An Automated System for Remote Elephant Tracking to Reduce Human Elephant Conflict

Ramkumar R, Sanjoy Deb
Dept. of ECE
BIT Sathy, Sathyamangalam, Tamilnadu-638401

Rajanna .K .M
Department of Telecommunication Engineering,
Dr. Ambedkar Institute of Technology,
Bengaluru, KARNATAKA

ABSTRACT
The conflict between humans and elephants has been reported as a serious socio-economic problem in various regions in India and across the world. The cause, effects and reduction of such conflict, are a rapidly expanding areas of research across the world among the conservationists, scientists and technologists. On the other hand, presently Wireless Sensor Network (WSN) based systems are widely used as an effective warning system against different hazard scenarios e.g.; fire, tsunami etc. Such WSN based system can also be effective to generate an early warning against the presence of elephant and thus can prevent potential conflict scenario so such system design and implementation is high on demand. Under present work, a WSN based indigenously designed, low cost, accurate 'Automated System for Remote Elephant Tracking' (ASRET) has been proposed and studied with technical details. Proposed ASRET system will be having sensor nodes, gate-way node and a central processing unit (base station) with a warning unit for successful prediction and warning generation. Under present study, the algorithm of the central processing unit for the proposed system has been developed and software implemented with MATLAB Simulink. Simulated outcomes show that such system will be very much effective to generate a valuable early warning against the elephant presence at the conflict zone and will be helpful in preventing potential collateral damage.

General Terms
Intelligent System, Wireless Sensor Network, Elephant Communication, MATLAB Simulink Modeling etc.

Keywords
Human-Elephant Conflict, Seismic Wave, Geophone Sensor, Wireless Sensor Network, MATLAB Simulink

1. INTRODUCTION
Around the globe, large-scale loss and degradation of natural landscapes due to human activities has resulted the reduction and fragmentation of habitat for a myriad of wild species. Such habitat fragmentation and the ensuing interception of human habitation and cultivation has brought wildlife into greater contact with humans, leading to an escalation in human-animal conflict, particularly in the case of large, wide-ranging mammal species such as African and Asian elephants [1]. Cause and solution of human-elephant conflict is a rapidly expanding area of research across the world where conservationists are working hard to understand the circumstances under which tensions are high between people and their wild animal neighbors and scientists and engineers are trying to find a way out from such conflict [2].

Studies have shown that an early detection of elephant heard near human habitat, railway or road track especially at night time and generation of a fallowing alert, is the best solution to this bloody conflict [3-4]. But still real problem comes with the difficulties of detecting elephant heard especially in dense vegetation and in the dark when they are mostly active [5]. Along with trench digging, electric fencing etc., recently some advanced WSN based techniques have been investigated to design such early warning system e.g.; animal monitoring/detection technique, non-invasive Radio Frequency technique (RF fingerprinting) etc. [6-9]. These advanced techniques are not so effective, because of the large extent of area to be covered and some technical difficulties towards their practical implementation due to inefficient sensing technology [10].

Under these circumstances, such system can be built by sensing a unique communication technique which is being used by the elephants during millions of years with pin-point accuracy and perfection for their own survival. In 2004, the behavioral ecologist Caitlin O'Connell-Rodwell of Stanford University in Palo Alto, California, found that along with the air born sound elephants can communicate between them from kilometers away through ground vibrations generally known as seismic waves [11]. Seismic waves are low frequency waves of energy that travel through the Earth's layers, and are generally a result of an earthquake, explosion, or a volcano and also belong to the arsenal of huge mammals like elephant [12]. Later many other researchers have explored this unique elephant communication technique along with the secret mechanisms that elephants may use to send and receive seismic signals from a physical, anatomical, behavioral, and physiological perspective [13].

Under present study an Automated System for Remote Elephant Tracking (ASRET) has been proposed which will be a type of wireless sensor network (WSN). Such system will work based on sensing the elephant activities nearby human habitat through seismic wave detection and will generate some alert for consequent actions. Present work has been devoted to develop an effective architectural and algorithm for such ASRET system. Along with the algorithm, the technical specifications and functionality of the different units of the proposed system have been discussed elaborately. The core algorithm of ASRET system has been designed and simulated with MATLAB Simulink and simulation outcomes have been analyzed. In other words, using the designed software model, proposed ASRET system algorithm has been verified with simulation experiment.

