RESEARCH SPOTLIGHTS

We are fortunate to have three topically diverse papers featured in Research Spotlights in the current issue. The first of these, “Stochastic Sensitivity: A Computable Lagrangian Uncertainty Measure for Unsteady Flows,” deals with modeling uncertainties in velocity data for the purpose of quantifying their influence when computing Lagrangian particle trajectories of fluids. One application that author Sanjeeva Balasuriya gives for pursuing this line of research is climate and environmental modeling: ocean and atmospheric models utilize velocity data to understand the movement of such quantities of interest as pollutants and plankton, and the trajectories of these quantities of interest have an impact on the environment and climate. This paper fills a gap in the current literature by addressing specifically the impact of velocity uncertainties—including those due to measurement error, turbulence at subgrid levels, or other effects uncaptured by the model—on trajectories. It offers the reader a “set of rigorous computational tools” to quantify the resulting Lagrangian uncertainties as a “physically interpretable field.” The final section contains an extensive discussion in which the author considers connections of this work to uncertainty quantification and illuminates important remaining research directions.

The second article, coauthored by Yuanzhao Zhang and Adilson E. Motter, is entitled “Symmetric-Independent Stability Analysis of Synchronization Patterns.” The stability of synchronization patterns in complex networks is important to understand because of the “significant ramifications in various biological and technical systems” in the absence of such analysis. The key innovation in the present work is the introduction of a new algorithm to find the finest simultaneous block diagonalization (SBD) for any given set of self-adjoint matrices. This permits the extension of the master stability function (MSF) formalism since the proposed method now allows for the optimal separation of perturbation modes from which the stability of arbitrary synchronization patterns can then be undertaken. The authors provide a convincing demonstration of the strength of the new approach by applying their method to characterize permanently stable chimera-like states in multilayer networks. The paper includes a gentle introduction to matrix $*$-algebras and their relevance in developing the new algorithm; code for the latter is available on a GitHub repository, along with test problems. Importantly, the reader should note the potential for SBD in applications beyond the topic considered here—indeed, the authors suggest it may be relevant in other applications that involve many matrices such as control of network systems and semidefinite programming.

The subject of the last of the three articles is extremely timely, as the title “Forecasting Elections Using Compartmental Models of Infection” itself suggests. Authors Alexandria Volkening, Daniel F. Linder, Mason A. Porter, and Grzegorz A. Rempala propose a data-driven mathematical model of the temporal evolution of political opinions during U.S. elections. Key features include the explicit modeling of how states influence each other through a compartmental model of disease dynamics, treating “voting intentions as contagions” that spread between states. Data fitting with polling data is used to specify the values of the parameters in the model, and the model predictions are compared to election outcomes from several recent U.S. elections. The initial model is expanded to a stochastic differential equations model in an effort to capture and quantify uncertainty in a given race. The authors are clear in describing their simplifications in modeling, yet the comparison reveals their forecasting method “performs as well as popular analysts.” In the interest of transparency and in an effort to encourage more readers to become engaged in the remaining research questions, all codes and data associated with the article are available to the public. And yes, the authors also provide a link where the reader can find their model's forecast for the 2020 U.S. election!

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