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DECLARATION OF GERARD P. GRENIER

I, Gerard P. Grenier, am over twenty-one (21) years of age. I have never been convicted of a felony, and I am fully competent to make this declaration. I declare the following to be true to the best of my knowledge, information and belief:

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8. The article below has been attached as Exhibit A to this declaration:

A.	Jacek Dmochowski, et al, "Direction of Arrival Estimation Using the Parameterized Spatial Correlation Matrix", IEEE Transactions on Audio, Speech, and Language Processing, Vol. 5, Issue 4, April 23, 2007.

9. I obtained a copy of Exhibit A through IEEE Xplore, where it is maintained in the ordinary course of IEEE's business. Exhibit A is a true and correct copy of the Exhibit, as it existed on or about May 19, 2020.

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11. Jacek Dmochowski, et al, "Direction of Arrival Estimation Using the Parameterized Spatial Correlation Matrix" was published in IEEE Transactions on Audio, Speech, and Language Processing, Vol. 5, Issue 4. IEEE Transactions on Audio, Speech, and Language Processing, Vol. 5, Issue 4 was published on April 23, 2007. The article is currently available for public download from the IEEE digital library, IEEE Xplore.

12. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001.

I declare under penalty of perjury that the foregoing statements are true and correct.

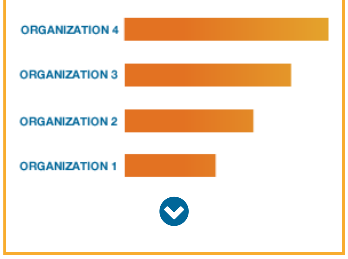
Executed on: 20-May-2020

EXHIBIT A

Direction of Arrival Estimation Using the Parameterized Spatial Correlation Matrix

Publisher: IEEE

3 Author(s) Jacek Dmochowski ; Jacob Benesty ; Sofine Affes **All Authors**



Abstract

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Abstract: The estimation of the direction-of-arrival (DOA) of one or more acoustic sources is an area that has generated much interest in recent years, with applications like autom... **View more**

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Abstract:
The estimation of the direction-of-arrival (DOA) of one or more acoustic sources is an area that has generated much interest in recent years, with applications like automatic video camera steering and multiparty stereophonic teleconferencing entering the market. DOA estimation algorithms are hindered by the effects of background noise and reverberation. Methods based on the time-differences-of-arrival (TDOA) are commonly used to determine the azimuth angle of arrival of an acoustic source. TDOA-based methods compute each relative delay using only two microphones, even though additional microphones are usually available. This paper deals with DOA estimation based on spatial spectral estimation, and establishes the parameterized spatial correlation matrix as the framework for this class of DOA estimators. This matrix jointly takes into account all pairs of microphones, and is at the heart of several broadband

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their performance to TDOA-based locators. In addition, an eigenanalysis of the parameterized spatial correlation matrix is performed and reveals that such analysis allows one to estimate the channel attenuation from factors such as uncalibrated microphones. This estimate generalizes the broadband minimum variance spatial spectral estimator to more general signal models. A DOA estimator based on the multichannel cross correlation coefficient (MCCC) is also proposed. The performance of all proposed algorithms is included in the evaluation. It is shown that adding extra microphones helps combat the effects of background noise and reverberation. Furthermore, the link between accurate spatial spectral estimation and corresponding DOA estimation is investigated. The application of the minimum variance and MCCC methods to the spatial spectral estimation problem leads to better resolution than that of the ...

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Contents

I. Introduction

Propagating signals contain much information about the sources that emit them. Indeed, the location of a signal source is of much interest in many applications, and there exists a large and increasing need to locate and track sound sources. For example, a signal-enhancing beamformer [1], [2] must continuously monitor the position of the desired signal source in order to provide the desired directivity and interference suppression. This paper is concerned with estimating the direction-of-arrival (DOA) of acoustic sources in the presence of significant levels of both noise and reverberation.

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