"Neural Network and Wavelet Transform Scheme for Radar object Recognizing"

Subhash kumar lodhi[1], Sangita solanki[2],Rajit Ram Singh[3]

ABSTRACT
The paper is based on method of radar object recognition by wavelet transform and neural network. Analyzing range profiles by wavelet transform can show information about tracking object more clearly. It also gives a method of constructing feature vector for automatic recognition, which can make the dimension of feature vector be much smaller than dimension of primitive echo signal. A three-layer back propagation neural network is used as recognizer. This problem is aimed to radar systems with the duration of transmitted pulses longer than size of object.

In this work, we apply wavelet thresholding for removing automatically ground and intermittent clutter (airplane echoes) from wind profiler radar data. Using the concept of discrete multi resolution analysis and non-parametric estimation theory, we develop wavelet domain thresholding rules, which allow us to identify the coefficients relevant for clutter and to suppress them in order to obtain filtered reconstructions. These reports on an investigation into the use of neural network approaches for the initial recognition of objects within images. This research considers the initial identification of the objects as a visual rather than cognitive process. The back propagation algorithm and the genetic algorithms is used. The increase of the neural network learning efficiency is shown. neural network is used for the object recognition based on radar signals. The report presents the problem of the learning process coefficients evaluation, which determines the network run.

Keywords: Neural network, Wavelet Transform, Back propagation Algorithm, Radar, GUI, ATR.

I. INTRODUCTION

1.1 **Target Recognition Techniques**:

The objective of Automatic Target Recognition (ATR) algorithms is to correctly identify an unknown target from sensed radar signatures whereas in target detection case, the requirement is to detect target from clutter. The need for ATR and target detection technology is evident from various "friendly fire" incidents. The most popular algorithm for ATR is the template-matching algorithm. Given a sensed signature from an unknown target, the ATR systems compare the observed signatures with a set of stored target hypotheses. The target decision is based on some form of optimum similarity between the observed signature and one of the stored targets. Template based ATR provides encouraging results as demonstrated in the work of Novak. Where as in target detection case, the classifier is trained to determine the threshold, which is a discriminate factor between target and clutter. Based on this threshold the classifier will perform target detection while nullifying clutter.

1.2 **ATR/Target Detection**:

The present era of limited warfare demands precision strikes for reduced risk and cost efficient operation with minimum possible collateral damage. In order to meet such exacting challenges, Automatic Target Recognition (ATR)/Target Detection capability is becoming increasingly important to the Defense community. The overall goals are to analyze image data using digital computers in order to detect, classify and recognize target signatures automatically, i.e., with minimum possible human assistance. The image data for processing may be generated by one of many possible imaging sensors including radar, optical, infrared or others. Hence target detection/recognition is considered to be one of the most challenging among current research problems because the system developers have little control over the possible target scenario and the operational imaging condition. Also, compared to the diversity of possible images during operations, only a relatively smaller subset of images may be available at the development or training stage. Furthermore, the operational target detection/recognition algorithms may have to deal with intelligent adversary attempting to defeat the system, as opposed to a more controlled environment during development .Traditionally, air to ground acquisition of ground target information is categorized into two general areas: Moving Target Indication (MTI) and Synthetic Aperture Radar (SAR). The original purpose for developing these radar technologies had been to achieve all weather and all day/night imaging, i.e., to transcend traditional photographic camera based imaging that must rely on sunlight and is susceptible to clouds, fog or precipitation.

1.3. **Moving Target Indicator**:

Most surface and airborne radar systems operate in an environment where the clutter return obscures targets of interest. If the target is moving relative to the clutter it is possible to filter out the undesired clutter return by exploiting the differential Doppler frequency shift produced by relative target to clutter radial motion. Systems following this principle are called Moving Target Indicator (MTI) radar.MTI has the capability to detect target reflections having differential radial motion with respect to the clutter. The clutter causing background may be either terrain, sea, weather or chaff.

