MAE Seminar Series

Fusing Information Theory with Single-Target and Multi-Target Filtering

Friday, February 9
11:00 AM
206 Furnas

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ABSTRACT

Filtering is commonly employed to aid solving a wide array of engineering problems, such as in navigation of vehicles, air traffic management, urban environment monitoring, and space object tracking. In each situation, the focus can be laid upon tracking single objects or towards the estimation of the whole scene involving estimation of both the number and location of multiple objects simultaneously. Many common estimation approaches make use of only limited information regarding the scene. This effectively restricts their ability to provide accurate uncertainty representations, thereby limiting the subsequent probabilistic analyses that can be carried out and the results that can be derived. This is most severe in nonlinear systems that do not lend themselves to a simple Gaussian representation. Information theory provides an array of tools for understanding, analyzing, and interpreting the information content of uncertain systems. It is not, however, straightforward to incorporate these tools in classical estimation systems. The difficulty resides in how to appropriately leverage information-theoretic measures, such as entropy and divergence, to the estimation of uncertain systems.

This talk will begin with an overview of research related to the development of nonlinear/non-Gaussian estimation theory, with a particular focus on application to the sparse-data environment of space object tracking. An information-theoretic approach is then developed for use with filtering algorithms to construct a novel approach to determining conjunction events between multiple objects within a multi-target tracking problem. Finally, advancements in the understanding of the information content of observations are shown, leading to a distributional characterization of the strength of measurements, which can be utilized in information-theoretic sensor tasking.

BIO SKETCH

Kyle J. DeMars received his Ph.D. in aerospace engineering from The University of Texas at Austin in 2010. In his thesis work, he developed a navigation filter for the NASA ALHAT project that was designed to facilitate precision autonomous planetary landing navigation and led to two successful real-time field tests. During his time at UT, he also worked on topics related to space object tracking and developed an adaptive Gaussian mixture method for uncertainty propagation. After completing his studies, Dr. DeMars was a National Research Council Postdoctoral Research Fellow with the Space Vehicles Directorate of the Air Force Research Lab, where he developed novel non-Gaussian approaches to initial orbit determination and worked on methods to assess the information content of measurements. Currently, Dr. DeMars is an Assistant Professor of aerospace engineering at Missouri University of Science and Technology, where his research group focuses on developing computationally efficient methods for uncertainty quantification. His research has led to advances in approaches for rigid-body attitude uncertainty propagation using directional statistics, developments in multi-target tracking for space object tracking, techniques for the determination of conjunction events including uncertainties, and novel information-theoretic sensor tasking methods. At Missouri S&T, he has carried out multiple research projects with AFRL, MDA, NASA JSC, NASA GSFC, and private industry, among others.

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