…quantifying uncertainty and capturing the essence of complex and dynamic data sets with innovative mathematical approaches…

My name is Fariba Fahroo, and I have been a DARPA DSO program manager for over two years. Ever since I came to DSO as a Math PM (program manager), I have been trying to answer this question of what it would mean to support fundamental mathematics research in the risky and innovative environment, which is characteristic of DARPA. The big questions I have been grappling with are quantification and management of uncertainty in complex systems, dynamics of Big Data and characterization of complex dynamic networks and their control and influence.

This past year I started a program called EQUiPS (Enabling Quantification of Uncertainty in Physical Systems) where the goal is to identify, quantify, model, propagate and ultimately manage different sources of uncertainty in our modeling and simulations. The effort here is to make UQ (uncertainty quantification) part of our simulation and modeling practice, and therefore make our computational models more predictive. That should apply widely in areas ranging from new aerospace structures to leading-edge integrated circuits.

I have also focused on putting data directly in the discovery process for physical systems. In most cases of complex, dynamical systems that we'd like to analyze, we don't have the luxury of well-defined mathematical models describing the phenomenon of interest. The phenomenon of interest is high-dimensional, nonlinear, uncertain and multiscale, and the mathematical tools are not there to handle the complexity at all these levels. But we have access to large datasets. Here, in considering data in its noisy, incomplete and high-dimensional form, we need to address the fact that data is being obtained from dynamical systems whose behavior is changing and evolving in time.

To address these challenges, I have been exploring mathematical approaches using emerging ideas from algebraic and differential topology, dynamical systems theory and geometric methods for dealing with the extreme high-dimensionality of datasets and physical models. I have been looking for new methodologies and algorithms for extraction of dynamic information. All these programs are multidisciplinary in nature, and this is where I believe DSO can play a unique role by looking at fundamental mathematical questions across various applications and bringing different communities together.

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