MTI's are operated with either fixed based or a moving platform such as an aircraft or a satellite. Considering detection of low flying aircraft's, i.e. the radar is surface based, flying over terrain through possible weather disturbances. In such an event, MTI rejects the returns from terrain and weather while retaining the return from the aircraft. This property gives it good detection capabilities for air borne targets. In cases where the target is surface based, as in Air to Ground ATR application, the ground clutter are stronger than the expected target return. The ground clutter extends out to a range where terrain features that cause the clutter are masked due to earth's curvature. In such cases, the ground clutter extends to the full operating range of the radar. This makes MTI without any recognition capabilities.

1.4. **High Range Resolution (HRR) :**
MTI and SAR are active Doppler systems that transmit and receive electromagnetic waveforms in the microwave bands that have superior penetrating capabilities than visual frequency bands. These radar technologies are being researched and developed over several decades now and both concepts have some share of strengths and weaknesses. MTI makes use of target movement for image formation and hence, it is highly effective for distinguishing moving targets from ground clutter. It is a mature radar technology that allows airborne sensors to survey large areas of land and it has coarse target detection and range determination capabilities. However, although very useful for target detection, the MTI technology lacks target recognition capability. In case of SAR, in contrast, ground target information is available for processing in both range and cross-range domains, and it has excellent target recognition and identification capabilities. However, processing requirements for SAR is considerably high, preventing it from being used as a wide area surveillance technology. Unlike SAR and MTI, the HRR technology considered in this work would rely on processing high resolution `Range Profiles', as distinguished from traditional SAR-ATR that utilizes SAR image data. Its potential target recognition capability promises to bridge the gap between the wide area surveillance target detection capabilities of MTI and the very narrowly focused target identification capabilities of SAR. HRR images are used to overcome the disadvantages of SAR data whereas moving targets are concerned. In case of SAR images, the ability to achieve high Cross-Range resolution is limited by the migration of scatterers into neighboring resolution cells.

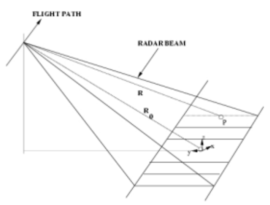

Figure 1.1 Side looking radar system geometry

II. ALGORITHM AND IMPLEMENTAT

2.1 **Wavelet Transform:**
A wavelet is a mathematical function used to divide a given function into different frequency components. A wavelet transform is the representation of a function by wavelets, which represent scaled and translated copies of a finite length or fast-decaying waveform (known as the "mother wavelet"). Wavelet analysis represents a windowing technique with variable-sized regions. Wavelet analysis allows the use of long time intervals where more precise low-frequency information is needed, and shorter regions where high frequency information is necessary.
All wavelet transforms may be considered forms of time frequency representation for continuous-time (analog) signals. Given a signal with some event in it, one cannot assign simultaneously an exact time and frequency respective scale to that event. Almost all practically useful discrete wavelet transforms use discrete-time filter banks. These filter banks are called the wavelet and scaling coefficients and may contain either finite impulse response (FIR) or infinite impulse response (IIR) filters. Wavelet transforms have advantages over traditional Fourier transforms because local features can be described better with wavelets that have local extent. Fourier analysis consist of breaking up a signal into sine waves of various frequencies, while wavelet analysis breaks a signal into shifted and scaled versions of the original (or mother) wavelet. Sinusoids do not have limited duration (they extend from minus to plus infinity), a wavelet is a waveform of effectively limited duration that has an average value of zero. Mathematically, the process of Fourier analysis is represented by the Fourier transform, which is the sum over all time of the signal multiplied by a complex exponential. The results of the transform are the Fourier coefficients, which multiplied by a sinusoid of a specific frequency yield the constituent sinusoidal components of the original signal.

