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Research Article

SPECTRUM SENSING FOR COGNITIVE NETWORK USING NEURO-FUZZY MECHANISM WITH BAYESIAN DETECTION

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Abstract

Cognitive radio is highly developing technology to exploit the unused portions of spectrum in an opportunistic manner, the area of spectrum sensing increasingly important. To improve the utilization of spectrum in CR, we implement the efficient spectrum sensing using Neuro-Fuzzy Mechanism with optimal Bayesian detector. This proposed technique include three stage spectrum sensing schemes for identifying available spectrum. In the first stage, we derive the optimal Bayesian detector structure for primary signals with known order AWGN channels and it gives corresponding suboptimal detectors in both low and high SNR (Signal-to-Noise Ratio) regimes. Using this technique only the signal is given as input to the Neuro-Fuzzy Mechanism. In second stage, four parameters such as spectrum utilization efficiency, degree of mobility and distance to the primary user of cognitive radio network and probability of detection which the output of Bayesian detector are considered as inputs to fuzzy decision making process, while output of fuzzy process gives spectrum access decision, based on linguistic knowledge more than twenty seven rules.

Feedback neural network configuration included in third stage of spectrum sensing, which is trained with the help of delta learning rule. Neural network has two input parameters such as output of fuzzy based spectrum sensing and desired values. Once the spectrum is sensed, to utilize the radio resources more efficiently, an intelligent decision to allocate an optimum spectrum is a prime requirement.

Keywords: Cognitive radio, Bayesian Detection, spectrum sensing, spectrum allocation, fuzzy logic, neural network, primary users and secondary users.

I. Introduction

Demand of more radio spectrum in wireless communication leads to less utilization of some licensed spectrum. To improve the spectrum utilization by unlicensed users to access the spectrum unused by licensed users in Cognitive radio. CR is wireless communication technology, which is aware of it surrounding environment and use the methodology to learn from the environment and adapt its internal statistical variations in the incoming radio frequency by making corresponding changes in certain operating parameters in real time system, with two primary objectives: highly reliable communications and efficient utilization of radio spectrum.

The receivers acquire the channel quality information and the interference parameter details from the surrounding radio environment by observing. After that the transmitter receives the necessary feedback information from their corresponding receivers, they determine the strategies, which respond to the radio environment. The main functions of the CR are spectrum sensing, spectrum mobility, spectrum sharing and optimization of resources. Spectrum sensing aims to determine spectrum availability and the sensing of the licensed user. Spectrum management is the task of capturing the best available spectrum to meet user communication requirements. Spectrum sharing is refers to providing a fair spectrum scheduling method among the users. Sharing of spectrum is the major challenge in the open spectrum usage.

Spectrum mobility is defined as the process where the cognitive user change and share its frequency of operation. With these functions a model is proposed where an unlicensed user can use available licensed spectrum in dynamic manner depending on the possibility of access based on external parameters. Many researchers are in progress and ways are being found for efficient spectrum utilization and seamless communication between CR and licensed user or primary user (PU). If unused slots are identified, they can be allotted to secondary users (SU) with provided condition is that, SU need to quit the frequency bands as quickly as possible when again required by PU in order to avoid interference and this process is called spectrum sensing.

Numerous detector strategies, for instance, energy detector [3–5], covariance based detection [6, 7], cyclostationarity based discovery [10–13], coordinated channel based recognition [12] and wavelet-based detecting technique [8], have been proposed and concentrated widely [9, 11]. Energy detector and covariance Based detector accept that the essential signs are irregular.

Cyclostationarity based discovery is the cyclostationarity elements of the essential signs, nonetheless, it won't completely utilization of the qualities of the balanced signs. Matched filter based identification requires the complete learning of the essential signs, which is infeasible for viable applications. In this paper, we propose a Bayesian finder for balanced essential signs to amplify the range use, without the earlier data on the transmitted succession of the essential signs. The proposed technique makes utilization of the earlier measurements of PU action and the flagging data of the PU, for example, image rate and regulation request to enhance the SU throughput and the general range use of both PUs and SUs.. In low SNR administration, BD is approximated to vitality locator for BPSK and MPSK (M > 2) signals when all is said in done. In high SNR administration and for BPSK signals, BD is approximated to a finder which utilizes the aggregate of the got signal amplitudes to recognize the essential signs.

