideas through interactions with students and faculty at your institute, which will allow me to broaden my research horizons and expose me to new topics and new problems. I am looking forward to an enriching academic experience that will allow me to pursue my academic career.

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