2.**2 Artificial neural networks**
An artificial neural network (ANN), usually called neural network (NN)**,** is a mathematical model or computational model that is inspired by the structure and/or functional aspects of biological neural networks. A neural network consists of an interconnected group of artificial neurons, and it processes information using a connectionist approach to computation. In most cases an ANN is an adaptive system that changes its structure based on external or internal information that flows through the network during the learning phase. Modern neural networks are non-linear statistical data modeling tools.
The original inspiration for the term Artificial Neural Network came from examination of central nervous systems and their neurons, axons, dendrites, and synapses, which constitute the processing elements of biological neural networks investigated by neuroscience. In an artificial neural network, simple artificial nodes, variously called "neurons", "neurodes", "processing

elements" (PEs) or "units", are connected together to form a network of nodes mimicking the biological neural networks — hence the term "artificial neural network".

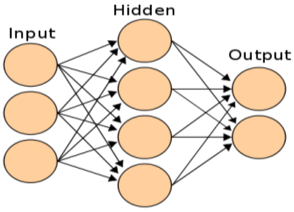

Fig 2.1 An artificial neural network

2.3 **Back Propagation Algorithm**:
Back propagation is a form of supervised learning for multi-layer nets, also known as the generalized delta rule. Error data at the output layer is back propagated to earlier ones, allowing incoming weights to these layers to be updated. It is most often used as training algorithm in current neural network applications. The back propagation algorithm was developed by Paul Werbos in 1974 and rediscovered independently by Rumelhart and Parker. Since its rediscovery, the back propagation algorithm has been widely used as a learning algorithm in feed forward multilayer neural networks.

2.4 Learning with the Back Propagation Algorithm:
The back propagation algorithm is an involved mathematical tool; however, execution of the training equations is based on iterative processes, and thus is easily implement able on a computer.
(1)Weight changes for hidden to output weights just like Windrow-Hoff learning rule.
(2)Weight changes for input to hidden weights just like Windrow-Hoff learning rule but error signal is obtained by "back-propagating" error from the output units.
During the training session of the network, a pair of patterns is presented ($X_{k,}$ T_k), where Xk in the input pattern and T_k is the target or desired pattern. The Xk pattern causes output responses at teach neurons in each layer and, hence, an output O_k at the output layer. At the output layer, the difference between the actual and target outputs yields an error signal. This error signal depends on the values of the weights of the neurons I each layer. This error is minimized, and during this process new values for the weights are obtained. The speed and accuracy of the learning process-that is, the process of updating the weights-also depends on a factor, known as the learning rate.

2.5 **Graphical user interface (GUI) :**

The graphical user interface block is necessary for simulation of any Simulink model containing SimPower Systems blocks. It is used to store the equivalent Simulink circuit that represents the state-space equations of the model. we must follow these rules when using this block in a model:
Place the GUI block at the top level of diagram for optimal performance. However, you can place it anywhere inside subsystems for your convenience; its functionality will not be affected.
We can have a maximum of one Power GUI block per model.

We must name the block power GUI.

The main purpose of the Power GUI block is to provide useful graphical user interface (GUI) tools for the analysis of SimPower Systems models. It allows you to choose one of the following methods to solve our circuit:
Continuous method, which uses a variable step Simulink solver

- Discretization of the electrical system for a solution at fixed time steps
- Phasor solution method

III. SIMULATION & RESULT ANALYSIS

3.1 **Experimental Setup:**
The objective of radar object recognition system is to assign observed input vector to one of several types. In general an object recognition system has two stages, extraction stage and recognition. The purpose of the feature extraction stage is to reduce the complexity of the input space by mapping raw inputs into feature vector in a feature space. This is designed to preserve type discriminate information while ignoring information that is orthogonal to the discrimination task. This is done by either reducing the dimensionality of input vectors or by mapping a large number of inputs into a relatively small number of feature vectors.
Radar object recognition system based on wavelet transform and neural network shown in figure is simulated in MATLAB 7.7.0(R2008b). A three-layer back propagation neural network is used as the recognizer, which has 4 neurons in input layer, 16 neurons in hidden layer and 1 neuron on output layer.The learning process containing 10000 epochs. Output of the neural network is picture, which is associated with one of recognized radar object. Recognition is simulated four kinds of objects called object 1 through 4. These simulated backscattered signals from objects, which are represented by signal x,(i) after preprocessing, are shown in fig.

