ARTIFICIAL NEURAL NETWORK BASED SPECTRUM SENSING USING SOFTWARE DEFINED RADIO

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Abstract: Spectrum inefficiency and spectrum underutilization over wireless communication challenges can be solved by the Cognitive Radio. It helps the secondary users to use the primary users spectrum without any intrusion. In this paper an Artificial Neural Network (ANN) based spectrum sensing is proposed for accurate and rapid detection. ANN is used because it provides versatile learning and firm performance. SNR and Channel Capacity values are used to train the ANN. Finally, the ANN model is evaluated for FM Broadcasting Signal.

***IndexTerms* — Spectrum sensing, ANN, Channel Capacity, MATLAB, USRP B200 Board.**

I. INTRODUCTION

Spectrum allocation (or frequency allocation) is the regulation and allocation of the electromagnetic spectrum into the radio frequency or commonly called RF bands. This allocation is usually done by governments in most countries across the world. The allocation for Information and Communication Technologies are done by United Nations agency International Telecommunication Union (ITU).

Current Radio system are unable to identify the Radio spectrum and operate in a particular frequency band using a particular system. The study shows that in the current spectrum allocation schemes some frequencies of the frequency band are unoccupied or partially occupied. Cognitive Radio is the solution for the spectrum insufficiency. Spectrum sensing is the key feature of cognitive radio. Secondary users should reliably identify the spectrum opportunities across spectrum time and region. They should also vacate the allocated resources if the primary user becomes active.

A different number of spectrum sensing schemes have been proposed to identify the primary users [1], [2]. Every sensing scheme provides different detection capabilities and complexities. The sensing scheme is categorized into two types parametric sensing schemes and nonparametric sensing schemes. In parametric sensing scheme prior requirement on primary user is required, but in majority of the scenario the prior information is not available to a cognitive radio user. Because of this limitation we would choose non parametric sensing over parametric. In non-parametric sensing scheme, Energy detection method is most popular. It performs well if the noise at the receiver is known in prior.

But the perfect noise variance information is required for energy detection in cognitive radio. Energy detection compares the received signal energy to a pre-defined threshold and makes decision. But the performance of energy detection can be degraded by uncertainty in noise power.

Considering the above limitation for energy1detection, a new approach using Artificial1Neural1Network is proposed in this paper.A cognitive radio spontaneously identifies unoccupied channels in wireless communication system and accordingly modifies its transmission and reception parameters so that more wireless communication may run contemporaneously in a given spectrum at a given geographical location. Cognitive radio alters its transmission and reception characteristics conforming to the environment surrounding it.

II.RELATED WORK

A new approach of artificial neural network based spectrum sensing is put forward which can sense the availabilityof an unoccupied channel in the primary users spectrum and allocates it to secondary users [1].
A new technique is introduced to identify spectrum holes. A neural network model is designed to predict channel state information for spectrum sensing. The proposed ANN model predicts the channel capacity and the output is used to compute and find whether channel is occupied or not [2].
The neural network toolbox in MATLAB software for BP Neural Network evaluation model was discussed [3].
The spectrum sensing method using ANN to detect low SNR environment was analysed. Simulations discussed in this paper outperformed previous approaches in noisy environment for cognitive radio systems [4].
Multi antenna Cooperative spectrum sensing in cognitive radio network is considered. Simulations are enabled to check the accuracy of the obtained results and compared with other detectors in realistic sensing situations [5].

III.PROPOSED METHODOLOGY

In this paper a artificial neural network model that predicts the channel capacity of the received signal is proposed. This information is analysed theoretically which is subsequently verified by a suitable simulation scheme for identifying possible white space in a given band.

The efficiency of the neural network depends on the parameter and data set used for training. Database comprising of 52 SNR values, Channel Capacity, mean square values of the signal and power of the signal is developed. ANN model is trained to predict channel capacity.

Table 1 Training parameters

Parameters	Value
Number of input neurons	1
Number of output neurons	1
Number of neuron in hidden layer 1	40
Learning rate (η)	0.01
Training time	5 min.
Activation function in hidden layer and input layer	Tan sigmoid function
Activation function in output layer	Pure linear
Training Algorithm	Levenberg Marquardt Back propagation

The above table shows the training parameters. The ANN model is designed for various input parameters and results are compared. The ANN model with the above training parameter showed least mean square error. Training is performed using Levenberg-Marquardt (LM) Back propagation training algorithm. Tan sigmoid is used as the activation function for hidden layer. Linear transfer is used as the activation function for output layer.