In this paper, a novel approach is proposed in which three stage spectrum sensing is employed. The detection probability of BD is given as input to next stage. In second stage fuzzy logic decision making scheme is included with three inputs such as Spectrum utilization efficiency, Degree of mobility and Distance to the PU. The output of third stage in spectrum sensing is spectrum access decision.

The linguistic knowledge of spectrum access based on four descriptors is obtained from a group of network experts. More than 27 fuzzy rules are set up based on this linguistic knowledge. While in third stage, feedback neural network is employed and trained with generalized delta learning rule, for getting optimized decision making purpose. Here, first input to the neural network is output values of fuzzy logic decision making scheme based on Mamdani Fuzzy Inference System (FIS).

Second input is nothing but desired values obtained from transformation of output membership function in second stage to their singleton values. The output of neural network gives optimized decision making based on indirect Takagi- Sugeno FIS model, which designed through fuzzy neural system.

The rest of this paper is organized as follows. In Section II, we briefly introduce the CR with their basic elements. Opportunistic spectrum access using the fuzzy neural with Bayesian detector is proposed in Section III. In Section IV, we discuss the simulation results. Conclusions and future works are presented in Section V.

2. Bayesian Detector

In range detecting, there are two theories: H0 for the speculation that the PU is truant and H1 for the theory that the PU is available. There are two imperative outline parameters for range detecting: likelihood of identification (PD), which is the likelihood that SU precisely distinguishes the vicinity of dynamic essential signs, and likelihood of false caution (PF), which is the likelihood that SU erroneously recognizes essential signs when PU is truth be told truant. We characterize range usage asand normalized SU throughput as respectively.

$$P(H0)(1 - PF) + P(H1)PD \qquad (1)$$

$$P(H0)(1 - PF) \qquad (2)$$

Note that P(H1)PD is PU throughput when there are essential signs and the SUs recognize the vicinity of the essential signs. To figure out if the range is being utilized by the essential client, the identification measurement TD is contrasted and a foreordained limit £. Likelihood of false caution PF is the likelihood that the theory test picks H1 while it is truth is told H0:

$$PF = P(TD > £/H0) \quad (3)$$

Probability of detection PD is the likelihood that the test accurately chooses H1 when it is H1:

$$PD = P(TD > £/ H1) \quad (4)$$

Where £ =P(H0)/ P(H1) We consider the guess of our proposed locator for MPSK balanced essential signs in the low SNR administration. When x → 0, cosh(X) ≈ 1 +X2 /2 and ln(1 + X) ≈ X, we can obtain

$$\approx \sum_{K=0}^{N-1} \text{In}\left(\sum_{n=0}^{\frac{M}{2}-1} \cosh(v_n(K))\right) \quad (5)$$

$$\approx \sum_{K=0}^{N-1} \sum_{n=0}^{\frac{M}{2}-1} v_n^2(k) + N\text{In}(M/2) \quad (6)$$

We consider the high SNR administration in this area When x =0, cosh(x) ≈ e^x/2 or when x =0, cosh(x) ≈ e^(- x)/2. In other words, when $|x| \gg 0$, $\cosh(x) \approx e^{|x|}/2$

$$\sum_{K=0}^{N-1} \text{In}\left(\sum_{n=0}^{\frac{M}{2}-1} \cosh(v_n(K))\right) \approx \sum_{K=0}^{N-1} \text{In}\left(\sum_{n=0}^{\frac{M}{2}-1} \left(e^{|v_{n(k)}|}/2\right)\right) \quad (7)$$

As appeared in Fig. 2, the false caution likelihood has a tendency to be monotonically diminishing with SNR for the case with a lower estimation of P(H0)/P(H1) without shock. The higher estimation of P(H0)/P(H1) at the higher SNR we can see the most extreme of false caution probability. We plot PF and PD versus SNR for BD in Figs. 2 to 3, respectively,

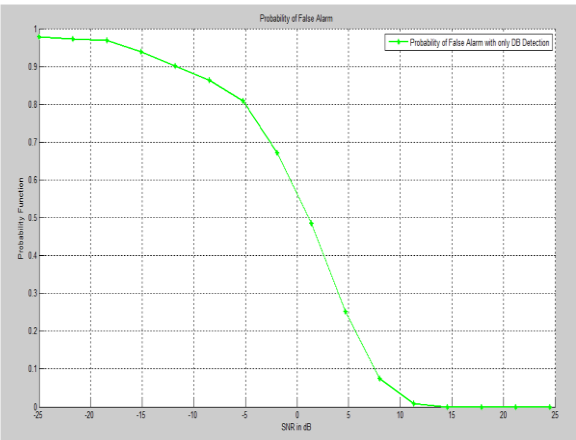

Fig.1: False alarm probabilities for BD.

