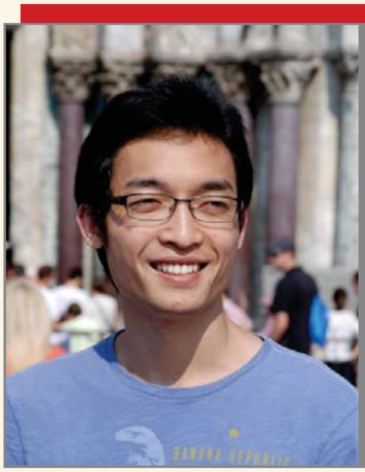
FEB 16, 2017

The art and science of densities and density flows: when densities meet control



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ABSTRACT:

The study of densities and density flows is a rich area both theoretically and practically. Densities may describe the collective response of dynamical systems as well as the distribution of resources, image intensities, and so on, and are key in a wide range of applications. I will present several recent developments of the subject. More specifically, I will cover three interrelated basic topics i) modeling and control of collective dynamics, ii) robust transport of resources over networks, iii) matrix-valued optimal mass transport. In all these, the central task is to estimate, compare and control distributions. The first topic, concerns the steering of a particle system from an initial distribution to a final one over a specified finite time-window with minimum-energy control. It turns out that this is closely related to Optimal Mass Transport (OMT) and to a problem in probability theory with deep physical roots known as the Schrodinger bridge problem (SBP). Recognizing that both, OMT and SBP, are in essence control problems allows the development of a substantial broader theory. Our second topic concerns optimal transportation over networks -- once again an OMT problem over a discrete space. The scheduling amounts to selecting a transition mechanism so as to effect the desired transport. Insights gained from classical SBP has led to a stochastic control formulation that allows equalizing transport over alternative paths, and hence, ensuring a degree of robustness and ensuring reduced congestion. Our final topic is a far reaching generalization of OMT to the novel setting of matrix-valued densities. Our original motivation aimed at developing tools for multivariate time series modeling and matrix-valued power spectral analysis. However, the emergent theory turned out to have immediate applications in diffusion tensor imaging (DTI) where ``images'' are now tensor fields representing orientation and shape of brain white-matter. Thus, the framework I have developed and will present allows us to compare, interpolate and fuse DTI images in a disciplined manner and, thereby, may lead to high resolution advances that in turn promise improved in vivo imaging of important brain structures.

BIOGRAPHY:

Yongxin Chen received his BSc in Mechanical Engineering from Shanghai Jiao Tong University, China, in 2011. He obtained his Ph.D. in Mechanical Engineering from University of Minnesota in 2016 under the supervision of Tryphon Georgiou, with a Ph.D. minor in Mathematics. He is now a postdoc fellow in the Department of Medical Physics at Memorial Sloan Kettering cancer center. He is interested in the application of mathematics in engineering, physics, economics and biology. His current research focuses on control theory, stochastic processes and optimal mass transport theory.