From the Editor-in-Chief:

December 2016

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Guest Editorial: Foreword to the Special Issue on Estimation Involving Directional Quantities

Estimation problems that involve directional quantities naturally arise in applications that range from signal processing, robotics, and aerospace to bioinformatics and geosciences. Directional approaches differ from traditional estimation methods intended for real vector spaces because they consider the underlying manifold structure of directional problems, e.g., the unit circle, the hypertorus, or the group of rigid body motions.

The question of how to apply methods from directional statistics in the context of estimation and filtering problems has recently gained significant interest as directional problems are abundant in a plethora of applications and classical estimation methods are being pushed to their boundaries. As a result, we believe that this field of research is highly relevant for the estimation and information fusion community.

We are proud to present this special issue of the Journal of Advances in Information Fusion. It comprises eight papers in total, some of which are extended versions of papers originally presented in the special session on directional estimation at the International Conference on Information Fusion in 2014 and 2015.

We start the special issue with the paper "Stochastic Filtering Using Periodic Cost Functions" by Eyal Nitzan, Tirza Routtenberg, and Joseph Tabrikian. This paper proposes two novel approaches for estimation of circular states, a sample-based method and a Fourier-based method, which can be used to minimize a predefined cost function.

The second paper "Methods for Deterministic Approximation of Circular Densities" by Gerhard Kurz, Igor Gilitschenski, Roland Y. Siegwart, and Uwe D. Hanebeck deals with deterministic sample-based approximations of circular densities and presents novel algorithms based on superposition of multiple sample sets as well as an algorithm that relies on a binary tree.

Afterwards, we turn our attention to the sphere with the paper "Multitarget Tracking with the von Mises–Fisher Filter and Probabilistic Data Association" by Ivan Markovic, Mario Bukal, Josip Cesic, and Ivan Petrovic. Here, the authors apply the idea of the joint

probabilistic data association filter (JPDAF) to spherical multitarget tracking problems and combine it with von Mises-Fisher-based filtering.

On the topic of the rotation group SO(3), the special issue includes the paper "Density Estimation on the Rotation Group using Diffusive Wavelets" by Nicolas Le Bihan, Julien Flamant, and Jonathan H. Manton. Their paper is devoted to density estimation using two novel methods, the first being based on characteristic functions and the second relying on wavelets using the heat kernel.

Then, the paper "Uncertainty Propagation of Correlated Quaternion and Euclidean States using the Gauss-Bingham Density" by Jacob E. Darling and Kyle J. DeMars considers the problem of uncertainty propagation on the group of rigid body motions. For this purpose, a generalization of the Bingham distribution is presented that can consider Euclidean vectors along with quaternions while taking their correlation into account.

Another relevant manifold in directional estimation is the hypertorus, which is investigated in the paper "Multivariate Angular Filtering Using Fourier Series" by Florian Pfaff, Gerhard Kurz, and Uwe D. Hanebeck. The paper presents novel algorithms for multimodal filtering on this manifold based on a multivariate Fourier series representation either of the probability density or its square root.

More generally, Salam Said and Jonathan H. Manton do not restrict themselves to a particular manifold in their paper "Particle filtering with observations in a manifold: A proof of convergence and two worked examples," but rather present some very universal results. The paper includes a proof of convergence as well as examples involving SO(3) and the unit sphere.

We conclude the special issue with the paper "Direct Position Determination for TDOA-based Single Sensor Localization" by Christian Steffes and Marc Oispuu. This paper deals with the application of localization using TDOA sensors, a practical problem that involves directional quantities. Four different localization methods are proposed and compared with the Cramér-Rao Lower Bound.

At this point, we would like to thank the Journal of Advances in Information Fusion (JAIF) Editorial Board, the editor in chief Uwe D. Hanebeck, as well as all involved authors and reviewers for making this special issue possible.

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