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Author contact	*fernando.delahuchaarce@esat.kuleuven.be* *Phone number: + 32 (0)16 32 45 67*
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Comparison of bit depth allocation problems for signal estimation in wireless sensor networks

Fernando de la Hucha Arce
STADIUS group, Dept. of Electrical Engineering (ESAT)
KU Leuven
Kasteelpark Arenberg 10, 3001 Leuven, Belgium
fernando.delahuchaarce@esat.kuleuven.be

Marc Moonen
STADIUS group, Dept. of Electrical Engineering (ESAT)
KU Leuven
Kasteelpark Arenberg 10, 3001 Leuven, Belgium
marc.moonen@esat.kuleuven.be

Marian Verhelst
MICAS group, Dept. of Electrical Engineering (ESAT)
KU Leuven
Kasteelpark Arenberg 10, 3001 Leuven, Belgium
marian.verhelst@esat.kuleuven.be

Alexander Bertrand
STADIUS group, Dept. of Electrical Engineering (ESAT)
KU Leuven
Kasteelpark Arenberg 10, 3001 Leuven, Belgium
alexander.bertrand@esat.kuleuven.be

***Abstract*—In wireless sensor networks (WSNs) it is crucial to use resources, such as energy and communication bandwidth, in an efficient manner. The bit depth used to encode the sensor signal samples heavily influences energy consumption, as it strongly impacts the amount of information to be transmitted between the sensor nodes. Bit depth allocation problems seek to assign a certain bit depth to each sensor signal such that the total energy consumption is minimized while a performance constraint is still respected. We focus on a multi-channel signal estimation task for the WSN, which has applications in, e.g., speech enhancement for wireless acoustic sensor networks [1] and artifact removal in electroencephalography (EEG) networks [2]. For the sake of simplicity, we assume a centralized architecture where all sensor signals are transmitted to a fusion centre (FC). Two common approaches for signal estimation are linearly constrained minimum variance (LCMV) beamforming [3] and minimum mean squared error (MMSE) estimation, also known as multi-channel Wiener filter [1]. We compare the bit depth allocation problem based on MMSE with the bit depth allocation problem in [3] for the case of LCMV beamforming. A difficulty of both problems is the non-convexity of their constraints, which for the LCMV case is solved through the use of convex relaxation via the matrix inversion lemma [4]. We show how the application of the matrix inversion lemma allows to transform the MMSE constraint into a convex constraint, which can then be interpreted as a constraint on the excess MMSE due to quantization, without requiring convex relaxation. This has the important consequence that the bit depth allocation problem based on MMSE is less complex to solve, and its solution is guaranteed to be optimal up to discretization. To conclude the paper, we compare the complexity of the algorithms to solve both problems with numerical simulations.**

***Index Terms*—Signal estimation, beamforming, noise reduction, rate allocation, wireless sensor networks**

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