TAMPEREEN TEKNILLINEN YLIOPISTO
TAMPERE UNIVERSITY OF TECHNOLOGY

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examiner's statement

Hamza Benzerrouk's PhD thesis of "Modern Approaches in Nonlinear Filtering Theory Applied to Original Problems of Aerospace Integrated Navigation Systems with non-Gaussian noises"

This review is based on a draft which is 130 pages long and includes an introduction (pp. 1-68) and 6 scientific papers (2 journal papers. 4 conference papers). The introduction summarises the work reported in these papers and in other journal and conference publications written by the candidate. However, I only consider the material in the (draft) thesis.

In summary, I find that the thesis fulfils the requirements of a PhD in engineering. The main contribution is a large number of simulation and experimental case-studies. These studies compare the effectiveness of state-of-the-art Kalman-type filtering algorithms in tracking applications with GNSS and INS measurements. A novel feature of the work is its consideration of noise signals containing outliers, which it treats by extending a method of Djeddi & Benidir (2006).

Detailed remarks

Because I was asked to provide a review quickly (within one week), I can provide only a few detailed remarks. I will focus these remarks on the non-Gaussian filtering algorithm.

Filtering for non-Gaussian probability distributions is an important and current topic of research. These distributions require approximate filtering methods. With particle filters, non-Gaussian distributions are not a practical challenge — in the code one simply replaces the Gaussian random number generator by a RNG for the non-Gaussian distribution. With Kalman-type filters, it is not so easy. There are a however a number of "robust Kalman" filters in the literature, some (e.g. variational Bayes) quite recent. The thesis discusses only two such methods: a divided-difference filter method by Karlgaard and Schaub (2007) and a UKF method by Djeddi & Benidir (2006). The thesis (p. 38) asserts that it contains comparisons of these two methods but I did not find such results in the thesis.

The robust filter focused on in the thesis is the UKF method of Djeddi & Benidir. The thesis does not include a mathematical derivation of the method. Kullback-Leibler divergence is mentioned, but the method is very different from the variational-Bayes filter, which is also based on Kullback-Leibler divergence.

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The thesis presents (p. 58-59) some details about how to adapt the method of Djeddi & Benidir to cubature filters. As cubature filters have the same structure as UKF, I expect that such an adaption should be relatively straightforward.

The thesis presents results of case-study comparisons of robust vs conventional filters and asserts that these the robust filter shows better performance. However, the Figures are poor (too many curves, cryptic labels, etc) and I did not find the evidence that supports the assertion. A simple example with two filters and a single clear outlier would help show whether the proposed robust filter is able to handle outliers.

In general the English language is correct and readable. There are unfortunately many signs of hastiness (mispellings, incorrect equation references etc) which could be corrected by more careful editing. Also, the algorithm and test example descriptions are sketchy and not complete enough to allow replication.

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