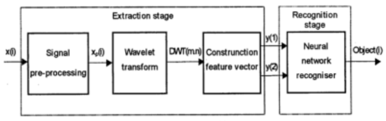

Fig 3.1.Block Diagram Of Experiment Setup of object recognition

Here reflected signals from target are processed and decomposed using wavlet transform,which reduces complexity,noise and dimension of the signals for easy recognition of object.

3.2 **Simulation results:**
There are four objects to be recognized :
1) Car
2) Helicopter

3) Group of persons
4) Aero plane

There are four transmitters, transmitter 1 to 4 that transmit four signals. These signals strike on the targets and four scattered signals are received at the receiver for each transmitter. Than recognizer recognize the target by processing these scattered signals from these targets.

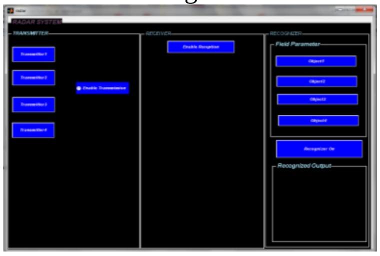

Fig 3.2 Radar object recognition system (GUI)

Neural network training tool :

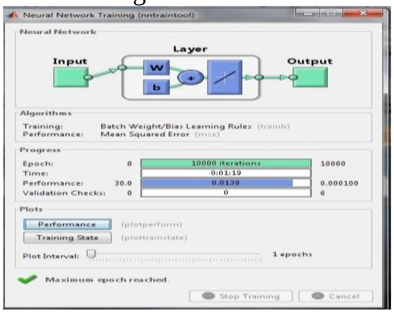

Fig 3.3 neural network training tool

Neural network training tool perform training for object recognition. To achieve this 10000 calculations are performed for each object using back propagation learning method.

3.3 **System description:**

Transmitter-1:

1) Modulating signal: x = sin(20*pi*t)

2) Modulated/transmitted signal y = ammod(x,Fc,Fs).

Where x = sin(20*pi*t)

Fc = Carrier frequency (300 Hz).

Fs = Sampling frequency (8000 samples per second)

Ammod = amplitude modulation

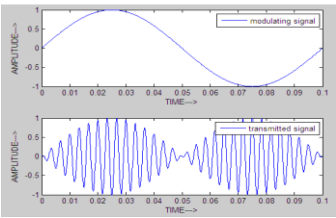

Fig 3.4 modulating and transmitted signal of transmitter - 1

Received/scattered signals and first recognized object :

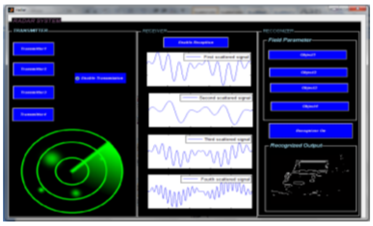

Fig 3.5 first recognized object (car)

Output threshold:

[0.0105 0.0317 0.0511 0.0685 0.0837 0.0963 0.1059 0.1123]

It is a [1x8] matrix having threshold values to which first object detected.

Transmitter-2

1) Modulating signal: x = cos(40*pi*t)

2) Modulated/transmitted signal: y = ammod(x,Fc,Fs)

Where x = cos(40*pi*t)

Fc = Carrier frequency (300 Hz).

Fs = Sampling frequency (8000 samples per second)

Ammod = amplitude modulation

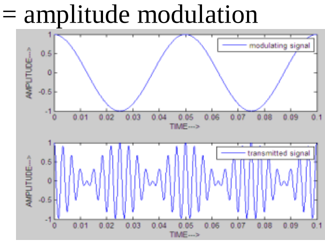

Fig 3.6 modulating and transmitted signal of transmitter - 2

Received/scattered signals and second recognized object :

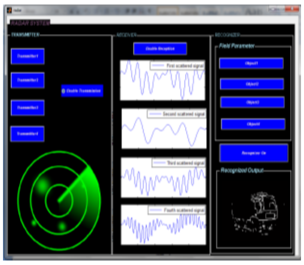

Fig 3.7 second recognized object (helicopter)

Output threshold :

[0.1154 0.1150 0.1112 0.1040 0.0936 0.0805 0.0653 0.0489]

It is a [1x8] matrix having threshold values to which second object detected.