2. SYSTEM ARCHITECTURE
Proposed ASRET system will be a type of wireless sensor network (WSN) having a sensor node or primary node (geophone, seismograph etc.) placed in some remote location near the edge of the forest or railway track or road side etc. which will pick the seismic wave created by the elephant hard from a large distance. A group of sensor nodes or primary units will be connected to a secondary units or gate-way node which will be having a bi-directional transmitter and receiver and a signal processing unite to filter specific signal of particular frequency and amplitude [14]. Signal from such

multiple secondary nodes will be received by a central processing unit (base station). This processing unit will look for a pattern match of incoming signal with a reference signal and if elephant presence is detected in close distance, it will generate some local warnings and also send the information to the nearby forest office with specific location codes (or also can warn the train or vehicle drivers to take safety measures) and also can generate mobile sms alert to nearby people through GPS. Functioning of the proposed ASRET system has been shown in Fig. 1.

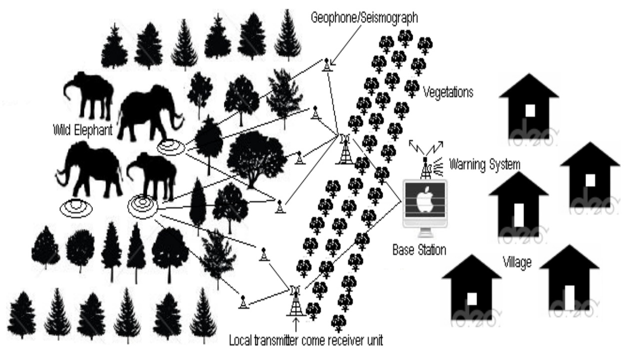

Fig 1: A picture showing the functioning of an ASRET system

2.1 Primary Unit

This will consist of a sensor, a transducer, a transmitter with antenna and a power source. Sensor is a very important issue related with the proposed project since it needs to be small, reliable, highly sensitive, cost effective and easily installable. All though sensors like geophone and seismograph both can detect seismic wave but for the proposed project geophone will be much suitable due to its small size, low cost, high sensitivity and better endurance. Recent designs of geophones have been based on micro electro mechanical systems (MEMS) technology which generates an electrical response to ground motion through an active feedback circuit to maintain the position of a small piece of silicon. The frequency response of a geophone is that of a harmonic oscillator, fully determined by corner frequency (typically around 10 Hz) and damping (typically 0.707) which is suitable for detecting seismic wave created by the elephants. Transducer part will be as simple as possible which will generate a signal to be transmitted to the secondary node. For less complexity it will be a unidirectional unit [14-15].

2.2 Secondary Unit

It will be having a transmitter and receiver with bidirectional communication ability and a microcontroller based signal processor unit which will filter the incoming signal for a specific frequency and amplitude [15].

2.3 Central Processing Unit (CPU)

This will be a main frame computer which will be mounted in some secure place and having a GPS transmitter and receiver, a local warning system and communication link with the secondary nodes [15].

Precise requirements of technology and instrument specifications can be properly figure out through some practical field survey and related analysis.

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3. SIMULATION MODEL OF CPU

The functioning algorithm of CPU has been software implemented with MATLAB Simulink. To establish the algorithm of the proposed system, a scalable mathematical relationship has to be formed between input parameters and Output Warning Signal (OWS). Under present analysis input parameters have been considered are Elephant Count (EC), Herd Position (HP), Detection Time (DT) and Conflict History (CH) of that location [2]. Along with the EC, HP, DT and CH at a particular location can also play a dominating role in flash flood prediction [3]. First three parameters will be the outcome of the sensor and the last will be coming from the saved data of CPU memory. Every parameter will be assigned a weight in percentage based on its predicted role on OWS generation. In the present model, the considered weight for each parameters for OWS calculation are; EC=40%, HP=30%, DT=20% and CH are 10%, respectively. Again, each parameter will be categorized into three sub-parameters based on its value e.g.;

For, EC, more number of elephant will be defined as ECH (Elephant Count High) and will be having 50% weight of total EC, medium elephant number will be defined as ECM (Elephant Count Medium) with weight percentage 30 of total EC and low number will be defined as ECL (Elephant Count Low) with weight percentage 20 of total EC.