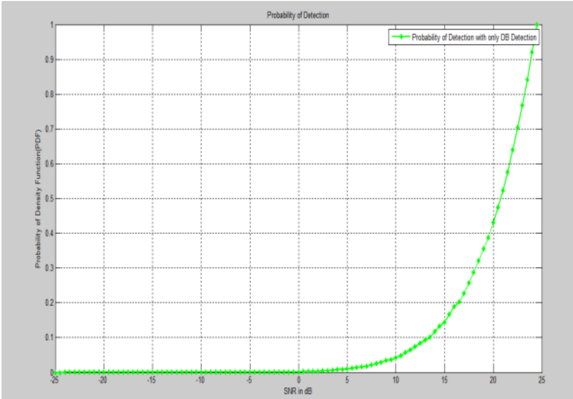

Fig-2: probabilities of detection for BD.

3. Fuzzy Logic System

In Cognitive Radio system, the choice making of asset administration depends on information of the operational environment. Fuzzy rationale is utilized to choose the most suitable SU to whom authorization can be conceded to get to the unused range. The principle based choice making plan consider different parameters of SU, for example, range proficiency, client versatility and separation in the middle of PU and SU [11]. The fuzzy methodology is talked about in this segment, with configuration steps required to build fuzzy surmising framework are specified as

Step 1: Identify the inputs, yields and status of CR's.

Step 2: Partition the universe of talk or the interim spread over by every variable into various fuzzy subsets, appointing each an etymological mark.

Step 3: Assign or decide a participation capacity for each fluffy subset.

Step 4: Assign the fluffy connections between the inputs or states fluffy subsets from one viewpoint and the yields fluffy subsets then again, along these lines shaping the guideline base.

Step 5: Choose fitting scaling elements for the information and yield variables so as to standardize the variables.

Step 6: Fuzzify the inputs to the choice making plan.

Step7: Use fuzzy surmised thinking to induce the yield contributed from every principle.

Step 8: Aggregate the fluffy yields prescribed by every guideline.

Step 9: Apply defuzzification to frame a fresh yield.

The practical piece outline of a fuzzy deduction framework utilized as a part of the proposed methodology is as appeared in Fig.4, in which fresh inputs are changed over to fluffy inputs by utilizing procedure of fuzzification. At the point when inputs are connected to the mamdani FIS then surmising motor figures the yield set comparing to every principle. The defuzzifier then registers a fresh yield from the quantity of fuzzy If-Then standards.

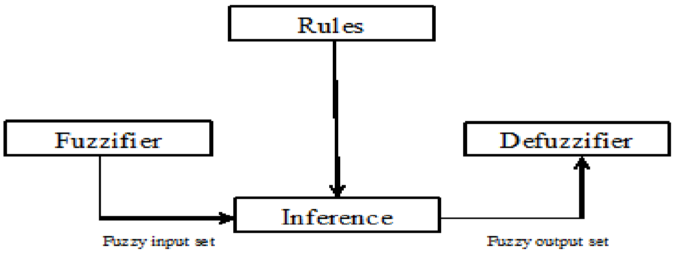

Fig.3 Fuzzy Logic System.

