AN INTRODUCTION TO WIRELESS ACOUSTIC SENSOR NETWORKS AND ITS APPLICATIONS

K. Banuroopa, D. Shanmuga Priyaa*

Abstract

Wireless acoustic sensor networks (WASNs) or Wireless microphone networks are a future enhanced technology for acoustic data acquirement and processing. Conventional microphones pick up the audio for processing from huge distances from the source. But WASNs cover a large area of interest and can pick up the audio near to the source. The applications of WASNs are inclusive but not conclusive to underwater wireless Acoustics applications, environmental pollution monitoring and smart city using loT, etc. This paper gives an overview of applications using WASNs and the challenges in implementing the same.

Keywords: Wireless Acoustic sensor networks, WSN, Under Water WASN.

I. INTRODUCTION

An audio network is a technique of arranging equipment to detect the audio waves. It is chiefly used under water [1]. They might be as tiny or as bulky as necessary by the consumer's stipulation. The audio sensor networks were first used as uncomplicated ping-based sonar in the audible range throughout the cold war period to observe the movement of submarines. Now more advanced acoustic networks are there for submarine and hostile ships detection [2]. The uncomplicated audio network compromises of one observation in one frequency involving audio source and audio receiver. The working principle of every acoustic network is the same; Distance covered is the product of velocity of the audio signal and time travelled. When the time travelled and speed of audio waves are known then calculation of the distance among source and recipient is easily done. Generally in all networks, the speed of the audio wave will be pre-defined for a certain environmental condition [3].

An acoustic sensor network consists of several nodes each of which has the capability of sensing, sampling audio signals and computing facilities. They are linked in a wireless network [1]. Even though they are spatially distributed, they can envelop a huge area and however have a sensor near to pertinent audio sources. The rationale of the network is the momentous summation of acoustic signal from an assortment of sensors consecutively to convey high-fidelity audio output or to categorize environmental sounds or acoustic scenes [4]. Applications vary from prop up for smart home to superior teleconferencing and extensive environmental observation [5][6].

In the viewpoint of acoustic signal processing, WASNs also offer merits relating to conventional (wired) microphone collections [7]. For instance, they facilitate augmented spatial exposure by dispensing microphone nodes over a generously proportioned amount, a sizable structure, and probably improved signal-to-noise ratio (SNR) features. Indeed, as the accuracy of the range depends equally on the signal transmission speed and the meticulousness of the Time of Arrival (TOA), aural signals possibly favoured with regard to radio signals [8].

Larger networks are restricted only by the quantity of paraphernalia obtainable and computing power essential to determine the ensuing data. The most recent sound networks used in the marine seismic industry can determine a network

Department of Computer Science,
Karpagam Academy of Higher Education, Coimbatore, Tamil Nadu, India
*Corresponding Author

of around 16,000 finite ranges within few seconds.

Several applications involving processing of acoustic signals like hearing aids, hands-free devices or immersive sound recording has acoustic array processing. Although a few auditory sensing and processing systems have been planned over the most recent years, these are classically depended on high efficiency computing systems and high-priced microphone arrays. Even though microphone arrays give a superior efficiency than single-microphone systems, a few restrictions occur because of the location of the microphones are fixed, and a centralized processor processes all the signals. The substitute is to utilize reasonably lower cost products with sensing devices and algorithms which can detect, localize, or characterize auditory events. As the wireless, battery-powered nodes are less costly, they can be easily used in an extensive assortment of places. In addition, as opposite to conventional microphone arrays that can sense an acoustic environment in the vicinity, disseminated audio sensing systems sanction several supplementary sensors to envelop an enormous vicinity of significance.

II. APPLICATIONS

Wireless Acoustic Sensor Networks (WASN) has been used in the Smart City application and Internet of Things (IoT) [6]. In last few years, there has been a speedy development of WASNs, and countless mechanism has been developed. The amalgamation of remote acoustic sensors with automatic sound recognition has given a prevailing promising technology for studying both natural and urban environments. So far, copious authors have designed and deployed WASNs for assorted purposes, such as noise monitoring or sound identification of road traffic, people, animals, or gun shots.

The underwater acoustic sensor networks (UWASNs) are using WSANs under the water in sea or rivers. The applications for using this technology are numerous ranging from bio-life monitoring to seismic pressure sensing during an earth quake in an ocean [9].UWASNs unearth their deployments in areas reminiscent of extraction of off-shore oil and gas, ocean oil spills, surveillance and investigation in the army, mining, monitoring of pollution, predicting natural calamities like tsunami and forecasting hurricanes, coral reef and habitat monitoring of aquatic life and fish cultivation [2]. In [10], the authors put forward a method for monitoring an underwater pipeline to damage. Engineers at L3 Oceania [11] have deliberated a sub-sea wireless network to be used in deep sea inhospitable regions for running significance. AUSSNet can collect, process, store and forward imperative observation data to get better vigilance and devotion to any unforeseen situations.

In [12] and [13] the authors propose an UWASN to observe the quality of water and the extent of pollutants. pH, turbidity and temperature of the testing surfaces can be collected by underwater acoustic sensors. The gathered data is communed to a node having GPRS connectivity, that will in turn transmit the data gathered to the closest control centre. Authors in [13] have offered a disseminated system based on underwater audio sensors which have small range aural modems for communication, for monitoring pollution in the ocean and discovering wreckages in the ocean,

The environmental sound monitoring has been influenced by the augment of Internet of things technology within smart cities using the design and improvement of wireless acoustic sensor networks (WASNs) [14].In [15] the authors propose a method using wireless acoustic sensor networks for surveillance of bio diversity in a natural environment. The structural design of the setup and assembly of the sensors are also shown.

