

Mark Kim

## Essay 1

As a graduate student researcher at San Francisco State University (SFSU), I have had the opportunity to explore diverse research areas. My current work under Prof. Hui Yang on the “AdvisingGPT” project involves using foundation models for automated course equivalency evaluation and personalized academic advising. This research focuses on utilizing foundation and embedding models to enhance student success, while employing techniques such as instruction fine-tuning, retrieval-augmented generation, and prompt engineering. In addition, I am leading the “AI-STAARS” project under Prof. Anagha Kulkarni, where we aim to improve retention and academic achievement in Computer Science through providing academic support and stimulating students’ sense of belonging and identity. This work has informed the forthcoming poster presentation “Metacognition in Computer Science Learning: Perception vs. Reality,” at the National Association of School Psychologists Annual Convention. In previous research roles, I have also delved into topics like clustering and analysis of phishing emails as a research engineer intern at Cofense Inc., where I significantly improved computational efficiency and data utilization. My work at the University of Houston’s NSF REU program equipped me with skills in multi-threaded algorithm development and exploratory clustering. During my undergraduate studies at SFSU, I was also provided the opportunity to work closely with several professors in the fields of Statistics, Mathematics, and Mathematics Education, which included change-point analysis, graphical models for brain networks, and remote instruction pedagogy in Mathematics.

Beyond research-related experiences, I was also very active with instructional activities. These roles included grading, teaching assistant, facilitator, program liaison, and as an instructor. I started as a simple grader for Multivariate Calculus and expanded to being a full

teaching assistant before moving on to facilitating my own supplemental instruction courses. As a facilitator, I was provided the opportunity to teach supplemental courses in: Calculus, up to and including Multivariate Calculus; Introduction to Programming; Data Structures; and Programming Methodology. After completing my undergraduate studies, I was offered a program liaison position, whose role is to lead and manage the facilitators in the Supplemental Instruction Program. These roles have refined my ability to communicate complex concepts effectively to diverse audiences and provide mentorship for facilitators.

State-of-the-art deep learning algorithms today rely on mechanisms that are biologically implausible. They depend on gradient back-propagation, which computes the gradient of an objective function with respect to the weights of a neural network. Such back-propagation raises problematic issues that demonstrate the improbability of such a process in biology. First, back-propagation is a purely linear computation, while biological neurons apply both linear and non-linear operations. Credit assignment, which is the act of determining the influence that an action taken will have on future rewards, in such a paradigm, would require precise knowledge of the gradient in both directions and exact symmetry for the weights. Furthermore, artificial neurons communicate by continuous values, while their biological counterparts communicate through action potentials, which are binary in nature.

One area of research that is of particular interest to me is continual learning, which is a hallmark of human intelligence. Recent work into continual learning use a combination of multiple techniques to allow artificial neural networks to consolidate synapses to mitigate forgetting and strengthen connections between contextual information. Nevertheless, the research still relied on back-propagation of fully connected networks. Brain synapses are unidirectional with physically distinct feed-forward and feedback connections. It is also believed that the brain is capable of localized learning. Investigating neuron architectures with these features in continual learning is an exciting prospect of study for me.

Ultimately, however, I would like to investigate the relationship of affect, behavior, and cognition through computational models.