COLLABORATIVE PROCESSING OF ACOUSTIC AND MAGNETIC DATA VIA HETEROGENEOUS SENSOR NETWORKS

Lei Liu[1,2,3]*, Yongqiang Chen*[1,2]*,Jin Zhan*[2]*, Minhui Zhu*[1,2]

[1]National Key Laboratory of Microwave Imaging Technology, Beijing 100190, China
[2]Institute of Electronics, Chinese Academy of Sciences, Beijing 100190, China
[3]Graduated School of Chinese Academy of Sciences, Beijing 100039, China

Email:liulei211@163.com

ABSTRACT

Wireless sensor networks (WSNs) are made up from plenty of low-cost sensor nodes, which are well suited for a wide range of application including surveillance - terrestrial and oceanic surveillance. Being nearly close to targets for WSNS s sharply eliminates the influence of circumstance noise and collaboration of multi-sensors (acoustic, magnetic, radiation, mechanical) enhances the ability of detection. In this paper, an effective approach is proposed in order to process collaboratively acoustic and magnetic data from heterogeneous nodes in underwater sensor networks.

Methods of processing either acoustic or magnetic data are recently found in [1, 2], especially a new joint processing also is found in [3]. However, this joint processing of signals of acoustic and magnetic is not suit for sensor networks because of lightweight but large number of densely deployed nodes..

Most acoustic detection and location methods in WSNs are based on the fact that signal decay as a function of the distance. The signal intensity received by *i*th acoustic node is S_{Ai}

$$S_{Ai} = \frac{G_i P_0}{\left|\vec{r}_i\right|^2} \tag{1}$$

where the vector $\vec{r}_i = \vec{r}_{ith-node} - \vec{r}_{object}$ is the object position relative to *i*th node, P_0 is source signal power and G_i is the gain of ith node.

Anomaly magnetic detectors such as scale magnetometers are used to search for hidden ferromagnetic object or produce an alarm signal when moving ferromagnetic target passed nearly magnetic nodes. If the distance is larger than the size of object, the object can be considered as a magnetic dipole, which generates the magnetic field at ith node is

$$\vec{B}_i = \frac{\mu}{4\pi r_i^3}\left[3\left(\overleftrightarrow{M} * \vec{r}_i\right)\vec{r}_i - \overrightarrow{M}\right] \tag{2}$$

where $\mu = 4\pi * 10^{-7} H/m$, and $\overrightarrow{M}$ is the magnetic moment of object.

A signal of *i*th scale magnetometer is considered as the projection $\overrightarrow{B}_i$ onto the ambient Earth's magnetic field $\overrightarrow{B}_E$ ($\left|\overrightarrow{B}_E\right| >> \left|\overrightarrow{B}_i\right|$).Namely, the anomaly magnetic signal from *i*th nodes is S_{Mi}

$$S_{Mi} = \frac{\overrightarrow{B}_i \bullet \overrightarrow{B}_E}{\left|B_E\right|} \tag{3}$$

Both the acoustic and magnetic signal decay models are simulated and shown is Figure 1.

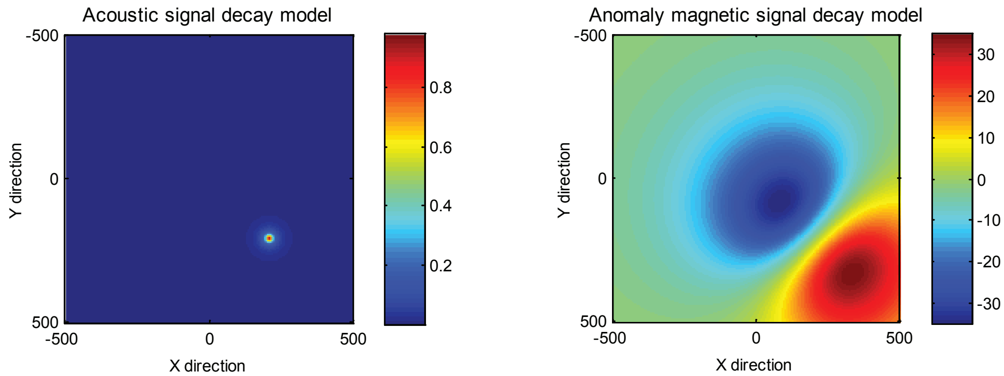

Figure 1 Acoustic (left) and anomaly magnetic (right) signal decay model

Since it more difficult to locate the object using anomaly magnetic data than using acoustic data, we can theoretically get the location of object and source power using acoustic data, then substitute its estimated position to equation (2) and (3) to get its magnetic moment. Based on the moment and source acoustic power, the feature of object can be extracted in order to classify the object. The processing is shown as Figure 2.

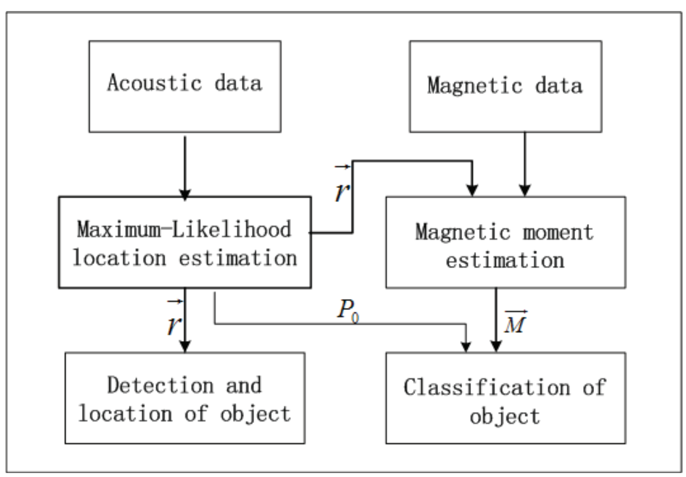

Figure 2 Collaborative signal processing in heterogeneous WSNs

Furthermore, its accuracy of estimating position, acoustic power and magnetic moment is discussed through simulation. And the collaborative processing would be compared to the processing using only acoustic or only magnetic data

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