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Teaching Statement

I have always believed that teaching is most efficient when learning is motivated by seeking solutions to real-world problems. Therefore, those real-world problems should be utilized as the foundation for effective teaching. While we have devoted much effort to developing complete knowledge systems and extensive learning curricula to shape the learning process, my teaching philosophy is largely based on motivations from the real world and a personalized curriculum starting from real-world problems.

My teaching philosophy has been shaped from challenges in my personal learning experience while taking a Linear Algebra course during my sophomore year of college. Instead of applying the linear algebra concepts as solutions to practical problems, the course dove right into the mathematics and theory in the very first class, starting with the determinant. For me, the entire Linear Algebra course seemed like a complicated game where we have to play by artificial rules, such as how to compute the determinant of a 4x4 matrix, Cramer's rule, and Gaussian Elimination. Although I became a master of this game and achieved a great score in the final exam, at that point, I still had no idea about what we were doing. I wasn't able to appreciate the beauty of linear algebra until my first year in graduate school. When I was taught Computer Vision, I finally realized that the previously abstract concept of loosing rank of a matrix corresponds to the degenerate cases where all calibration points lie on the same plane. When I took Linear Systems, I finally understood that all the elimination methods are basic tools to solve large optimization problems in the real world. Those concepts are not only game rules developed by the Linear Algebra teacher, but serve the purpose of solving real-world problems. Unfortunately, I learned it the hard way: because I didn't appreciate the purpose of these abstract principles in my sophomore year and therefore most of them had already been forgotten, I had to re-learn many of the ideas through Professor Gilbert Strang's online course.

The lessons from my bad learning experience have formed my teaching philosophy: never teach (or learn) without a problem in mind. I applied this philosophy when I taught Robotics 778 Mechatronic Design as a teaching assistant at CMU. In this class, the students are given a real-world problem and have to build a real mechatronic system, or a robot, from scratch to solve that problem. For the class I taught, I offered the students two practical problems to chose from: a window washing robot or a pre-tinning machine. Other than some basic introductory information during the first lectures, the teaching and learning were happening purely based on seeking solutions to the practical problems the students encountered during their journey to solve the ultimate window-washing or pre-tinning problem. I taught the students thresholding methods in Computer Vision when they didn't know how to identify and localize the piece to be pre-tinned; I taught PID control and gain tuning when the students found the motor of their conveyor belt did not function well; and I taught the differences between a brushed and a brushless motor when they did not know how to choose a motor for the window cleaning head. Much engineering knowledge, and even some scientific theories, have been taught when the students were actively seeking solutions for a real-world problem. My students were excited to discover the real applications of old knowledge which only seemed to exist in textbooks and were motivated to learn new things to solve a series of real-world problems.

Another class I taught as a teaching assistant was CSCE 121 Introduction to Program Design and Concepts at TAMU. CSCE 121 is an intro-level programming course in which the students were taught the basic ideas in computer programs and learned how to program in C++. When I taught the lab sessions, I also found out that teaching and learning become more efficient when the students have a specific real-world problem in mind. For example, abstract ideas such as class or data structure are difficult to understand without a concrete use case of these concepts. Therefore, when students are befuddled by them, I devised specific problems and encouraged them to implement the program without those concepts. In this way, the students can better understand and more deeply appreciate the learning content, compared to being simply lectured that this is the way to do it.

Motivating learning by real-world problems can also help to shape customized curriculum that can benefit the learning of specific individuals. I largely utilize this idea when I co-instructed CS309 Autonomous Intelligent Robotics at UT Austin, a Freshman Research Initiative course. CS309 is a two-part class in which the students first learn the fundamentals of robotics and artificial intelligence and then finish a final robotics project. Depending on the project the students chose and the approach they took, they may encounter a completely different series of real-world problems. For example, one of my students who was programming a mobile robot faced the problem of how to smoothly and efficiently follow a path first, for which classical control approaches, such as Line-of-Sight (LOS) or PID control, can be the appropriate learning target. Another student of mine saw his robot colliding with an obstacle first, and experienced the obstacle avoidance problem. This was a good opportunity to teach artificial potential field (APF) or cost function representation. It did not make sense to teach the first student APF or cost function, or the second student LOS or PID, first. But after they solved their line-following or obstacle avoidance problem and encountered the other problem, it is the right opportunity for them to learn the other technique. Both students will learn the two basic components of mobile robot navigation, but using a personalized curriculum that benefits their individual learning. I also encouraged students to share their own problems and convince each other that their problem is worth solving.

Another benefit of teaching to solve real-world problems is that it can spark research ideas. Not every real-world problem has a mature solution, and those problems are motivations for open-ended research. While I teach mature knowledge to solved real-world problems, I also value the problems the students encountered, or even imagined, without an existing solution. During my student mentoring experience at UT Austin, especially with undergraduate students, I encouraged them to explore the problem, learn from existing knowledge, and come up with new ideas for which existing solutions are not sufficient. This problem-driven strategy will transcend the simple teacher-learner relationship, and reach a synergy of advising, mentoring, or even collaboration for researching.

Concretely, I look forward to developing teaching components that are driven by real-world problems and complement existing curriculum. My robotics research background requires full implementation of the sense-plan-act (and learn) pipeline, which is therefore filled with real-world problems. I will use those problems as motivation to ignite curiosity, induce learning, or even spark research ideas. I would like to teach undergraduate courses using physical (or simulated) robot platforms as motivation and testbed, before and after teaching, respectively. I would also like to teach graduate-level seminars to identify, propose, define, and eventually address open problems in robotics. Last but not least, I would also like to teach core courses and motivate the learning of many engineering core concepts with real-world problems the students may encounter in their future engineering career. I am qualified to teach introductory engineering courses, such as Dynamics and Control, Linear Systems and Signals, and Introduction to Robotics/Machine Learning.

I am applying for an academic position primarily because I strongly believe in the synergy formed by the problem-driven teaching and learning paradigm, and more importantly, its strong potential to lead to valuable research. As a problem-driven roboticists, my teaching will start from encouraging students to identify real-world problems and try to solve them on their own, then guiding them through the necessary knowledge base through enlightenment rather than pure lecturing, and eventually motivating them to think beyond the already solved problem and identify future research ideas.

In summary, through a problem-driven philosophy, teaching and research will be seamlessly merged together and become one integral part of my academic life. Through motivating students with real-world problems and stimulating their curiosity, I look forward to an interactive teaching and learning paradigm which can lead to efficient learning and even valuable research endeavors.