Statement of Purpose

I would like to pursue graduate studies in the Department of Electrical Engineering in California Institute of Technology. My broad areas of interest are Information Theory, Coding Theory, Wireless Networks and Signal Processing.

My interest in research and academia has been greatly influenced by my experiences during my high school days. As a participant in National Science Seminar in 2002, I had an opportunity to visit Raman Research Institute (RRI), Bangalore. The passion and love that the researchers there had for their work and their inquisitive bend of mind has had a lasting impression on me and has instilled a dream of becoming a researcher. I developed a strong inclination towards mathematics when my teacher in class 11th and 12th, Professor H. L. S. Rao, went beyond merely teaching us the subject matter, and taught us how to learn and enjoy mathematics. His unique way of teaching without using the board helped me visualize and develop intuition in the subject. For this, I am indebted to him and aspire to be an inspiring and empowering teacher as well. Thus, in the long run I would like to pursue a career in academia which is a blend of both research and teaching.

In my three-and-a-half years of undergraduate studies at IIT Madras, I have had the opportunity to take a wide array of courses in Electrical Engineering, Physics and Mathematics. Mathematics has always inspired a sense of awe in me. I have always been amazed how mathematics, despite being abstract, can capture real world phenomena. The inspiring discussions and debates I had with my peers, my professors and friends helped me to gain further insight into the wonderful world of science and engineering.

My interest in Physics led me to become a part of the students' physics group at IIT Madras, *Boltzmann*, where discussions are held once a week on various topics in Physics that are generally not a part of the curriculum. Professor Suresh Govindarajan, faculty member at the Physics Department, guided us during these sessions, ensuring productive discussions. During one such session, I was introduced to the concept of Lie Groups which motivated me to study Algebra extensively on my own. The theme for Spring 2010 was Random Matrix Theory and my excitement knew no bounds when I came across its applications in the domain of wireless communication. I enjoyed studying the work of Professor Emre Telater on the *Capacity of Multiantenna Gaussian Channel* and presented the same to the group. In these meetings, I realized that nothing gives me greater joy than learning and exploring new things.

A strong background in Physics and Mathematics has enabled me to approach research problems with a broader perspective. During the summer (May - July 2010) I worked with Professor Anurag Kumar, Department of Electrical Communication Engineering, IISc, Bangalore. We worked on the application of *mean field limit* based approximations for wireless networks. It deals with the time evolution of the states of various nodes in a wireless network. We approached the problem by looking at the scaled empirical measure process [1] (the fraction of nodes in different states). I was fascinated to learn that the system turns out to be an autonomous system that lies on a K-dimensional simplex. Simulations of the system with different parameters hinted the existence of a global equilibrium. Analyzing the local stability at this equilibrium, we proved the existence of a zero eigenvalue. A closer look at an example 2D system and its phase portrait showed the existence of a unique equilibrium on the simplex. We are further probing the higher dimensional cases now. Understanding the stability of the system will give us more insight into the analytical approximations used in the study of wireless networks. While working on the problem, I thoroughly enjoyed learning concepts in convex optimization, properties of quadratic forms & more and using them to analyze wireless networks. This deepened my interest in *wireless networks*, *convex optimization* and *dynamical systems*.

As part of my undergraduate thesis, I am working on the application of Generalized Discrete Fourier Transform (GDFT) in OFDM systems with Professor David Koilpillai. We are exploring the possible advantages that GDFT would have over the traditional DFT, specifically in addressing the issues of timing and

[1] A Class of Mean Field Interaction Models for Computer and Communication System by Benaim & Le Boudec

frequency synchronization. While investigating high Doppler cases, we referred to the paper *Joint channel estimation, equalization, and data detection for OFDM systems in the presence of very high mobility* by Panayirci, Senol and Poor. It gave me an opportunity to learn about Karhunen-Loeve Transform (KLT), Discrete Cosine Transform (DCT) and this deepened my interest in *signal processing* and also exposed me to iterative algorithms like SAGE. The project has given me a tremendous opportunity to learn about Digital Communication, *Wireless and Multicarrier Communication* and also delve more into the theory of *transform techniques*.

My curiosity to know about the cutting edge research in various areas in Communication prompted me to attend the National Conference on Communication that was held at IIT Madras during January 2010 and the International Conference on Signal Processing and Communication (SPCOM-2010) held at IISc, Bangalore in July 2010. The tutorials on *Co-operative Communication* and *Physical Layer Security* in SPCOM-2010 introduced me to various interesting research problems in the respective areas. I was specifically intrigued by Professor Sanjoy Mitter's talk on *Towards a Unified View of Inference, Communication and Control* and the talks by Professor Kannan Ramachandran, Professor Telatar and Professor Urbanke on various applications of Coding Theory. These inspired me to take up courses on Error Control Coding and Information Theory during Fall 2010.

As a part of Error Control Coding, we studied LDPC codes. Having done a course on Graph Theory, I was able to appreciate the Tanner graph approach to LDPC codes and it deepened my interest in *graphical models*. Further, I read the survey paper on *Rethinking Information Theory for Mobile Ad Hoc Networks* by Jeffrey Andrews, Shakkottai et al. which introduced me to the possible applications of *non-equilibrium statistical physics*, *random graphs*, *stochastic geometry* and *control theory* to develop a frame work to analyze and understand ad hoc networks. These experiences have deepened my interest in problems in Wireless Networks, Information Theory and Coding Theory.

Discussions with my guides, Professor Anurag Kumar and Professor David Koilpillai, have taught me the methodology for research: identify a problem, formulate it, break it up into smaller tractable sub-problems, make reasonable assumptions and approximations, get an intuitive understanding of the system, try different ways of solving the sub-problems and finally put them together and address the problem as a whole. I am fascinated by the challenge involved in solving problems in research. In particular, the iterative process of learning from failed attempts and trying novel methods and finally the joy of conquering the problem excites me a lot. My love for working on intellectually stimulating problems, along with a deep curiosity and desire to learn more, have made me realize that research indeed is my calling.

My long term aim is to enter academia. At this important stage, I feel that Electrical Engineering department in Caltech would be ideally suited for me to gain a deeper understanding in the areas of my interest. I am keenly interested in the works of Professor Babak Hassibi on compressive sensing and wireless sensor networks and those of Professor Michelle Effros on network coding & functional compression. I also find the work of Professor Vaidyanathan in Signal Processing very fascinating. Opportunity to pursue my graduate studies at Caltech would provide me a platform to work on challenging problems, experiment with my ideas and do productive research work leading to a PhD. I am confident that my motivation to do research coupled with my academic & research abilities will help me achieve my goal.

Thank you for considering my application.

Ramya Korlakai Vinayak

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