Abstract
Continuous Time Frequency Modulated Sonar was proposed to find stationary targets in underwater using frequency modulated signals. In CTFM Sonar, the chirp signal is transmitted periodically. The received signal echo is multiplied with the transmitted signal to get difference frequencies. This difference frequency is used to find the range. But we get wrong difference frequency for some duration of observation time. This duration in which we get wrong difference is known as blind time. Presently Dual Demodulator CTFM Sonar is used to overcome blind time. In this paper a Neural Network approach to overcome blind time problem in CTFM sonar is presented.

Keywords
CTFM, BPFF, Neural Network

I. Introduction
A. Basic Principle of CTFM Sonar
The CTFM sonar device is configured with one transmitter and one receiver transducer. The functional block diagram is shown in Fig. 1. A continuous transmission frequency modulated system is used, operating over a frequency range of $f_l$ (45kHz) to $f_0$ (90kHz), using a saw-tooth frequency pattern, better described in [1, 3]. The transmitted signal $S_T(t)$ is of the form

$$S_T(t) = \text{Re}\left\{e^{j2\pi\left(f_l t + \frac{m^2}{2}\right)}\right\} \quad (1)$$

where $t_s = t - t_n$ is the time during a sweep cycle, i.e. $0 < t_s < T_s$; $T_s = (184\text{ms})$ is the sweep period, and $m$ is a constant. The transmitted and received signal along with output of low pass filter is shown in fig. 2, 3 and 4. The time delay between two successive sweeps is ignored. Mixing the Returning Signal (SR) with the one currently being transmitted, and filtering out high frequencies, produces a difference signal, called beat signal. The amplitude spectrum of the beat signal is the CTFM sonar image which corresponds to an one dimensional range map. Higher the frequency higher will be the range of target. The time frequency curve of transmitted and received signal is shown in figure. As shown in fig. 5

Fig. 2: Transmitted Signal

Fig. 3: Received Signal

Fig. 4: Low Pass Filter Output

Fig. 5: Time Frequency Plot of Transmitted and Received Signal
if target is at greater range the received echo will have more delay and hence more frequency difference. As the difference frequency is proportional to target range, so the range resolution depends on frequency resolution [3].

II. Blind Time Problem of CTFM Sonar

As shown in fig. 5, at the time T<sub>2</sub> there is a jump because frequency changes from f<sub>0</sub> to f<sub>1</sub> abruptly. The duration from T<sub>2</sub> to T<sub>3</sub> (The time in which received echo from target is still changing in frequency from f<sub>0</sub> to f<sub>1</sub>) the difference frequency becomes more than what we are getting before jump. The difference frequency is used to determine the range, in the duration from T<sub>2</sub> to T<sub>3</sub> we get wrong difference frequency which leads to wrong range information. This duration in which the we get wrong frequency is known as blind time. Blind time does not mean no signal, in fact we get signal but with wrong difference frequency. As the blind time limits the total observation time this means that it limits the frequency resolution and hence the range resolution.

III. BPFF Neural Network Approach in Determining Range of Target

A. General BPFF

The general architecture of a feed forward neural network is shown in fig. 6. The most important characteristics of this network are: processing units are grouped by layers, and the processor interconnect is organized such that all inputs to a layer come exclusively from outputs originating in some previous layer (the specific BPFF NN used does not have connections skipping layers). The FFNN training process consists of determining the weights W (m) and the units in biasing b(m) order to make the network respond in a given way. The training method used in this work was the well known back-propagation algorithm [4].

B. Neural Network for CTFM Sonar Signals

The key here is that the whole pattern of signal, in observation as well as in blind time is used to detect the range of target. First all the received echoes are passed to a hard limiter to bring them to same amplitude. A algorithm is used to correct the phase of the difference frequency signal at the output of low pass filter. The phase correction algorithm uses the detection of first zero crossing of received echo. The idea of taking samples after first zero crossing in received signal, is to ensure that there will be no phase errors. Total 1024 sample points are taken from received echo. Now we have a MATLAB signal classification program that all the received echos are passed to a hard limiter to bring them to same amplitude. A algorithm is used to correct the phase of the difference frequency signal at the output of low pass filter. The phase correction algorithm uses the detection of first zero crossing of received echo. The idea of taking samples after first zero crossing in received signal, is to ensure that there will be no phase errors. Total 1024 sample points are taken from received echo. Now we have a MATLAB signal classification program that trains a neural network to classify different sinusoidal signals of the same amplitude and phase, and separated only in frequency [5]. These sinusoidal signals which are output of low pass filters contains range information. The better the classification better will be the range resolution.

IV. Conclusion

A new method for target localization and identification using a neural network was introduced in this paper. The ability to accurately detect and classify underwater objects of interest in an automated system is of great importance. It provides human operators with enhanced capability and can greatly reduce information overload. As is often the case, human classification of signals of interest is often impractical due to situational or operational constraints. Two benefits of automated classifier systems are immediately apparent. The first is the tireless nature of computers to perform tedious tasks such as data analysis. The second and equally important benefit of machine pattern recognition is the ability to perform classification in areas where the presence of humans may not be desirable or possible. The advantage of this method is that now we get and fixed range resolution that does not depend on the range of target but depends on the sweep time. As compared to Dual Demodulator CTFM sonar this method cannot give infinite range resolution but this reduces the hardware at the cost of finite Range resolution [6-7].

V. Acknowledgment

The authors would like to thank Satyendra Kumar, Dr.Pankaj Kumar Srivastava, Shraddha Singh, for their support for this work they would also like to thank Kashinatham, mr. Arvind Kumar Tyagi for valuable discussions, conversations and suggestions.

References

Vaibhav Bhushan Tyagi received M.Tech. degree in solid state electronics (Signal Processing specialization) from IIT Roorkee, India in 2010, working as Assistant Professor in JNU University, India. His research interest include acoustic localization, SONAR, RADAR.

Kapil Dev Tyagi received B.E. in Electronics and Communication Engineering from University of Rajasthan in 2003 and the M.Tech. Degree In signal processing from IIT Delhi in 2010 and currently working as a Lecturer in JIIT Nodia, India. His research interest include Underwater signal processing, SONAR, characterization of materials using acoustic.

Gunjan received M.Sc. Electronics from CCS University, Meerut. Currently she is PhD scholar in CCS University. Her research area are Neural Networks and Fuzzy logic.

Sandeep Dager received M. Tech. degree in Radio Frequency design and Technology (Signal Processing) from IIT Delhi India in 2010, working as Assistant Professor in UP technical University, India. His research interest include Underwater signal processing, OFDM, MIMO, RADAR.

Pushpendra Singh received B.E. in Electronics and Telecommunication Engineering from APSU in 2000 and the M. Tech. Degree In Electrical Engineering, IIT Kanpur in 2003 and currently working as a Sr. Lecturer in JIIT Noida, India.

Suresh Bushetty received B. Tech. in Electronics and Communication Engineering from JNTU in 2006 and the M. Tech. Degree In Electrical Engineering, from IIT Delhi in 2010 and currently working as Lecturer in JIIT Noida, India.