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Research paper

Detection of Natural Disasters from the Acoustic Signal Generated by the Aquatic Species Using Dbn Algorithm Through Underwater Communication

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Abstract

Dangerous natural disasters like earthquake and tsunami occurs very often in many islands and seashore areas without any alerts or symptoms of occurring. It is known to all that these disasters originate from the sea level and transmitted to the ground surface. Species living in the sub aquatic regions are capable of sensing these disasters earlier than their occurrence. Hence an effective technique is proposed in this paper so as to detect the disaster happenings from the acoustic signals generated by the aquatic species. Blue whale in particular is an intelligent species which has capability of sensing the distress condition in the deep underwater region and transmit the alert signal to its peer group. A method to extract the distress alert signal using the DBN algorithm and feature extraction algorithm from the acoustic signals generated by the blue whales is demonstrated and the results are simulated using the CHORUS tool , which is an enhanced framework of MATLAB software.

***Keywords**: DBN algorithm, Feature extraction algorithm, AWUC*

1. Introduction

Communication has developed to its peak in the last few decades. The improvement was drastic from earlier wired communication to the modern Optical-Fibre cable (OFC) and Wireless sensor Network (WSN) communications. But now the attention of the researchers has turned towards the different perspective of communication, Which gave a new era of underwater communication (UWC). UWC finds its extensive application in the fields like Marine researches and studies, Navy, Water transport, commercial sectors which include oil and petroleum units, etc. There are many researches going in different disciplines in UWC.

Most important among them is to find the meteorological conditions with the behaviour of species under the water through their communication. Blue whale identified as an magnificent mammal in the oceans has the natural ability of sensing the dangerous natural disasters like tsunami and earthquakes. During that unpleasant situation they communicate with the other whales so as to alert them. This paper proposes an excellent method of monitoring the acoustical behaviour of blue whales using machine learning and Deep belief Networks to predict the natural disasters earlier.

Blue whales are the widespread marine species found in all oceans which are listed in the endangered species list. These whales has the capability of producing High pitched and low frequency vocal signals for their communication [1][2].

To record the Acoustic of these whales underwater sensors are used. These sensors help us to study and examine the happenings in the sub aquatic regions and to predict the seasonal changes and the natural disasters.

The acoustic communication in these regions are similar to the physical layer communication in the WSN. These radio waves are transmitted by means of the saline water due to their conductional property with a very low effective frequencies ranging from 30-300 Hz. Terrestrially these waves requires the installation of huge antennas and high power transmitters. Using of any other communication technology underwater may result in the attenuation and scattering of the signals. Even Laser signals need the exact transmission without any disturbances or obstacles in between to reach the destination, which is highly impossible due to the wandering of aquatic species. Hence we are going for the Acoustic Wireless underwater communication (AWUC)[3].

For AWUC a collection of nodes or sensors are placed at the sub aquatic region of observation. These sensors are interconnected by the acoustic links. These links are directed towards either one or more gateways. these gateways are responsible for the transmission of the acoustic signals from the aquatic region to the terrestrial surface. This transmission of the underwater acoustic signals is aided by the vertical and horizontal transceivers. The former is used for the transmission of the signal from aquatic to sub-lunar region whereas the later is employed in the transmission and collection of the signals between the sensors in ground and water surfaces[4]. The gateways are connected by means of multi-hop path so as to optimize the power, as the power transmitted greater than the distance between the gateways gets faded due to its signal strength dispersion[5]. Due to this the BW of the AWUC is limited. Hence in most cases the direct connection is preferred than multi hop links.

2. Experiment

For the study of the acoustics of the blue whale the sensors are fixed at the aquatic regions. The experiments were conducted in two different regions at two different periods due to the relocation of the whales with the climatic changes. The temporal patterns of the blue whale were analysed in the northern and southern region of the Indian Ocean. To record the acoustic pattern of the blue whales CHORUS tool is used.

Chorus is an enhanced framework of the general simulation software, MATLAB. This framework involves the individual execution of large set of data. The data used here the acquired acoustic samples from the sub aquatic sensors. There are findings that the Acoustic signals generated by the aquatic species tends to create some chemical reaction in the water. These actions are captured by means of the machine learning and artificial intelligence to observe as signals for the human interpretations. Earlier many researches were done to analyse the sub aquatic happens in the real world scenario. Researchers are still working over such enhanced environmental study. The Chorus tool used in this paper focuses on the accumulation of the acoustic signals and pre-process them as per the requirement and extraction purpose.

