1989c

"A Simple Kalman Filter and Smoother for Spacecraft Attitude," M. D. Shuster, *The Journal of the Astronautical Sciences*, Vol. 37, No. 1, January–March, 1989, pp. 89–106.

This work, the second in the QUEST trilogy showed the connection between the Kalman filter and Kalman smoother prediction and update steps and the accumulation and extrapolation of the attitude profile matrix $\boldsymbol{B}$ for systems without process noise. An approximate method was also developed for simulating the effects of process noise through a fading-memory factor. This attitude-only filter, Filter QUEST!, as it was called, performed quite well, given that it was only approximate, but the estimate error levels (in standard deviation, worst axis) were twice as large as those of the unapproximated Kalman filter for the real system (MSX) for which it was being examined as a candidate attitude estimation algorithm. The attitude estimation algorithm that was eventually used for MSX was that of 1989d and 1990d.

The REQUEST algorithm of Bar-Itzhack (1996, *Journal of Guidance, Control and Dynamics*) and his later conference report (*Proceedings of the 12th International Symposium on 'Space Flight Dynamics,'* ESOC, Darmstadt, Germany, June 2–6, 1997, pp. 153–158) are trivial, less direct, and computationally more burdensome variations of Filter QUEST! and Smoother QUEST! The many publications of the REQUEST filter and REQUEST smoother simply repeat slavishly the equations of 1989c with trivial modification. In a more recent paper on Optimal REQUEST (*Journal of Guidance, Control and Dynamics*, May–June 2004), Choukroun, Bar-Itzhack and Oshman referred to 1989c so obscurely that readers (and reviewers) of the Optimal REQUEST paper would be unlikely to examine it. The same treatment was given to the first REQUEST paper published in 1996. Both my 1989 article and the 1996 REQUEST article of Bar-Itzhack are references 23 and 24, respectively, and are references for a statement so vague that it could refer to any sequential estimator. The result of the obscurity of these references is to make the Optimal REQUEST paper seem more original to readers and reviewers unfamiliar with the previous literature than it actually is. I ask readers to determine for themselves whether this was the intent of Choukroun, Bar-Itzhack and Oshman in making the citation of these two works so unnecessarily obscure. Should not the 1996 REQUEST paper have been the first cited reference?

The justification of some of the assertions of the first REQUEST paper of 1996 can be questioned. Bar-Itzhack claimed in 1996 that he was studying the filter in terms of Davenport's $\boldsymbol{K}$ matrix rather than the $\boldsymbol{B}$ matrix (see 1989c), because it is more fundamental. $\boldsymbol{K}$, a 4×4 matrix, is a trivial linear function of the 3×3 matrix $\boldsymbol{B}$. I know of no presentation of the $\boldsymbol{K}$ matrix in the literature (including Bar-Itzhack's 1996 REQUEST article), which does not derive $\boldsymbol{K}$ from $\boldsymbol{B}$. Hence, the statement that $\boldsymbol{K}$ is more fundamental than $\boldsymbol{B}$ is simply false.

The QUEST algorithm, like every other batch quaternion-based algorithm for solving the Wahba problem, calculates the quaternion by first calculating K from B. In the update step of Filter QUEST!, one first calculates $B(+) = B(-) + \Delta B$, and then calculates $K(+)$ from $B(+)$ (within the QUEST algorithm) to obtain the quaternion. The "innovation" of REQUEST is to first calculate $K(-)$ from $B(-)$ and ΔK from ΔB (using the same linear equation) and then to calculate $K(+) = K(-) + \Delta K$. REQUEST simply reverses the order of two steps which may be performed in either order. The resulting $K(+)$ is the same in both cases. We note also that ΔB is very simple in form, while ΔK is very messy, giving further lie to the assertion of Bar-Itzhack that K is more fundamental than B. The transformation of the prediction step from B to K is equally trivial. However, in Filter QUEST!, one simply multiplies two 3×3 matrices, while in REQUEST, one must multiply three 4×4 matrices at an enormously greater computational burden. I ask readers to examine my 1989 article and the Bar-Itzhack REQUEST paper of 1996 and decide for themselves whether or not Bar-Itzhack's paper is a trivial plagiarism of my work.

The 2004 Optimal REQUEST paper did contain an innovation. This was a set of equations for computing the fading-memory factor in a point-by-point manner. This is a truly stupid innovation, however, because Optimal REQUEST has a computational burden as great as that of the unapproximated Kalman filter (see 1982c) while being only an approximation of the latter. It is, thus, a valueless, silly innovation. Thus, the strength of the Optimal REQUEST paper of 2004 is in material already published by Bar-Itzhack in 1996, which itself was a trivial modification of material that I had published in 1989!

I contend that this article could not have been published without the collusion of reviewers and the associate editor.

Succeeded 1981a,1989b

Succeeded by 1990d. (See the comment for 1981a for the complete sequence of QUEST-related archival publications.)