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Elephant Localization And Analysis of Signal Direction Receiving in Base Station Using Acoustic Sensor Network

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ABSTRACT: Direction of Arrival Estimation and monitoring the animals is one of the crucial examine focuses in our Acoustic Sensor Network. Using hyperbolic circular array the elephant vocalization Direction of Arrival is estimated with various external factors affecting Non-Line of Sight areas. In our experimental analysis each acoustic microphone array are seperated by 0.5M(mts) and circularly sensed the acoustic signal by 3Kms and each sensor node deployed circularly 360^{o} deg by TOP, BOTTOM, LEFT, RIGHT hyperbolic arrangement. The sensor hardware circuit audio recording and playback using Atmega Microcontroller Schematic Arduino On-Board Interfaces are supported for recording elephant signals are illustrated with its pin diagrams in the following chapters. The experimental results focus on analysis of signal receiving from base station and estimation of random error difference.

KEYWORDS: Acoustic Sensor; Atmega Microcontroller ; Base station; Hyperbolic Circular Array; random error.

I. INTRODUCTION – NECESSITY OF THE PROBLEM

Elephants are major input to tourism proceeds in many countries like South Africa and Asia, they have a considerable part of our enlightening and chronological heritage and they give us enchantment to take a look at. Elephant take over the pride and act as a role of representation for the need and take care of animals and environment. During April 10,2010 state forest service college coimbatore held a state level workshop on Human Elephant divergence[1]-[3]. The workshop was structured by Tamil Nadu Forest Division and Project Elephant (MoEF).

Recent Techniques to Track Movement of Elephants

(The Hindu Dated– JULY-1-2013) 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.

II. RELATED WORK

Previous work includes the development of array signal processing algorithms using baseline acoustic arrays to perform Direction Of Arrival(DOA) tracking and classification of moving sources from their recorded acoustic signatures[11]. The baseline arrays typically have regular circular or linear structures consisting of several microphones although, recently, studies of wideband DOA estimation performed using arrays of randomly scattered microphones have been carried out. Incoherent and coherent wideband extensions of MUSIC (Multiple Signal Classification) algorithm have shown some promise for detection and DOA tracking of multiple ground vehicles[10]-[12].

III. ABOUT THE RESEARCH PROBLEM PROBLEM DEFINITION

A set of acoustic sensors microphones in known locations, our goal is to estimate two or three dimensional coordinate of the acoustic sound source. Our real time experimental implementation involves sensor hardware circuits for data acquisition[6]. The acoustic sensor has the ability to sense the sound emitted from all direction and circularly covered 3 kms in forests. Each sensor node can transmit and receive the information based under ring topology.

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In forest, source and sensor is present in a defined coordinate system, in which the signal emitted from the forest can sense by atleast any one of the sensors in their network coverage area. The sound source is excited using a broad band signal with defined band width and the signal is captured by each of the acoustic sensors.

In general the problem which should be solved is to detect and locate n-th radiating sources by using an array of m -th passive sensors[4]-[5]. The problem of estimating the acoustic source Direction-Of-Arrival (DOA) of one or more signals from same direction or opposite direction using an acoustic microphone array of sensors. In our proposed architecture all the M microphones (4) are equally spaced between 0.5m each and each sensor has received at least on signal emitting from the source.

PROBLEM STATEMENT:

A acoustic signal propagates in a forest and open areas with a lot of external factors that affects the sound propagation. Our primary objective is to determine the acoustic source Direction Of Arrival, which is represented by the source vector u that points from the sensor to the source. 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 considerd as 50 different target cases located and recorded in different type of environments. The signal originates in the far-away from the sensor and may be considered to be a plane wave at the location of the receiver[7][8]. Let us consider a set of acoustic sensor nodes A in a array, each with known location and unknown angle θ_i with respect to direction of the n^{th} sensor field, the location of the source S is generally unknown. Each acoustic source emits a known finite length signal that begins at time t_j, the emitted signal from source unknown.

1. source is very long the sound receiving level is low
2. the source sound is very low receiving level is less
3. Using microphone circular array the sensor covered some unwanted sounds also
4. The sound emitting other natural source may be disturbed the ori
5. In sensor network topology implemented as ring topology.

