Statement of Purpose

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"Either mathematics is too big for the human mind or the human mind is more than a machine" (Kurt Godel). I believe that machines could someday outperform humans in every task and one of the most promising approaches towards this is **Machine Learning**. I am interested in designing theories and algorithms in machine learning, specially in presence of **large-scale** data. I believe that tools like **probabilistic methods** and **geometric analysis** (e.g. convex analysis) are essential parts for a better understanding of the challenging problems. I specially like to see improved performance of machines in vision, one of the easiest tasks to humans. I am planning to get a phd degree in Machine learning or Statistics. After graduation, I intend to continue working in academia as an active researcher as well as a dynamic faculty member.

All through my academic career, I have performed exceptionally well in my coursework. I was always among the best, but I performed the best in subjects on mathematics. During highschool, I spent most of my time preparing for IMO, and even by that time, I was mostly focusing on combinatorics and geometry. Later, after scoring among the top 0.1% in the University Entrance Examination, I joined the Department of Electrical Engineering at University of Tehran, the oldest, largest, and most prestigious university in Iran. It was during my bachelor thesis, where I first encountered topics on machine learning. Encouraged by that, I applied for programs in Computer Science and I got admitted to IMPRS-CS graduate program with scholarship at Saarland university.

Mathematics knows no boundary; In Winter 2013, I was a research intern at Combinatorial Image Analysis group, where I worked with Dr. Bjoern Andres. I worked at a basic theoretical project which aimed at finding necessary and sufficient facet defining conditions for the problem of graph decomposition extended with long range edges. It was a new problem which hasn't been formulated yet. Therefore, In the first step, we defined the problem both as partitions of sets, and also multicuts of a graph, allowing us access to both worlds. Next, we proved full dimensionality of the polytope, letting us start with the facets. Several non-trivial necessary conditions were extracted, proven to be sufficient for many applications, like image segmentation, but not for the general problem. In the end, I designed an algorithm using linear independence preserving operations on a specific Hasse diagram of the problem. For this purpose, I had to rethink basic definitions of linear independence in linear algebra, graph theory, and matroid theory. It was during these three months that I learned that mathematics knows no boundary, as long as you are creative and devoted. I had to temporarily leave the project uncompleted because the new semester had already begun.

Simple but enormously useful; In my second semester, I mainly focused on the course Convex Optimization given by Prof. Matthias Hein and read quite beyond the course materials . Therefore, I could achieve a deep understanding on basic topics like convexity analysis, conjugacy, duality, and metric spaces. In my view, a researcher should always go

back to the basic concepts and doubt them. As programming assignments, we implemented the very simple KKT conditions in various forms to various problems in Matlab and C++ providing me experience in using libraries like LAPACK and BLAS. I got specially interested in challenges that large data introduce in optimization problems and would like to investigate these problems. Ideas like:

- Stochastic and randomized approaches.
- Exploiting sparsity which was insisted a lot by Prof. S. Boyd in his publicly available video lectures.
- Geometric optimization which I first got to know about during a talk by Dr. Suvrit Sra at MPI Saarbruecken and his publicly available notes.

Beauty of uncertainty; During both my semesters, I focused a lot on probability theory, by taking courses like Probabilistic Graphical Models and Random Discrete Structures. I studied the concepts of powerful modeling and inference tools, the importance of stochastic sampling, and their application in machine learning. It is amazing how you can derive different properties of general structures by the use of probabilistic methods. Results like dimension reduction and metric embeddings, ϵ-nets and VC-dimensions, critical results on random geometric graphs, and many more. I think that these tools can be very useful in understanding the structure of the problems in machine learning and the design of new algorithms, specially in presence of large-scale data.

Mathematics really works; In the course High Level Computer Vision, I studied the basic tools used in computer Vision. As a course project I used CAFFE, which is based on recent developments in Deep Convolutional Neural Networks to implement a classifier. In that year, almost all the advancements in different challenges in Computer Vision was based on this recent technique from Machine Learning. By that time, I understood the importance of Learning Theory, how Large Data can be advantageous, but also challenging to work with.

Mathematics is beautiful and one can delight in it; In course of my brief experience, I found research-work both challenging and fulfilling. The joy of sharing ideas through teaching and negotiation with colleagues, and the delight in solving a previously unsolved problem draws me towards this career option. Given my academic qualifications and prior involvement in research, I am certain that I will be a valuable member of the research community. To be more specific, I could benefit the community, more from a theoretical perspective, specially in the fields of probability and geometrical analysis. Moreover, I am a critical thinker and passionate about new ideas.

Thanks for your consideration. For more information about my academic background, curriculum vitae or research interests, please visit http://ashkan-mokarian.github.io or let me know if I can answer any additional questions.