Transmitter - 3

1) Modulating signal : x = cos(40*pi*t+20)

2) Modulated/transmitted signal: y = ammod(x,Fc,Fs)

Where x = cos(40*pi*t+20)

Fc = Carrier frequency (300 Hz).

Fs = Sampling frequency (8000 samples per second)

Ammod = amplitude modulation

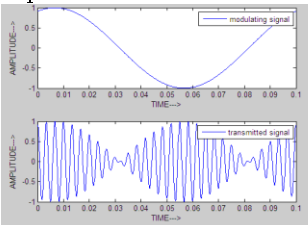

Fig3.8 modulating and transmitted signal of transmitter - 3

Received/scattered signals and third recognized object :

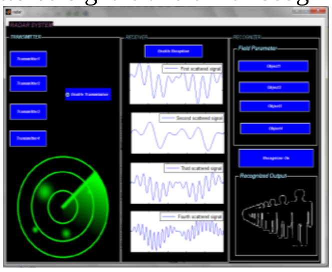

Fig3.9 third recognized object (group of persons)

Output threshold :

[0.0322 0.0163 0.0022 -0.0093 -0.0174 -0.0214 -0.0205 -0.0140]

It is a [1x8] matrix having threshold values to which third object detected.

Transmitter – 4

1) Modulating signal : x= sin(20*pi*t+20)

2) Modulated/transmitted signal: y = ammod(x,Fc,Fs)

Where x= sin(20*pi*t+20)

Fc = Carrier frequency (300 Hz).

Fs = Sampling frequency (8000 samples per second)

Ammod = amplitude modulation.

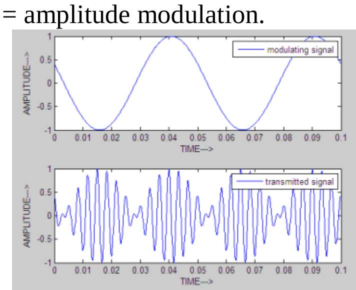

Fig 3.10 modulating and transmitted signal of transmitter - 4

Received/scattered signals and fourth recognized object :

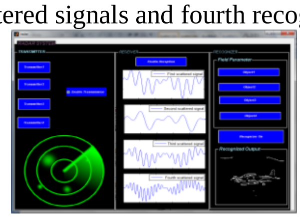

Fig 3.11 fourth recognized object (aero plane)

Output threshold :

[-0.0013 0.0177 0.0431 0.0745 0.1113 0.1534 0.2001 0.2508]

It is a [1x8] matrix having threshold values to which fourth object detected.

Conclusion:

The object recognition method based on wavelet transform and neural network is described here. A wavelet based recognizer is not computationally intensive and produces reliable recognition results that are, under certain measurement scenarios, superior to those of other recognizer. This report presented radar object recognition method based on wavelet transform and back propagation neural network. Wavelet transform and pre-processing of input vector by the algorithm presented above, we can decrease dimension of feature vector, which feed the neural network recognizer. The simulation results suggest that, with a further sophisticated a truly practical system will be developed. Some issues are addressed in the future in particular, strategies for recognition of low SNR.

Our contribution: we develop this model using MATLAB 7.7, use four input signals as transmitted signals, amplitude modulate them, then compress them using wavelet tool box. These compressed signals then applied to neural network where we use back propagation learning method to learn four signals, set input parameter like learning rate, MSE, threshold to detect targets and assign four images as output parameters which are to be detected for four input signals at output stage which is a recognizer.

Future scope:

Object recognition is a very important method specially for security purpose in military by making use of this method a practically very advance RADAR security system can be implemented that can enhance security system of our country. It can recognize enemy weapons entering in the country and can also sense speed, dimension and direction of that. It can also useful at airports for correct information about the position of flights.

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