Fuzzy framework with a p-inputs and single yield is depicted by a gathering of l etymological If-Then guidelines is given R^l : IF x_1 is A_l^1 and x_2 is A_l^2 ...and x_p is A_l^p THEN y is B_l where, A_l^1, A_l^2 , ... and A_l^p are the fuzzy sets speaking to the l^{th} forerunner sets and B_l the fuzzy set speaking to the l^{th} ensuing. For set of conjunctive standards, the totaled yield for the l tenets is given by

$$u_y(y) = \min [\ u_y^1(y), u_y^2(y), \ldots\ u_y^l(y),] \text{ for } y \in Y \qquad (8)$$

The weighted normal strategy is the most every now and again utilized procedure for defuzzification however typically limited to symmetrical yield enrolment work and is given by,

$$z^* = \frac{\sum u^y(\bar{z}).\bar{z}}{\sum u^y(\bar{z})} \qquad (9)$$

Here, we plan fuzzy deduction framework to take care of the pioneering range access issue in CR systems. Master learning for selecting the best suitable SU to get to the accessible band is gathered in view of three forerunners, for example, range usage productivity, level of versatility and separation to the PU, with one subsequent as range access choice. In view of the learning of phonetic variables, 27 If-Then fuzzy principles are utilized to take the choice for pioneering range access [6]. In this work, utilizing standard based fuzzy rationale framework, we consolidate the above three descriptors to decide ideal answer for dole out range artfully. In radio environment, numerous clients will get to accessible range and successfully use range band specifically time term. In this way, range use productivity n_s is presented in our outline. n_s is characterized as the proportion between the range band which will be utilized by the SU and the accessible band

$$n_s = \frac{BW_s}{BW_a} \qquad (10)$$

Where, BW_s and BW_a are the range band which will be utilized by the optional and the accessible band, separately.

Versatility of the SU is the essential perspectives in our configuration. At the point when the SU is moving at a speed v m/s, it causes the Doppler Effect.

$$f_d = \frac{v\cos\emptyset}{c} f_c \qquad (11)$$

where, f_d is the doppler shift, $\emptyset$ is the entry edge of the got signal in respect to the heading of movement, c is the wave speed and f_c is bearer recurrence. Versatility can decrease ability of recognizing sign from the PUs. In the event that the SU is not fit for distinguishing the essential sign, it will mistakenly establish that the range is unused; subsequently prompting potential obstruction between the clients. The third variable is the separation of the SU, on the grounds that SU at a nearer separation ought to be offered need to get to range, which relies on the sign to clamor proportion. Separation of SU is given by

$$y_s = 10\log\left(\frac{p_{1\,g(R)}}{\sigma_1^2}\right) \qquad (12)$$

where, $p_1$is the transmit power of the PU and σ_1^2 is commotion power measured at the optional client. We can infer the separation R is between the PU and SU [17]. In fluffy induction framework, three predecessor recommendations can be communicated in three fluffy segments, for example, Low/Near, Moderate and High/Far. The outcome ie the likelihood

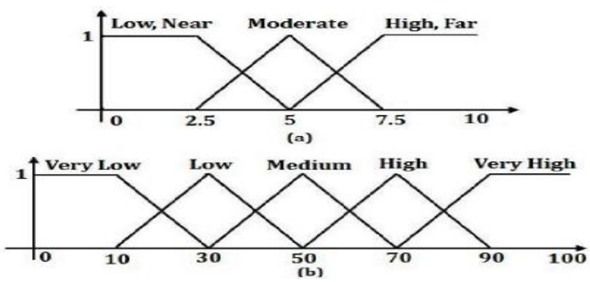

Fig.4 Input-Output Membership Functions in Fuzzy Decision Making.

That the SU is gotten to the range is isolated into five levels which are Very Low, Low, Medium, High and Very High. We utilize trapezoidal and triangular enrollment capacities to speak to enter and in addition yield parameters of choice making structure. MFs are appeared in Fig. 5, since we have three forerunners and three fuzzy subsets, we have to set up 27 rules for this fuzzy framework. At that point, we plan rules, which will be contingent upon different working conditions and human information. As indicated by guidelines as takes after [6].

