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ELEPHANT VOCALIZATION DIRECTION OF ARRIVAL ESTIMATION FOR REAL TIME DATA IN FOREST UNDER ACOUSTIC SENSOR NETWORK USING HYPERBOLIC CIRCULAR ARRAY

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Abstract

Target Coverage and estimating Direction of Arrival is one of the essential research focuses in our Acoustic Sensor Network. In our work, the real time data and offline data collected by passive acoustic sensor at 3 different forests for estimating Direction of Arrival and localization using enhanced hyperbolic circular array. Using MATLAB WAVE tool performed data pre- processing (A/D conversion, Filtering and Compression) and analyse the various external factors affecting the sound propagation and localization accuracy. Our results shows that unexpected changes occurred in metrological parameters strongly affects the real time and simulated tool localization difference.

Keywords*:* acoustic sensor; hyperbolic circular array; target coverage; localization;

1. Introduction

According to naturalist the Acoustic Sensor Network become an revolutionize in the area such as animal ecology and sensor network technology. Acoustic Sensor allows and access the resource of nonstop examination of plants, animals and woodlands is a tremendous outstanding approach to analysing ecosystem in a remote area network [1]. Sensor network allows us to supervise or observe in remote area or protected area where we cannot physically available. To avoid and monitoring of forest fires and elephant intrusion has become a worldwide concern in forest prevention organization [2]-[3]. A Wireless Sensor Network (WSN) consists of a large number of sensor nodes that co-operatively monitor and deployed in a specific region of interest.

India is home to 25,000 to 30,000 wild elephants, making up over 50% of the total remaining population of Asian elephants. Elephants and their habitat also pay the price of conflict; while forty to fifty are died in a year while crop-raiding, forests are destroyed in the belief that it will prevent them from using the area. In order to protect elephants [15] and other animals, implementation of sensor network research in thick woodland is rapidly increasing in recent years. Elephants are valuable in their own right. Therefore, interest has been growing in detecting elephant for safety. The rest of the paper is structured as follows. Chapter 2 discusses the existing approaches for finding the Direction of Arrival. Chapter 3 explains the drawbacks of existing methodology. Chapter 4 reveals the Advantages of Proposed Methodology. Chapter 5 outlines the Results and Analysis. Finally, Chapter 6 concludes the paper.

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II. Literature survey

Specific target Direction of Arrival (DOA) estimation in forest is one of the essential sensor network applications in forest. Estimating DOA for an acoustic source of narrow band sources where origin of the source is far away from the sensor array optimal algorithm are processed in existing techniques such as multiple signal classification (MUSIC) [4]-[5] the minimum variance method of Capon , estimation of signal parameters via rotational invariance technique (ESPRIT)[5] and more. Better performance was achieved at higher the SNR. The standard method for estimating DOA is ML method.

Observed parameters are essential for formulating likelihood function. Estimation of ML [6] with respect to all unknown parameters, which may include the source DOA angles, the signal covariance, and the noise parameters by maximizing the likelihood function. There are different optimization techniques[6]-[7] available in literature for optimization of ML function like AP-AML, simulated annealing (SA) , genetic algorithms (GA) fast EM and SAGE algorithms and a local search technique e.g. Quasi-Newton methods. The evolutionary algorithms like genetic algorithm, particle swarm optimization and simulated annealing can be designed to optimize the ML function. Genetic algorithm and particle swarm optimization had already used as a global optimization technique to estimate the DOA for uniform array.

III. Existing methods and drawbacks

Estimation of DOA in array signal processing has been proposed for decades, and its super-resolution performance is appreciated by many scholars. A series of classical algorithms, e.g. MUSIC, ESPRIT, are often used in estimation of DOA, however, the biggest drawback of these algorithms is that they cannot process the status of coherent signal sources. So it is necessary to remove coherency in advance. Though estimation of DOA has been applied in many fields about measurement, very few studies concern low-angle tracking in the surface and proposed a method of polarization diversity and blind central DOA estimation algorithm.

Recent Techniques To Track Movement Of Animals - Under the new warning system infrared rays would pass between two pillars that will be installed along the conflict – prone pockets, especially in well-known exit points.

SHORT MESSAGE SERVICES - Whenever an elephant passes through the pillars, the disruption in infrared rays will trigger a Short Message Service (SMS) to five pre-determined mobile numbers.

IV. Research Data Flow And Problem Formulation

A set of acoustic sensors microphones in known locations, our primary objective of our research is using acoustic sensor network coverage deployment within 3 kms circularly in thick forests situated in and around Coimbatore areas. The primary goal for our proposed methodology is to determine the elephant direction of arrival location within nearby any village.

Our secondary goal is to identify the different external factors that affecting the sensor network coverage area and also estimate the error analysis report and error rectification methods. Real time Data for research is considered as 50 different target cases located and recorded in different type of environments.

Each sensor node can transmit and receive the information based under ring topology. In real time research data gathering, acoustic source is a enlarged object and positioned in a diverse types of forest such as Mangarai, Palamalai,Annaikatti and Mudumalai, Thepankadu, Baraliyar and Sathyamangalam areas situated in and around Coimbatore areas. The necessity of doing this research is to avoid the collision between human beings and elephants and also to protect the both communities. Research data transmission in proposed methodology is split up in to 4 stages. They are i) Sensor deployment in forests ii) Analog to Digital Conversion iii)Filtering of signal iv) Splitting of filtering signal v)Direction of arrival estimation

1. **Sensor deployment in forests**

The real time elephant sound recording system is deployed by the four microphones arranged in a “circular array” covered 3 kms within our sensor network coverage area. It is indicated as Sensor 1 to sensor 4. Each sensor database can store the signal in a wave file form. In our sensor recording, the sample rate of elephant sound is fixed as

500msec. If the sampling frequency > 500 msec then the corresponding signal is stored in the sensor database as acoustic wave file in the analog form and sampling frequency < 500 msec are considered as noise or unwanted sound.

