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# Personal Statement

Computer Science Ph.D. applicant for Fall 2017

I am a researcher at NEC central research labs, Japan working on vision-based infrastructure maintenance using deep learning techniques. Prior to this, I got my master's degree in Electrical Engineering from Indian Institute of Technology (IIT), Bombay in 2014. My research interest lies in the fields of computer vision, graphics and machine learning. With recent developments in the field of deep learning and availability of large datasets, I believe there is an immense scope of future research on designing better algorithms for data-driven feature representations, especially for solving multi-modal AI problems. I am particularly interested in developing better features that can efficiently map fine-grained visual concepts to detailed natural language format, even with limited training samples. After doctoral studies, I wish to pursue my career as a researcher in academia.

I studied Bachelors of Electrical Engineering at Jadavpur University, India. While working on a project 'Face Recognition using Zernike Moment Features by Nearest Neighbor classifier' in my 3rd year of undergraduate study, I found my interest in the field of computer vision and machine learning. In order to explore these domains further, I decided to work on the problem of vision-based door detection for autonomous robot navigation using fuzzy classifier, as my undergraduate project under Prof. Amitava Chatterjee. I also developed a micro-controller based system for reducing errors in high voltage measurement by learning error characteristics using polynomial regression methods, which was published in IEEE CALCON conference in 2011.

Looking to delve deeper into research on computer vision and machine learning, I decided to pursue M.Tech at IIT Bombay for the next two years. I worked in the area of computer vision, graphics and human-computer interaction under the supervision of Prof. Subhasis Chaudhuri. My notable contribution was modeling volume preserving virtual clay deformations with real-time interactive graphical rendering and force computation for tactile feedback. The goal was to create an immersive virtual pottery making system. The simple yet realistic design of my proposed deformable virtual clay model allowed real-time force computation at 1 KHz and graphical rendering at 25 fps, while producing deformation results very similar to real life pottery. This work was accepted as an oral paper in IEEE HAPTICS 2014. I also patented a virtual reality headset based chat system, where users can get tactile feedback from a wearable suit while touching objects in a shared multi-client virtual space. Furthermore, while mentoring intern students at Vision and Image Processing (VIP) lab at IIT Bombay, I worked on a project to develop a real-time virtual cloth fitting system using 2D video stream, which was published in Indian Conference on Computer Vision, Graphics and Image Processing (ICVGIP) 2014. Details about all my research projects and publications can be found at my website:https://sites.google.com/site/subhaweb1411/.

Although my primary focus has always been on project-based learning, my avid interest in the concise theoretical understanding of fundamental concepts enabled me to constantly perform well in class. I completed my bachelor's from Jadavpur University with a CGPA 8.9/10 (absolute grading) securing a departmental rank of 3rd/125 students. During my masters studies from IIT Bombay, I obtained a CPI of 9.81/10 ranking among the top students of my class. Courses on computer vision, computer graphics, foundations of machine learning, linear algebra, and statistical signal analysis were instrumental in strengthening my core understanding of the field and further spurred me to pursue graduate study on these topics.

After completing M.Tech, I decided to join NEC Central Research Labs, Japan to gain insight about the industry related practical problems in my field of interest. At NEC, my research revolves around designing computer vision methods for finding deterioration in concrete surfaces. I proposed a crack detection algorithm which analyzes motion fields obtained by frame-wise optical flow from captured videos to find local strain discontinuity. The main advantage of my proposed method is the use of motion fields based inference in a Conditional Random Fields (CRF) framework rather than inferring directly from image intensity. This enabled micro-crack detection that are often not visible in captured image frames. My proposed method got an improvement of 0.14 to 0.22 in F1 score compared to state-of-the-art image based methods. This work has been submitted to IEEE Winter Conference on Applications of Computer Vision (WACV), 2017 and is currently under review. Additionally, I also implemented a fully convolutional network (FCN) based crack detection system that produces localization accuracy close to state-of-the-art methods but at less

