Review of TUFFC-05649-2013: "A Fast Minimum Variance Beamforming Method Using Principal Component Analysis"

I. Summary

The authors present a PCA-based fast MV beamformer that displays performance close to the full MV beamformer with reduced computational complexity. The method is tested on simulated and experimental data.

II. Concerns

1) $w_m[n]$ should be complex conjugated in (1).
2) No motivation is given for Section II. Is this simply general background theory, or will it be used later. This should be stated.
3) Specify that (5) is the *spatially smoothed* covariance matrix. Is this the covariance matrix that will be treated in your algorithm and used in Section III-A? This should be specified.
4) It is not a good explanation that MV beamformed images tend to "look awkward". What are the actual errors; amplitude errors, misplaced sources, something else? What is "this problem"; the authors need to be more specific.
5) Are you averaging across time, or across the depth direction or both in (10)? Is this applied throughout the paper, or are you simply stating what is commonly done by other people.
6) It is very confusing that the results of (5), (8), and (10) are all denoted by $\tilde{\mathbf{R}}[n]$ when they are quite different. It is not at all clear which one is applied in Section III-A. Can anyone be applied, and if so what are the differences?
7) Section III-A should be started with some sort of motivation. It should also be made quite clear which results from Section II you are using. A suggestion would be to specify what you mean by "standard MV" (which covariance matrix from Section II is actually used) and make it much more clear what you mean by "applying PCA".
8) "Sample number" after (11) should be "number of samples". Actually, it should be neither, because it is not at all clear that you are here referring to the number of calculated weights. "Sample" is a very vague description.
9) The authors should repeat the definitions of L and K in Section III-A for clarity; you could e.g. call them "subarray length" and "temporal snapshot length".
10) Have the authors investigated the beampatterns of the eigenvectors $\mathbf{v}_l$? If the resulting weight vectors can be written as a linear combination of a small number of such eigenvectors, it is my intuition that these eigenvectors might make sense on their own. It would be especially interesting to compare them to the transformation vectors in the beamspace transformation matrix from [11], the better to understand the relationship between beamspace and PCA.
11) Theoretically, the method is interesting. However, I am not convinced about the practical application of the method. I am referring to the fact that you assume that the weights can be calculated off-line for a "similar situation". This is both unlikely and unrealistic, especially for adaptive beamformers such as MV, which are very sensitive to the situation. In fact, this large restriction of the method was not mentioned neither in the abstract nor in the introduction, which gives an unfair impression that the PCA method is an "equal peer" to alternatives such as [11] and [15]. The authors should discuss this critical and limiting aspect of the method to a much larger extent, thus I would also like to see more simulations of weights calculated from different scenarios.

11 and [17] refer to the same document.

III. Conclusion

The derivation in Sections II and III-A should be made much more consistent. They are actually highly dependent on each other, but in this paper they seem like two separate parts. In addition, the fact that the weights must be calculated for similar situations should be discussed more and the specification of what constitutes a "similar scenario" should be presented. If the conclusion is that practically any scenario will do, I suspect that there exists a theoretically much simpler method (perhaps like [11] or [15]) that does the job just as well. If not, then the effect of different scenarios must be investigated much more.