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PREFACE
SPECIAL ISSUE ON SEQUENTIAL MONTE CARLO METHODS

Over the past three decades, Sequential Monte Carlo (SMC) methods have evolved into a central tool for probabilistic inference and learning in dynamical systems. Since their early development in the 1990s as particle filtering algorithms for nonlinear state-space models, SMC techniques have expanded to a rich and versatile framework underpinning advances in computational statistics, signal processing, machine learning, and the physical sciences. Their ability to generate empirical (sample based) approximations of evolving probability distributions has made them indispensable wherever analytical solutions are unattainable and uncertainty quantification is essential.

The papers collected in this special issue originate from contributions presented at the *5th Workshop on Sequential Monte Carlo*, held in Madrid from 4-6 May 2022. The workshop gathered researchers from diverse communities to share new theoretical insights, algorithmic developments and applications of SMC methods. This special issue reflects the breadth and vitality of current research in the field.

The contributions span a wide range of perspectives. Iñigo Urteaga and Chris H. Wiggins propose an SMC-based framework for Bayesian multi-armed bandits in nonstationary and context-dependent environments. Nicola Branchini and Víctor Elvira present a unified adaptive mixture view of particle filters that generalizes several existing algorithms and enables new design strategies. Alice Corbella and co-authors introduce the *lifebelt particle filter* to prevent particle collapse in discrete low-count settings. Andreas Lindholm and Fredrik Lindsten develop the *particle stochastic approximation EM* algorithm, combining SMC with stochastic approximation for efficient learning of state-space models. O. Deniz Akyildiz provides new convergence guarantees for optimized adaptive importance samplers, a key theoretical component underpinning SMC methodology. Xiongjie Chen and Yunpeng Li review recent advances in differentiable particle filters, highlighting the integration of neural networks into SMC frameworks. Younès Youssfi and Nicolas Chopin propose a scalable waste-free SMC approach for Bayesian bi-level variable selection in high-dimensional regression. Finally, Dan Crisan and co-authors apply SMC methods to noise calibration in stochastic partial differential equations, using the rotating shallow water model as a case study, and illustrating the application of particle filters in high-dimensional settings.

Together, these articles highlight the continuing dynamism of SMC research, bridging theory, methodology, and impactful applications. We hope that they will inspire further advances in this vibrant field.

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