The acoustic signals are transferred in the format of bits and stored as Waveform audio file format suited for the modern Operating systems. Thus file is then inputted to the chorus to limit the power spectrum density with the time window. The temporal signals recorded predicted the population of blue whales in the northern and southern oceans are given in the Fig.1 and Fig.2 respectively.

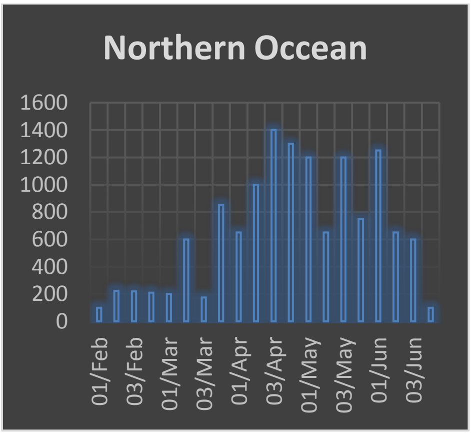

Fig.1: Whale Population scale in northern ocean

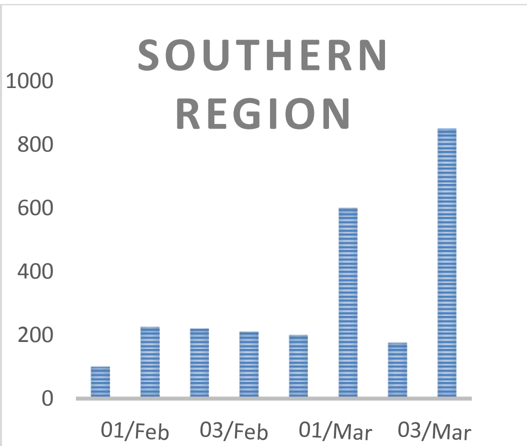

Fig.2: Whale population scale in southern ocean

The horizontal axis denotes the period when the signals are acquired and the vertical axis denotes the number of population of the whales. Change in population of the whale denotes the prediction of natural disaster or unusual climatic change in the particular region which alerts the whales to change their location. This pattern can be clearly explained with an example that in New Zealand a huge earthquake was predicted with the beaching of hundreds of whales. After this incident the scientists and researchers concluded that the stranding of whales are linked with the natural disasters. The temporal signals processed by the chorus tool is given the Fig.3.

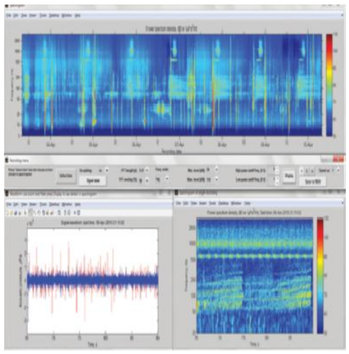

Fig.3: Processing acquired signals in chorus tool

To find the behaviour of the signals they are then classified using the Deep Belief Network (DBN).It is considered that these signals have more number of irrelevant unstructured hidden layers. They are used to identify the features like the behaviour and the prevailing conditions around the species. The modelling of the entire process is done with the DBN algorithm. For this purpose the accumulated signal over the stipulated time are stored in a waveform audio file format.

3. Dbn Algorithm

Deep belief learning algorithm is an enhanced version of the Artificial Intelligence. This is an leading technique in the machine learning process. This learning involves the statistical and deterministic calculations. DBN is also referred as the feed forward neural network, Which has one observation layer and many hidden layer between the input and the result. Each hidden layer uses an deterministic algorithm to map from the previous layer to the next layer. This algorithm is classified as unsupervised learning as there was no any previous training with the observed examples. This algorithm works in the Restricted Boltzmann machine (RBM).

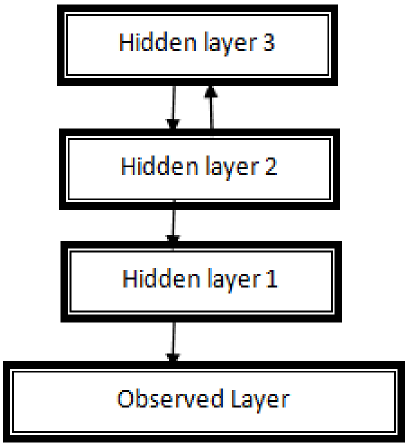

Fig.4: Layers of DBN algorithm

DBN is a complex learning model in which the sequence are stacked and trained in an greedy algorithm manner. Thus it is build with two disjoint sets of observed layer and hidden layers.