III. CHALLENGES

One of the foremost challenges in wireless acoustic sensor networks (WASN) based speech enhancement is

strong and precise voice activity recognition [16]. Another challenge faced by WASN systems is synchronization of the nodes. To overcome this challenge and method is discussed in[17].

IV. CONCLUSION

This paper gives an introduction to Wireless acoustic sensor networks. Its architecture, use-cases in various scenarios was also discussed. The challenges in deployment of the WASN in various applications were also reviewed.

REFERENCES

[1] Maximo Cobos, Fabio Antonacci, Anastasios Alexandridis, Athanasios Mouchtaris, and Bowon Lee. (2017). A Survey of Sound Source Localization Methods in Wireless Acoustic Sensor Networks. Wireless Communications and Mobile Computing Volume 2017, Article ID 3956282, 24 pages https://doi.org/10.1155/2017/3956282.

[2] Mohsin Murad, Adil A. Sheikh, Muhammad Asif Manzoor, Emad Felemban, and Saad Qaisar.(2015). A Survey on Current Underwater Acoustic Sensor Network Applications. International Journal of Computer Theory and Engineering, Vol. 7, No. 1, February 2015.

[3] Cevher, V. and Kaplan, L. M. 2009. Acoustic sensor network design for position estimation. ACM Trans. Sensor Netw. 5, 3, Article 21 (May 2009), 28 pages. DOI = 10.1145/1525856.1525859 http://doi.acm.org/10.1145/1525856.1525859.

[4] Personal, Enrique &Luque, Joaquín & Larios, Diego &Barbancho, Julio & León, Carlos. (2016). Evaluation of MPEG-7-Based Audio Descriptors for Animal Voice Recognition over Wireless Acoustic Sensor Networks. Sensors. 16. 10.3390/s16050717.

[5] Bertrand, Alexander. (2011). Applications and trends in wireless acoustic sensor networks: A signal processing perspective. 2011 18th IEEE Symposium on Communications and Vehicular Technology in the Benelux, SCVT 2011. 10.1109/SCVT.2011.6101302.

6. Kamruzzaman, J., Wang, G., Karmakar, G., Ahmad, I., & Bhuiyan, M. Z. A. (2018). Acoustic sensor networks in the internet of things applications. Future Generation Computer Systems, 86, 1167-1169.

[7] H. Wang, Wireless sensor networks for acoustic monitoring [Ph.D. dissertation], University of California, Los Angeles (UCLA), Los Angeles, Calif, USA, 2006.

[8] N. Priyantha, A. Chakraborty, and H. Balakrishnan, "The cricket location-support system," in Proceedings of the 6th Annual International Conference on Mobile Computing and Networking (MobiCom '00), pp. 32–43, August 2000.

[9] Mourya, R., Saafin, W., Dragone, M., &Petillot, Y. (2019). Ocean Monitoring Framework based on Compressive Sensing using Acoustic Sensor Networks. In OCEANS 2018 MTS/IEEE Charleston [8604663] (OCEANS Conference). IEEE. https://doi.org/10.1109/OCEANS.2018.8604663

[10] M. Nader, J. Imad, J. Al-Jaroodi, and Z. Liren, —Sensor networkarchitectures for monitoring underwater pipelines, ‖ Sensors, vol. 11,pp. 10738-10764, 2011.

[11] Oceania. [Online]. Available: http://www2.l-3com.com/oceania/

[12] M. Shakir, M. A. Khan, S. A. Malik, and Izhar-ul-Haq, —Design of underwater sensor networks for water quality monitoring, ‖ World Applied Sciences Journal, vol. 17, no. 11, pp. 1441-1444, 2012.

[13] A. Khan and L. Jenkins. —Undersea wireless sensor network for ocean pollution prevention, ‖ in Proc. 3rd International Conference on Communication Systems Software and Middleware and Workshops, 2008.

[14] FrancescAlías and Rosa Ma. Alsina-Pagès.(2019).Review of Wireless Acoustic Sensor Networks for EnvironmentalNoise Monitoring in Smart Cities.Journal of SensorsVolume 2019, Article ID 7634860, 13 pages.https://doi.org/10.1155/2019/7634860.

[15] Sheng, Zhengguo, Pfersich, Saskia, Eldridge, Alice, Zhou, Jianshan, Tian, Daxin and Leung,Victor C M (2019) Wireless acoustic sensor networks and edge computing for rapid acousticmonitoring. IEEE CAA Journal of AutomaticaSinica, 6 (1). pp. 64-74. ISSN 2329-9266.

[16] Zhao, Y., Nielsen, J. K., Christensen, M. G., & Chen, J. (2018). Model-Based Voice Activity Detection inWireless Acoustic Sensor Networks. In 2018 26th European Signal Processing Conference (EUSIPCO) (pp.425-429). [8553457] IEEE. Proceedings of the European Signal Processing Conferencehttps: //doi.org/10.23919/EUSIPCO.2018.8553457.

17. D. Cherkassky and S. Gannot, "Blind Synchronization in Wireless Acoustic Sensor Networks," in IEEE/ACM Transactions on Audio, Speech, and Language Processing, vol. 25, no. 3, pp. 651-661, March 2017, doi: 10.1109/TASLP.2017.2655259.