computational time producing 16 frame detections per second for VGA images. At present, I am working to improve crack detection further by developing a neural attention-based crack contour tracking method using Recurrent Fully Convolutional Networks for local crack segmentation, along with fully differentiable read and write operation for shifting visual attention. Recently, I was also involved in a project for reducing time complexity for inference in convolutional neural networks (CNN) by reordering pooling and activation layers, which was published in Workshop on Synthesis and System Integration of Mixed Information (SASIMI), 2016. Through my personal research, I am also investigating the possibility of using FCNs for image restoration tasks like image denoising and inpainting. Every project that I have worked on since my undergraduate studies, has given me relevant technical knowledge in my field of interest andhas incited a desire in me to learn more and solve difficult problems, which is exactly my primary motivation for graduate study. The research projects at NEC have especially helped me to keep up with the recent trends in the field of computer vision, deep learning and have also provided me the necessary groundwork to unearth interesting problems for my doctoral studies.

Drawing inspiration from my previous experiences, I have come up with a possible research plan for my doctoral studies. Through my future research in graduate school, I wish to develop deep learning based systems that extract meaningful features from multi-modal data. A possible idea that I would like to explore, is using sequential attention-based models for learning context-aware feature descriptions that can efficiently map fine-grained visual concepts to concise human understandable language. In order to attain my research goals, I wish to associate myself with a well-equipped environment where I can actively participate in cutting-edge research under the guidance of highly esteemed supervisors. I also wish to collaborate with other research groups and build on such collaborative ideas for my research. The College of Information and Computer Sciences (CICS) at the University of Massachusetts, Amherst (UMass Amherst) has some of the world's leading faculty members and researchers in the field of my interest. Hence I find CICS at UMass Amherst, a very promising choice to pursue my graduate study.

At UMass Amherst, I am particularly fascinated by the research conducted by Prof. Subhransu Maji on describable texture models. I am intrigued by his work on *Bilinear CNN Models for Fine-grained Visual Recognition*, which in addition to having the advantages of Fisher Vector-CNN, provides a differentiable framework for end-to-end feature learning. Additionally, his paper on *Visualizing and Understanding Deep Texture Representations*, which argues that bilinear CNNs perform favorably than other CNN methods for providing texture description, has also piqued my interest. Given the chance to work with him, I would like to explore the possibility of mapping features obtained from bilinear CNN models, to natural language descriptions of textures in human understandable form. I am also eager to work with Prof. Erik Learned-Miller after following his joint work with Prof. Maji on *Multi-view convolutional neural networks for 3D shape recognition*, which presents a state-of-the-art CNN architecture for 3D shape recognition from single and multiple views. I would love to work with either of them. Given my research goals and my relevant experience in topics of computer vision, graphics, probabilistic graphical models and deep learning, I believe that I can significantly contribute to the ongoing research at the computer vision lab in UMass Amherst.

While working as a teaching assistant (TA) for three courses at IIT Bombay, I felt great pleasure in exchanging knowledge with students in those courses. Through these assistantships, I have gained experience in the art of lucidly explaining difficult ideas to students and have also learned about proper exams and assignments scheduling for creating an effective course curriculum. Hence, in a few years from now, I see myself as a full-fledged academician, possibly starting my own lab to conduct research on computer vision and artificial intelligence. The training that I shall receive during my Ph.D. at UMass Amherst, will immensely help me in making this long term goal a reality. Therefore, I will be highly grateful if I am given the opportunity to join the graduate division of your esteemed university. I am well aware of the high level of dedication, tenacity and enthusiasm on the part of an individual, required to succeed as a graduate student and I can definitely guarantee my commitment to this cause. I would like to take this opportunity to thank the graduate admissions committee for considering my application and look forward to joining as a graduate student in the College of Information and Computer Sciences at the University of Massachusetts, Amherst.