Similarly for other parameters corresponding sub-parameters will be categorized as; HP: HPC (Herd Position Close) 50%, HPN (Herd Position Nearby) 30%, HPF (Herd Position Far-away) 20% of total HP respectively. For, DT: Long Detection Time (LDT) 50%, MDT (Medium Detection Time) 30%, SDT (Short Detection Time) 20% of total DT respectively. For, CH: FCH (Frequent Conflict History) 50%, MCH (Moderate Conflict History) 30%, LCH (Less Conflict History) 20% of total FH respectively.

At any time only one sub-parameter will be active and corresponding parameter value will be calculated based on the weight assigned to that particular sub-parameter and overall OWS will be calculated based on weight assigned to all the parameters. The formulated equation of input parameters and OWS will be;

OWS = (ECH or ECM or ECL)*40/100 + (HPC or HPN or HPF)*30/100 + (LDT or MDT or SDT)*20/100 + (FCH or MCH or LCH)*10/100 (1)

Like input parameters, OWS will be also categorized High (OWSH), Medium (OWSM) or Low (OWSL) based output warning signal strength.

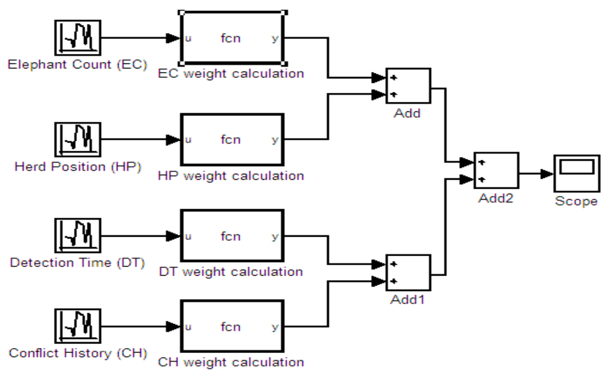

Fig 2: Matlab Simulink model of proposed ASRET algorithm

All though, the number of parameters and their actual impact on overall output signal generation is a subject of practical field study but those adjustments can be incorporated effectively with little or moderate modification of proposed simulation model.

4. RESULTS AND DISSECTION

Under the present study, the algorithm for the CPU of the proposed system has been developed and implemented with MATLAB Simulink. Input parameters are randomly generated from 0 to +5 with a dc offset bias value 0.2. Randomly generated negative value for any input parameter can be considered as a representation of physical noise. The different combinations of input parameters will generate subsequent OWS which are shown with time scale in Fig. 3 to Fig. 7.

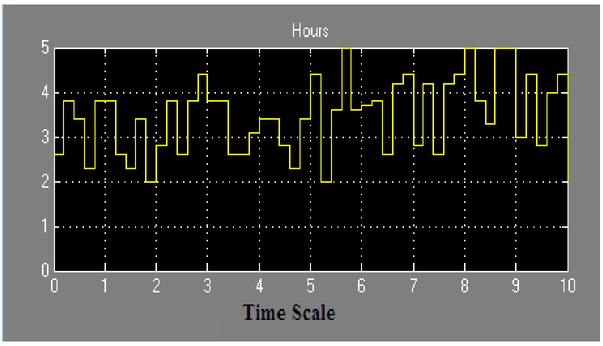

Fig 3: OWS with time has plotted with a scale of maximum 5 from 0and will be sub-categorized OWSH (value>=4), OWSM (3<=value<=4) and OWSL (value<=2).

