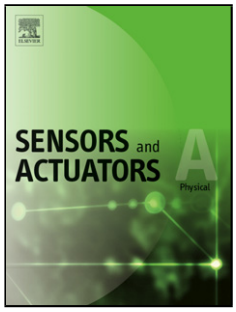

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Acoustic source localization using 10-microphone array based on wireless sensor network

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Highlights

- 1. We propose use of a 10-element microphone array to enable accurate location of a point acoustic source.
- 2. We propose use of a hardware method to measure the accurate timestamp instead of the traditional cross-correlation or other spectral analysis methods.
- 3. The sensor nodes can merely transmit these timestamps to the processing center, thus they have near real time characteristics and greatly reduce energy consumption and communication overheads.
- 4. Simulations and experimental results show that the acoustic source can be localized to within 1 m in 3D coordinates within a 300 m 300 m test area.

Abstract

To enable accurate location of an acoustic source in a large field using the lowest possible number of sensors (sensor nodes), we propose the use of a 10-element microphone array with the time delay of arrival (TDOA) method. The 10-element microphone array consists of a small five-element spatial sub-array and an external five-element planar sub-array. The former sub-array is used to calculate the angle at which the acoustic source is located, while the latter sub-array computes the distance from this source to the central sensor node. The processing center then combines these values using the least error approximation (LEA) to estimate the source location accurately. The TDOA measurement approach is commonly used in acoustic source localization. In previous studies, researchers tended to use cross-correlation or other spectral analysis methods to estimate the TDOA. However, in this research, we propose the use of a hardware method to estimate the TDOA. In the proposed network, each sensor node immediately captures the absolute timestamp when it receives the impulsive transient acoustic signal, i.e., the absolute time of arrival (TOA). The sensor nodes then simply transmit these timestamps to the processing center, thus greatly reducing both energy consumption and communications overheads. Simulations and experimental results show that the acoustic source can be localized to within 1 m in 3D coordinates within a 250 m $\times$ 250 m test area.

Keywords: detonation localization; microphone array; least error approximation; absolute timestamp; wireless sensor network

1. Introduction

Traditional methods for assessment of munitions performance commonly use optical instruments, radar or acoustic sensors. Optical methods have been used in various forms for many years. Operators set up manual theodolites to mark the angles from the observer posts to the event location. Use of a combination of the angles from multiple theodolites then allows triangulation of the detonation position [1]. Because of the high speed of the target and the limited frame frequency of the theodolite, it is often difficult to acquire the target and thus the smoke that remains after the explosion is usually used as a reference, which will then lead to large measurement errors. Radar