Furthermore, USRP B200 SDR board is used as FM receiver in MATLAB simulation. Different FM station is tuned to receive station signal. SNR values are collected using scope block in MATLAB SIMULINK. These SNR values of different stations are given as input to ANN to predict their presence.

IV. BLOCK DIAGRAM AND FLOWCHART

If the predicted channel capacity is above the hard threshold value, the user is absent. If it is below the hard threshold value then the user is present. The primary user channel which are inactive can be used by secondary user. This allocation of channel is taken care by cognitive Radio.

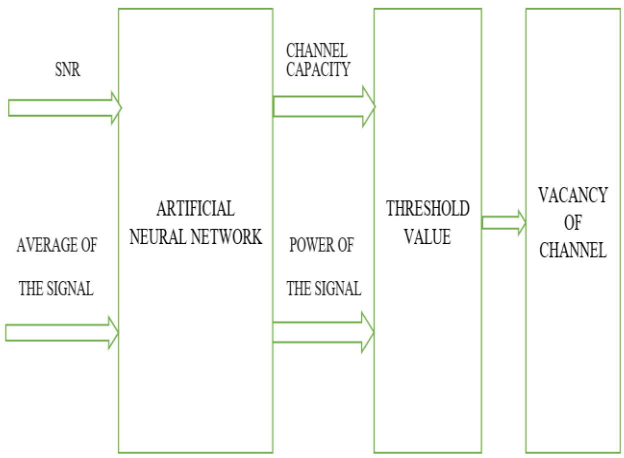

Fig.1 Block Diagram of the proposed method

Universal Software Radio Peripheral platform is a fully integrated, single board, which operates with a frequency range from 70 MHz to 6 GHz. It is a transceiver provides up to 56MHz of real time bandwidth.

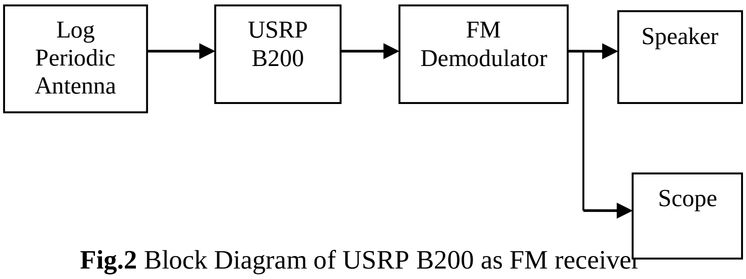

Fig.2 Block Diagram of USRP B200 as FM receiver

Users can instantly begin prototyping in GNU-Radio or MATLAB SIMULINK and participate in the open source Software Defined Radio community. The USRP block diagram in MATLAB Simulink is shown in Figure 2. The log periodic antenna connected to the USRP B200 is used to receiver live FM signals. The antenna is connected to the USRP B200 which is interfaced with MATLAB Simulink. The FM demodulator in the Simulink has built in code blocks to perform successful reception. The speaker receives the live FM audio. The scope helps to display the received signal.

In the proposed model, Frequency division multiplexing system is used for Seven primary users. It is based on sharing the available bandwidth of a communication channel among the signal to be transmitted. Each baseband data signal of the primary user is amplitude modulated with the carrier signal of assigned frequency of each user.

