Robotics has witnessed the formalization of algorithms and computation necessary to carry out simple dynamic tasks over the past six decades. We have closed-form and iterative-based algorithms for analyzing the dynamical behavior of rigid bodies and these methods are well-established for relatively coupled nonlinear dynamics. Nowadays, the research community is exploring the use of soft robots in achieving complex locomotion and manipulation tasks that ubiquitous rigid robots cannot manipulate. Correctly applying the morphological computation properties of these nonlinear, compliant soft robots requires rethinking our way of modeling such dynamical systems -- closed form solutions , when they exist, are often not physically realizable or have a very narrow application scope to physical processes.

I conjecture that the solution to modeling such complicated nonlinear dynamics of soft robots will come from learning the dynamics of such systems from a lot of data, rather than devising clever calculations that more often than not do not scale well to our expectation of the system’s behavior based on our calculations. In recent years, computational models composed of multiple processing layers have been shown to be capable of efficiently inferring nonlinear structure from data with the aid of multiple stages of abstraction. These models, termed deep networks, have dramatically pushed the envelope in modeling the latent spatial, temporal and spatio-temporal properties of nonlinear systems in domains with applications ranging from speech recognition, visual object recognition, object detection, drug discovery and genomics. While we know that deep networks work, progress in theory has been slow and much work remains before a reasonably complete and coherent theory is available.

I am on a quest, exploring the theoretical stability and analysis of these deep networks in order to find useful features from data that can coherently and consistently model nonlinear compliant devices such as soft robots for the purpose of the intelligent control of nonlinear systems. I am currently working on adaptive neuro-control applications that scale models that are learned from data to controllers that enable reachability and intelligent human-like grasp, articulation and control of objects. My specific application motivation is in the radiotherapy treatment of cancer of the head and neck (H&N) region.

I envision a network of compliant soft-robot systems that automatically compensate for the patient's head and neck motion deviation using adaptive deep neuro-control algorithms to compute robust models and generate controllers that scale well to task. The idea is that by actuating elastomeric polymer enclosures that inflate or deflate based on the amount of air that is sent into them or by the amount of pressure that is exerted on them by a human-body part (such as head or neck), we can achieve a desired level of pose in frameless or maskless radiotherapy without sacrificing patient comfort or treatment efficacy as existing rigid robotic motion compensations technologies allow. This would be a revolutionizing approach with applications to other domains of engineering where accuracy in modeling is important.