IV. SENSOR HARDWARE AUDIO RECORDING CIRCUITS:

For recording the real time elephant sound and other sound there is a need for sensor circuits. The following theory illustrates the working methodology of sensor circuit and block diagram of the sensor circuit. The total circuit in 5V/DC and the audio with direction will be identified by the sensor. For 5V/DC supply we convert the 230V/AC supply from the source. Then we give the AC supply voltage to the potential transformer on primary side. Then use the step down transformer so that the supply voltage will get reduced to 12V/AC[9][10]. The 12V/AC supply will be connected to the bridge rectifier circuit to convert the AC supply to DC supply; here the 12V/AC will be converted into 12V/DC supply. And by using regulator the 12V/DC supply will be converted or reduced to 5V/DC supply with noise filtering. Then the supply voltage of 5V/DC supplied to the main circuit to operate. The sensor is connected to the main board circuit, here the sensor will gives the analog signal and that will be converted into digital signal with inbuilt Analog to Digital Converter tool in our controller. Then at the same time the data will be automatically stored in micro memory card. The following figure 1 illustrates the sensor circuits.

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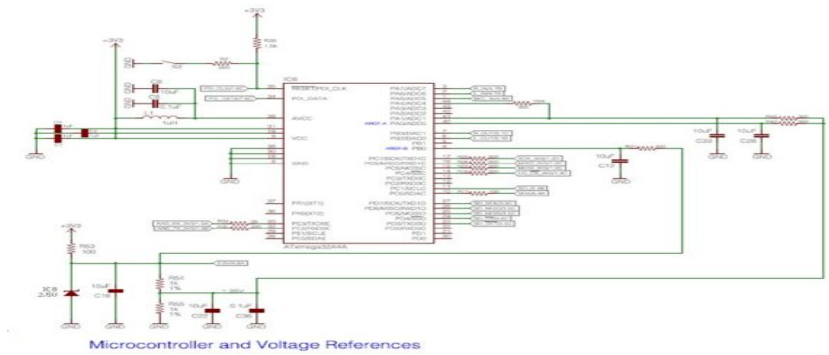

Fig 1: Sensor circuits- audio recording and playback using Atmega Microcontroller Schematic Arduino On-Board Interfaces

V. IMPLEMENTATION OF RESEARCH DATA IN PROPOSED METHODOLOGY

In this section implementation of research data and research data transmission in the proposed methodology for estimating elephant sound direction of arrival estimation is explained. Research data transmission in proposed methodology is split up in to 4 stages. They are

Sensor deployment in forests : The real time elephant sound recording system is deployed by the four microphones arrange 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[11]. If the sampling frequency > 500 msec then the correspondind 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.

Analog to Digital Coneversion As soon as the sensor senses the incoming signal, the signal pre-processing Analog/Digital(A/D) conversion, Filtering and Compression) are done. **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. **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.

Direction of Arrival Computation Using the pair of microphones, the proposed technique estimate 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 Diretcion 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.

VI. HYPERBOLIC CIRCULAR ARRAY ALGORITHM

Elephant direction of arrival estimation and distance estimation can be calculated using hyperbolic circular array algorithm. Initially 4 sensor's are deployed in hyperbolic circular array and then assign the elephant true position and calculate the elephant estimated location.

- STEP1 : set_position = [x,y,z]
  - STEP2 : true_position = zeros(trails,3) , r = x*50

  t = x*2*pi , x = r*cost(t)

true position (i,1)(i,2)(i,3) = True position (x,y,z)

Distance(I,j) = sqr(x1-x2) ^{2}+(y1-y2) ^{2}+(z1-z2) ^{2}

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Time delay = 2/340.29
Padding = Time delay*44100
m = max(dx)
x1 =mic1/Distance(i,1)
Out=(Length(d+1)/2-1/44100
<u>TimeDiffernce OfArrival</u>:
S=(d/410 ^{T}) s1=(- d/410)T h12 = h2-h1 = v(x_1d) = sqrt($x2^2$ + $(x1\text{-}d/4)^2$ – sqrt($x2^2$ + $(x1\text{-}d/4)^2$
<u>AngleOfArrival</u>:

$$\rho = \tan\left(\sqrt{\left(\delta / r_{12}\right)^2 - 1}\right)$$

VII. Analysis of Real Time Sensor Value Direction Of Signal Receiving In Base Station

In order to estimate signal arrival in our sensor network coverage area the following parameters such as distance between source and sensor (D), distance between sensor's(d), corresponding sensor id(1 to 4), target category cases(50), angle of arrival (AOA) θ and Elevation (height of the parabola) ϕ between estimated and expected value and time delay of signal reaching different microphones..