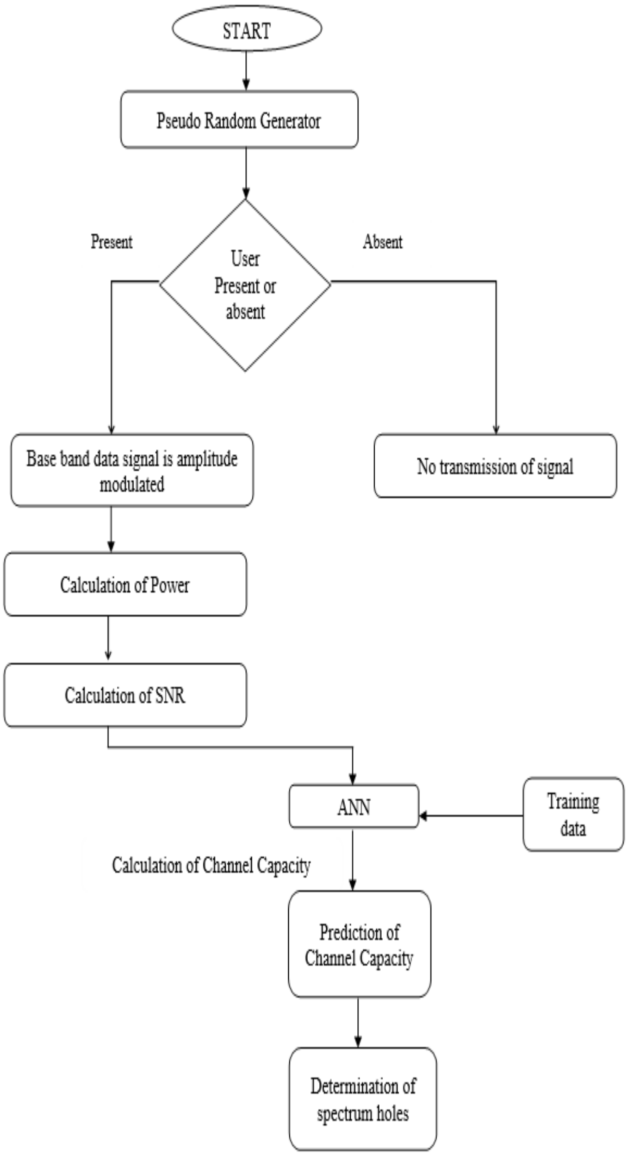

Fig. 4 Flowchart of the proposed method.

The modulated signal is added together in a linear mixer. The linear mixer is different from a normal mixer. In linear mixer the sum and difference of frequency components are not produced but only algebraic addition of modulated signals will take place.

Thereafter channel assignment is done and transmitted onto the channel. Additive White Gaussian Noise (AWGN) is added in the channel to the multiplexed signal.

At the reception side, the multiplexed signal is applied to group of band pass filter. Each band pass filter has a center frequency corresponding to each primary user. The output obtained from band pass filter is considered to determine Signal to Noise (SNR). Channel capacity of each signal is calculated theoretically. Power of the each received signals is also calculated theoretically. These power of the signals and channel capacity values are used as training dataset.

V. RESULTS AND DISCUSSIONS

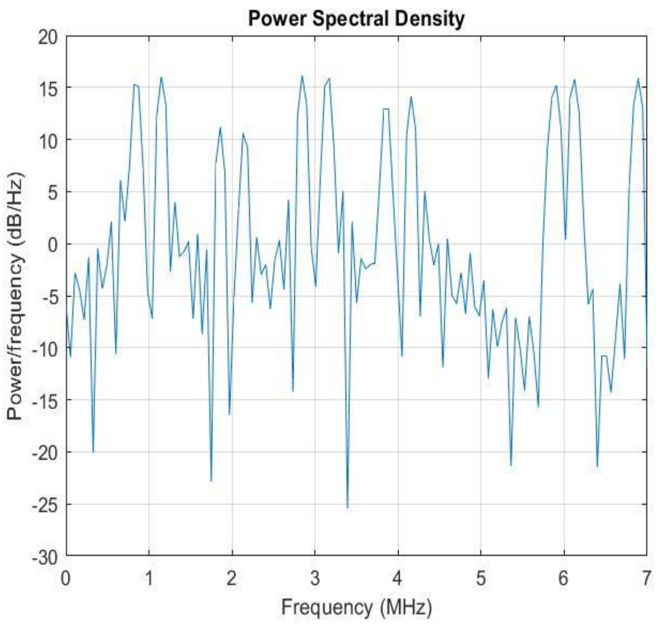

Fig. 5 Power Spectral Density of the received signal

Power spectrum density graph is obtained for the received multiplexed signal for the considered seven users in the Figure 5.