2. Analog to Digital Conversion

As soon as the sensor senses the incoming signal, the signal pre-processing Analog/Digital (A/D) conversion, Filtering and Compression) are done. A personal computer is used to capture the pre-processed filtered digitized signal for estimating the direction of arrival estimation. The digitized signals are accumulated to transfer to PC after pre-processing.

3. Filtering of signal

In order to remove the unwanted signal occurring from external environment the system is designed with adaptive filter to extract the specified frequency ranges.

4. Splitting of filtering signal

In order to estimate the acoustic source direction of arrival and localization estimation, the signals are first pre-processed and then pre-processed digital signal is split up for validation in our hyperbolic circular array algorithm. Depending upon the frequency, the filtering signal is split up as S1(f) to S4(f). Split up signal is next transferred in to proposed methodology for direction of arrival estimation.

5. Direction of Arrival Computation

Using the pair of microphones, the proposed technique estimates the minimum distance and Time Difference of Arrival between the microphone and acoustic source. The retrieved digital signals were post-processed inside the PC to determine the DOA arrival. Using this minimum distance calculation the acoustic source direction of arrival Direction of Arrival (DOA) with respect to the microphone array.

The above process is repeated for all the microphones when the acoustic source is present within the region of sensor array. The trigonometry angles are considered in order to estimate the sound source location and distance estimation between source and sensor. In order to determine the Time Difference Of Signal Arrival (TDOA) between the microphones the phase differences between the signals can be used. TDOA is nothing but there is a time delay between each pair of signals to reach the microphones that is situated either nearby or far away from the source.

HYPERBOLIC CIRCULAR ARRAY ALGORITHM

A set of acoustic sensors microphones [11]-[14] in known locations and our real time experimental implementation involves sensor hardware circuits for data acquisition. The following cases represent the pseudocode for hyperbolic circular array algorithm.

Pseudocode for Hyperbolic Circular Array Algorithm:

Step 1: Collect the elephant(s) real time pre-processed digital data in sensor database

Step 2: if digitized signal = N then

Step 3: Estimate the following constraints such as hyperbolic array height, hyperbolic distance from source and sensor, minimum distance between 4 sensor and source and sensor, Angle of Arrival (AOA) and Time Difference of Arrival(TDOA). Else Go to step 1

Step 4: if digitized estimated signal > expected signal Apply Error analysis methods(Signal to Noise ratio (SNR), Bias, Variance, Root Mean Square Error(RMSE) and error rectification methods.

Else go to step 5 Step 5: Terminate the process

V. SIMULATION RESULTS AND DISCUSSIONS

In order to estimate the average error accuracy, the following parameters such as Distance between source and sensor, real time sensor value localization distance and simulated tool localization distance have been estimated. The following figure 1, green colour represents the random error for real time Root Mean Square Error (RMSE)values is obtained as 9.666Mts, The red colour represents the random error for Simulated tool Root Mean Square Error (RMSE) value is obtained as 11.0305Mts Blue colour represents the difference between real time and simulated tool random difference is -1.3645Mts.

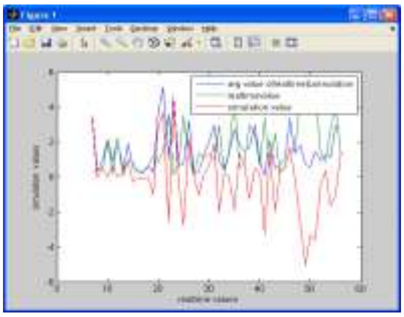
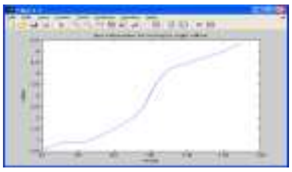


Fig 1. Random error calculation about real time and simulated tool difference -1.3645mts

Real Time and Simulated Tool Overall Accuracy

Due to difference in temperature, wind speed and distance between source and sensor the accuracy of Direction Of Arrival(DOA) is slightly affected in real time and simulated tool. In fig (2)and (3), simulated tool Direction Of Arrival(DOA) accuracy is affected and varies from 240 deg. and min threshold for wind speed is 3km/hr. respectively.

Fig 2. Sensor network Real time DOA estimation



By comparing the real time and simulated tool error rate values the range represents the distance and error rate represents the Root Mean Square Error values (RMSE).

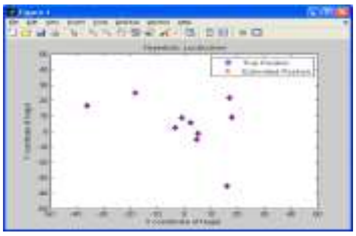


Fig 3. Sensor network proposed algorithm DOA localization accuracy

The fig 4, represents the error rate results obtained from proposed methodology. The Real time average value is estimated as 9.666 mts., The Simulated tool average value is estimated as 11.0305 mts, and Diff between real time and simulated tool values is estimated as 1.364 mts. Therefore the real time error rate Signal to Noise Ratio points also become very low so they can achieve less error rate compared to simulated tool data.

VI. CONCLUSION & FUTURE SCOPE

The proposed methodology for estimating route of arrival by means of differential hyperbolic circular array and nearest sensor localization shows the major impact and analysis of external metrological constraints such as temperature, wind and unexpected changes affects the accuracy of elephant localization. The SNR, RMSE error and ECF also plays the major role in Error rectification and Localization accuracy. In real time and tool generated implementation the

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localization error constant factor is estimated as -0.11Mts (-5.824/50). In future our work focusing on increasing the number of sensors and decreasing the error constant factor.

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