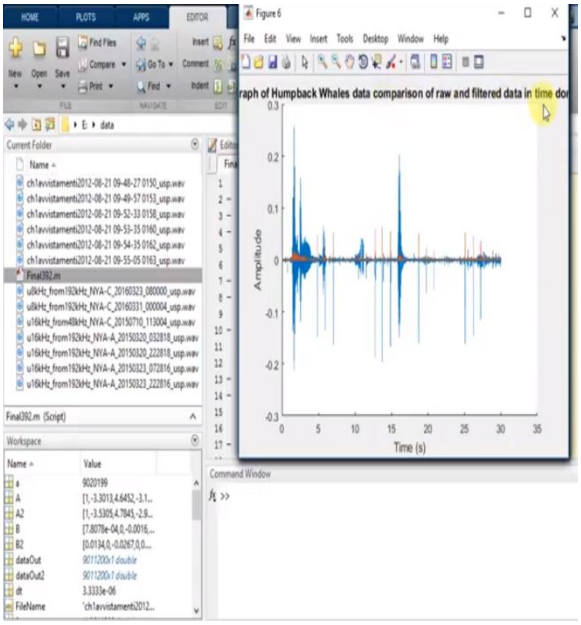

Fig.5: Time domain component of DBN in MATLAB

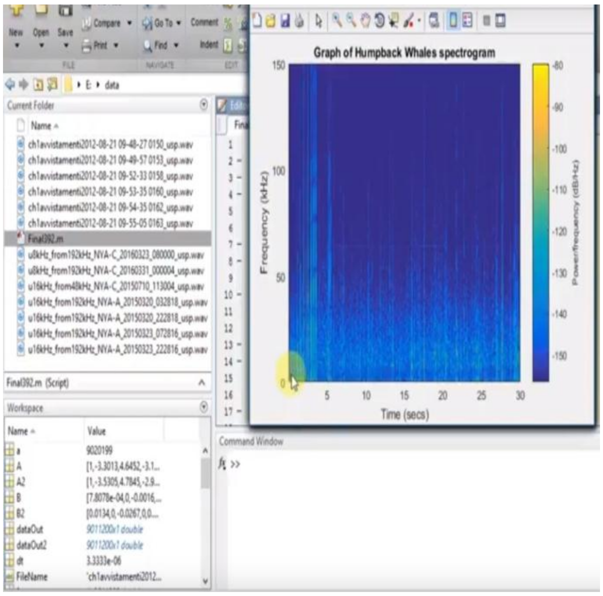

Fig.6: DBN Spectrogram analysis in MATLAB

The energy flow function of the DBN model is processed by the Gaussian process and the function is given as,

$$E\,(Vi\,h) = \sum\nolimits_{i\epsilon visible} \frac{(vi - ai)2}{2\sigma i2} - \sum\nolimits_{i\epsilon hidden} bjhj \sum\nolimits_{i,j} \frac{vi}{\sigma i}\, hj\, wj \tag{1}$$

Where, V resembles the Visible units, H refers the hidden units and W refers the Weights in the Gaussian. By applying this equation, we can predict the RBM training set when adjusting weights in the neurons. The DBN algorithm implemented in the MATLAB software is shown in the Fig.5 and Fig.6.

4. Feature Extraction

It is necessary to extract the features of the acoustic signals produced by the aquatic species as they convey some useful information to the terrestrial species which include the human race. Often the accumulated acoustic signals are represented in an imperative manner with the coefficients The acoustic signals accumulated for the proposed model are classified using DBN algorithm as discussed earlier. Feature extraction is an most important step as the decision is made on the AI to obtain the excellent and the efficient result.

The flowchart of feature extraction is shown in the Fig.7. The feature extraction is evaluated with the following formula.
Where the F_x denotes the Feature of the sensor x, n is the numeric count read by the sensor, with the time slot r_i where i is the regular interval.