Table1. Direction Of Signal Analysis in Base Station

Target Category	sensor ID	Distance Between sensor'(d)	Distance Between Source and sensor(mts) (D)	Expected Direction Of Arrival		Estimated Direction Of Arrival		Time Diff. Of Arrival (msec) TDOA
				Azimuth angle Θ	Elevation ϕ	Azimuth θ	Elevation ϕ	
walk object	1	0.5	10	40	20	40	20	5
Moving object signal	2	0.5	8.3	45	12	60	32	3
Running obj signal	3	0.5	6.5	75	25	70	24	6
signal stand alone	4	0.5	6.5	73	21	60	20	7
signal moving	2	0.5	5.8	80	-12	60	27	2

After estimating the direction of signal analysis from base station uisng matlab wave tool 8.1 , it is necessary to compare the real time sensor data with simulated tool data for identifing the average error rate .

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VIII. COMPARISION OF REAL TIME DATA AND SIMULATED TOOL LOCALIZATION DIFFERENCE

Due to the above external factors the accurcay of signal direction estimtion is affected and also signal propagation is also affected by metrological paramters such as(thunder, echo,reflection etc).

In order to reduce the sensor network coverage dircetion of arrival accuracy, there is a need to determine the folowing two cases. They are,

Localization Difference Between Real Time Sensor Network Value And Simulated Tool Values.

Average Error Accuracy Between real time sensor value and simulated tool values

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.

Table 2 Localization Difference between Real time sensor value and simulated Tool Data

Target id	Distance Between Source and sensor (D1) (Mts)	Real time localization distanceMts(D)~ +/-	Simulated tool localization distanceMts(D)~ +/-	localization difference between real time and simulated tool (Error rate)
1	7.3	1.36	1.45	-0.09
2	3.9	1.82	4.51	-2.69
3	4.5	0.73	5.8	-5.07
4	2.4	0.54	3.84	-3.3
5	3.8	1.44	5.07	-3.63
6	6.6	0.945	1.35	-0.405
7	6.4	1.28	0.9	0.38
8	5.2	1.1	2.75	-1.65
9	4.8	2.94	3.96	-1.02
10	3.1	2.64	1.2	1.44
Total				-5.824
			Average Error Rate =	-5.824/50 = -0.11MTS

The above table(2) shows that the Localization difference between real time sensor value and simulated tool data (error rate) with 50 target cases, are highly affected because of the various external factors.

Due to external metrological parameters in different environment Average Error rate is highly affected and it is indicated by red colour font.

The minimum localization difference is 0.49mts and maximum difference -1.07 mts are estimated.

The average difference between sensor value and simulated tool value is estimated as ~ +/- (-0.11 mts)

IX. SIMULATION RESULTS AND DISCUSSIONS

The following figure 2, 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 color represents the differemce between real time and simulated tool random difference is -1.3645Mts.

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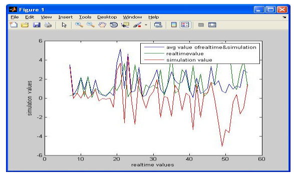

Fig 2.Random error calculation about real time and simulated tool difference -1.3645mts

During real time acoustic recording there are 50 different external factors encounetred such as (temperature, wind, lightning, echoes, thunder, reflection, refraction, scattering, etc)affecting the elephant sound propagation at forest. In our experimental analysis each acoustic microphone array are seperated by 0.5M(metres) and circularly sensed the acoustic signal by 3Kms and each sensor node deployed circularly 360^o deg by TOP, BOTTOM, LEFT, RIGHT[11]. The experimental results are carried out by MATLAB WAVE tool and anaysed the overall accuracy of Direction Of Arrival estimation for real time and simulated data.

Conclusion And Future Scope

In real time and tool generated implementation the localization error constant factor is estimated as -0.11Mts(-5.824/50). In future our work focusing on two directions (i) increasing the number of sensors and decreasing the error constant factor(-0.11Mts) (ii) Estimating the direction of arrival for moving objects in land and sea. In Future we would like to extend and evaluate the work in the following areas. Trace out the elephant network path , type of elephnat, alarm indication of elephnat network route and increase the distance of senosr coverage area. Decreasing the error rate by increasing the number of sensor, Identifying the additional external factors affecting sensor network coverage

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