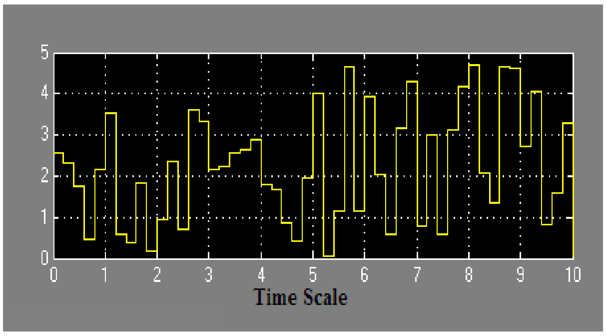

Fig 4: Randomly generated EC values with time. Value 0-2 will be ECL, 2-3 will be ECM, 3-5 will be ECH. Any generated value of less then zero can be considered as noise for this and all the other graphs.

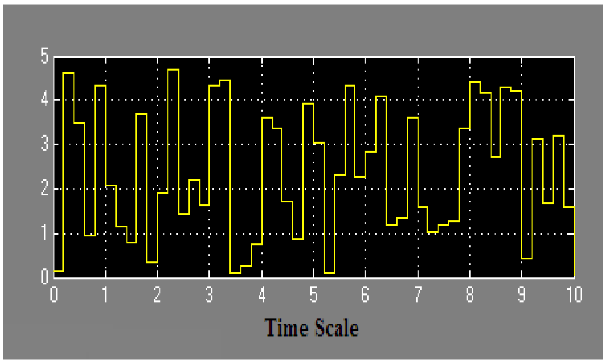

Fig 5: Randomly generated HP values with time. Value 0-2 will be HPL, 2-3 will be HPN, 3-5 will be HPC.

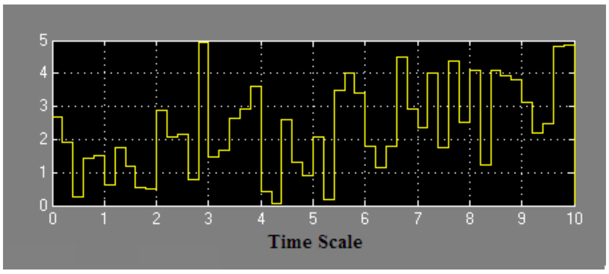

Fig 6: Randomly generated values with time. Value 0-2 will be DTL, 2-3 will be DTM, 3-5 will be DTH.

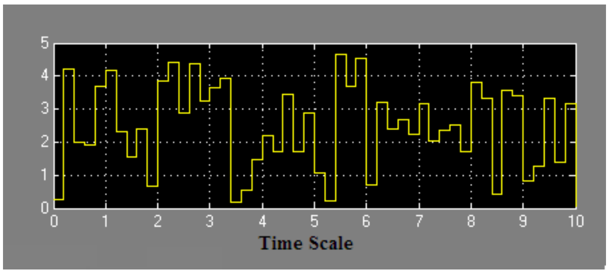

Fig 7: Randomly generated CH values with time. Value 0-2 will be LCH, 2-3 will be MCH, 3-5 will be FCH.

In the presented results, all the weight percentage of input parameters and output have been converted in a scale of 0 to 5. Any randomly generated negative value of input parameter can be considered as the representation of physical noise. When OWS value is less than 3 it will be considered as OWSL (e.g., time range 5.2 to 5.4) and if between range 3 to 4 it will be considered OWSM (e.g., time range 0.8 to 1.2) and more then 4 will be OWSH (e.g., the time range 8.8 to 9) as shown in the Fig. 3 and corresponding input parameters can be visible from Fig. 4 to Fig. 7.

5. CONCLUSION

Under present study, algorithm and architecture for an effective elephant early warning system has been presented with technical details. Proposed ASRET system has been divided into different functional units and sub units. The software model for the base station unit has been successfully designed and implemented with MATLAB Simulink and some important results have been simulated to understand the operation and performance of such system. The base station unit, designed under present study can be successfully integrated with other peripheral sub units and the complete ASRET system can be effectively designed and implemented. Practical implementation of ASRET in near future will provide early warning about the potential conflict between man and elephant so that early precautions can be taken to avoid life and property loss.

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