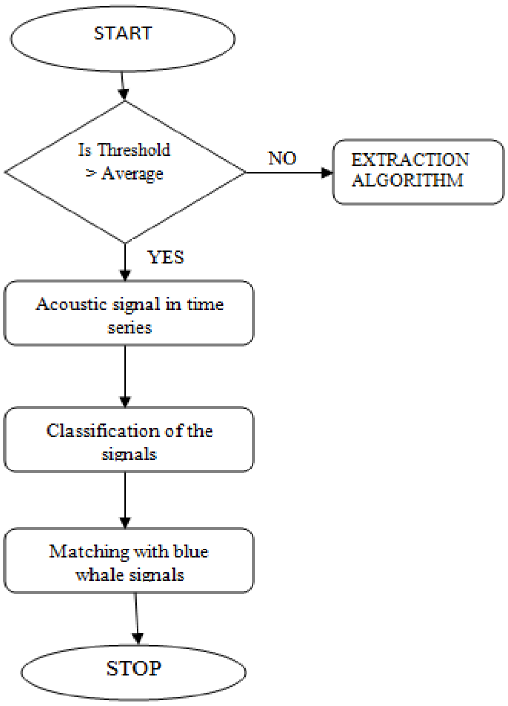

Fig.7. Flowchart of feature extraction

The acoustic signals collected from the whales are considered as the input signal for the feature extraction process. Time limits are set for each intervals. Algorithm is run individually in each quantum of time interval to extract the feature required for the Machine learning. As the collected samples for this proposed models are less in number pre-processing of the signals are not required as it is mandatory for batch quantity. Here the transformations and the computational complexity is less. For this model two methods of feature extraction are identified as the suitable methods, they are Acoustic extraction and Zero crossing of the signals within the specific quantum of time.
Acoustic extraction consists of features like energy of the envelop signals, Peak locations, analysing the windows, etc. Average threshold value is the value which is obtained when the whales are in the deepest location without any distress. If the obtained threshold value is higher than the average threshold value then the extraction has to be done in that particular quantum to find the alert signal communicated by the whales.
In zero crossing, the parameters are limited with the constant action and behaviour of the whales, which includes acoustic and seismic signals. Low frequency waveforms are generated by the whales and the data model is used at less than 650Hz . The sound which is converted into the frequency component using FFT are termed as zero. To normalize the frequency component and to modulate the amplitude the future vectors are defined.
Hidden Markov model classifier is an additional suggested method for multiple hypothesis. In this method the expected value is determined from the multiple signals. This process involves the usage of Markov chains, which are the hidden objects used in numerical analysis.

5.Results and Discussion

The primary steps involved in the statistical and mathematical analysis of the accumulated acoustic signals are as follows.
Step 1: Record the acoustic signals
Step 2: Calculate the signal rate, power and the Bit values.
Step 3: Parameter evolution is done with the help of unique features of the blue whales.
Step 4: DBN and feature extraction algorithms are applied to obtain the result.
The behaviour of the blue whales in our region of observation are estimated from the accumulated data. It is observed that during the normal and the critical situation the frequency of the whale sound changes as shown in Fig.8 and Fig.9.
Whales are capable of analysing the boat traffic and generate the alert as distress environment. This is the high potential signal generated by them For their safety and security.

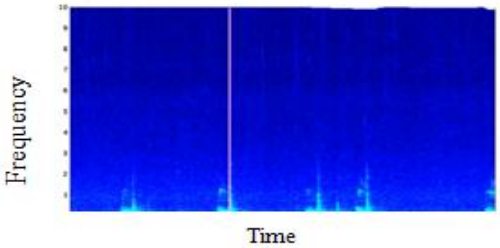

Fig.8: Frequency in normal environment

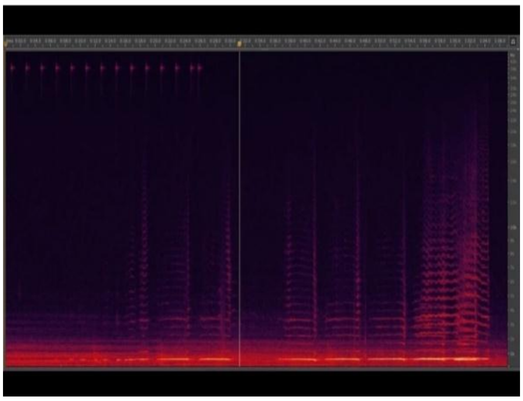

Fig.9: Frequency in critical situation

Generally the Acoustic samples and follow up of the Blue Whale's behaviour helps the researchers to study the distress in the deep underwater environments. To find the distress from the whale acoustic communication initially the weights of the neurons are initiated. Then the average value is fixed as an threshold value. The hidden matrix is then computed to find the expected output. If the obtained value is greater than the threshold value then it is classified as an distress alert. Else the data is being monitored for an alert communication.

6. Conclusion

An outstanding algorithm for classifying the signals produced by the whales are proposed in this paper. The collected samples from the sub aquatic sensors are pre-processed to find the hidden underlying layers using DBN algorithm. Then the data obtained from the DBN algorithm are processed with feature extraction algorithm to find the distress alert. From the results it is evident that the whales are capable of sensing the distress situation and communicate with their peer group for their safety and security. It is clearly observed from the frequency variation of their acoustics during normal and critical situation.

This method is very useful in predicting the natural disasters alerts raised by the underwater species, so as to take the preventive measures to save the sub lunar or terrestrial regions.

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