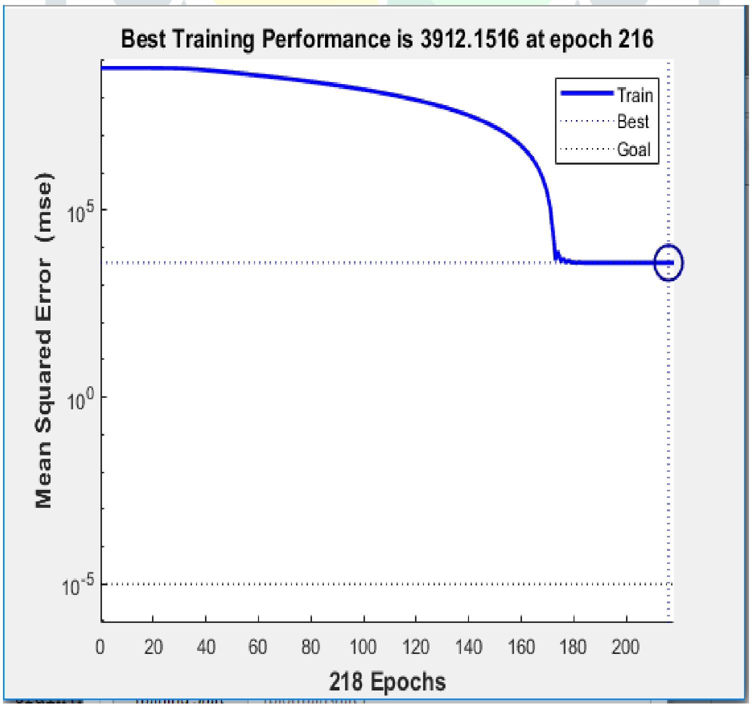

Fig. 6 Plot of Mean Square Error v/s Epochs of ANN

The performance of the trained ANN model is given by mean square error vs epochs graph in the Figure 6. Here, the set goal is reached for 218 epochs.

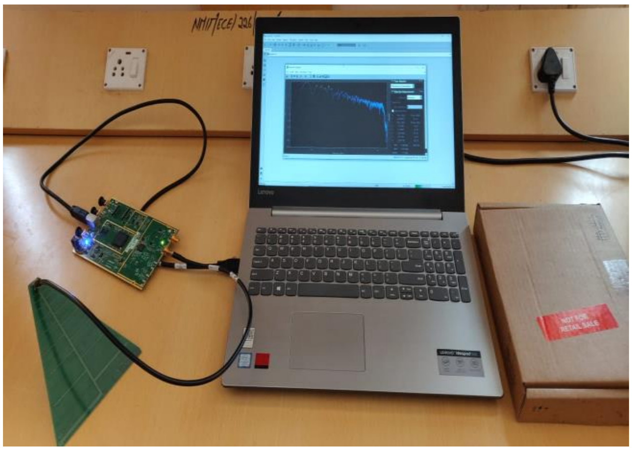

Fig. 5 Setup of SDR kit

USRP B200 is used to get live FM Broadcasting signals of four station i.e ;two allocated and two non-allocated station. USRP B200 is interfaced with Simulink. Code Blocks are available for the same. The SNR values obtained are used to calculate channel capacity and the results are tabulated in Table 2.

The channel capacity for these stations are theoretically calculated and also predicted using the trained ANN Model. These channel capacity values are tabulated along with error in the above table.

Table 2 Comparison of SDR and ANN output

Radio technology	F_{start} in Mhz	F_{center} in Mhz	F_{stop} in Mhz	Signal BW Mhz	SNR	CC using USRP (Mbps)	CC using ANN (Mbps)	Error
FM Broadcast	105.8	106	106.2	0.2	26.8	0.946	0.934	0.012
FM Broadcast	88.8	89	89.2	0.2	28.6	0.982	0.949	0.033
FM Broadcast	98.1	98.3	98.5	0.2	3.19	0.377	0.384	-0.007
FM Broadcast	93.3	93.5	93.7	0.2	1.79	0.259	0.313	-0.054

VI. CONCLUSION AND FUTURE SCOPE

In this project, we propose an Artificial Neural Network model which predicts the channel capacity. This channel state information is analyzed by determining the bandwidth for identifying the spectrum holes. It is observed that channel capacity predicted by the ANN model can be considered as a decision-making parameter to declare channel occupancy status. The analysis made from the graphs show that a channel, which is not transmitting, would have low channel capacity. Hence, we can identify white spaces in a particular geographical location. Also, USRP B200 is used to obtain real time Signal to Noise ratio for FM channels to determine Channel Capacity using Artificial Neural Network to estimate user status.

In this simulation we have successfully analyzed the performance of two neural network that is feed forward Neural Network where feed forward based spectrum sensing algorithm in cognitive radio network shows better performance. The future plan is to obtain real-time data beyond ISM bands and dynamically predict spectrum holes using ANN model. Also, to install this Cognitive Radio System in either base station or user's device. Enhancement in Cognitive Radio for emergency and public safety applications. To incorporate the effect of correlation in the design of the user-group assignment that selects the users with minimum correlation to sense in each group for performance enhancement.

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