4. Feedback Neural Network

The neural system is picked in second phase of range detecting plan has three layers with two data hub and one and only yield hub, while in shrouded layer five hubs are accessible. The structure of neural system for enhanced choice making in CR is introduced in Fig. 7. From criticism neural system setup, it is found that the upgraded choice qualities are figured by utilizing the iterative angle calculation to minimize the mean square mistake between the sought and real states. The system prepared in a directed manner. This implies amid preparing both the system inputs and target yields are utilized. Various calculations have been proposed for preparing the multilayered neural system and the most famous is the back-proliferation calculation (summed up delta learning principle) [16], which is utilized in second phase of range detecting. The quick mistake back spread calculation is inferred taking after the straightforward angle standard where, a normal weight w_{pq} is updated as follows:

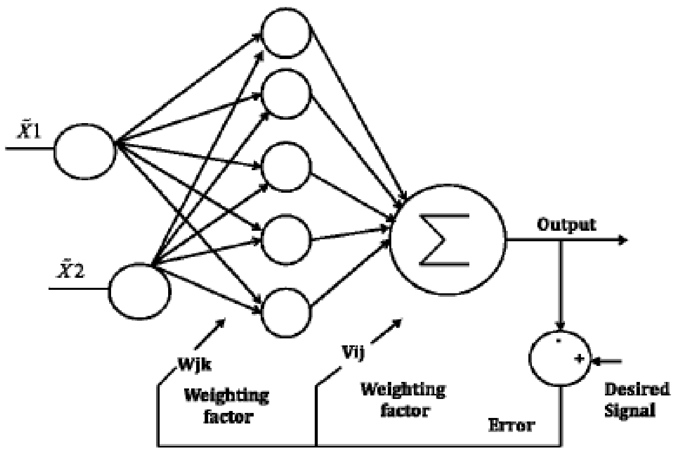

Fig. 5: Neural Network Structure in Spectrum Sensing.

$$w_{pq}(n+1) = w_{pq}(n) - \eta \frac{\delta E}{\delta w_{pq}} \qquad (13)$$

Where, η is the learning rate and $E = 0.5^* \left(y^d(n) - y_N(n)\right)^2$ is the blunder capacity to be minimized. The usage of mistake back proliferation can be given as takes after

1) Initialize the weights to little arbitrary qualities.

2) Choose a pattern $\overline{x_k}$ k = l,2...n and apply it to the information (input) layer.

3) Propagate the sign advances through the system utilizing

$$net_j = \sum_{k=1}^{n} w_{jk} \; x_k \qquad (14)$$

$$z_j = f(net_j) \qquad j = 1,2, ..h$$

$$q_i = \sum_{j=0}^{h} v_{ij} \; z_j \qquad (15)$$

$$y_{ni} = f(q_i) \qquad i=1,2.....m$$

4) Compute the deltas for the yield (output) layer

$$\delta_i = f(q_i)(y_i^d - y_{Ni}) \qquad (16)$$

By contrasting the real yields y_{Ni} and fancied ones y_i^d for the pattern $\overline{x_k}$ being considered, here fancied qualities are gotten from center singleton estimations of yield in fuzzy choice making plan.

5) Compute the deltas for the concealed layers by spreading the mistakes in reverse

$$\Delta_j = f(net_j) \sum_{k=1}^{n} v_{ij} \delta_j \qquad (17)$$

6) Use weight adjustment through after mathematical statements

$$v_{ij}(n+1) = v_{ij}(n) + \eta\delta_j z_j \qquad (18)$$

$$w_{ij}(n+1) = w_{ij}(n) + \eta\Delta_j \overline{x_k} \qquad (19)$$

7) Go back to step 2 and rehash for next example

Back propagation calculation, which is one of the angle plummet strategies is a broadly utilized weights conformity strategy for neural systems and has been ended up being successful by and by. Thusly, the neural system approach demonstrates critical change in exhibiting so as to detect exactness higher likelihood of discovery in CR for using range band successfully.

5. Results and Discussion

To assess the reaction of second and third phase of fuzzy neural framework in CRs, we arbitrarily created standardize succession estimations of three descriptors as range use effectiveness of each SU was an arbitrary worth in the interim [0 35] and its portability degree in [0 35] with third parameter as the separations to the PU were standardized to [0 35]. The yield of fuzzy choice making, ie the likelihood that a SU was chosen to get to the accessible range was registered and Fig.8 speaks to the sharp range access choice surface for the psychological client. At that point, the aftereffects of first stage is improved with help of criticism neural system, so that, the yield of fuzzy choice making given to on line prepared multilayered neural system by utilizing summed up delta learning principle and on line preparing procedure of neural system is spoken to in Fig.8.

The yield reactions of two stage range detecting plan as for every data parameters of CR are appeared through Fig.8. The effectiveness of the choice making process in CR is investigated with help of fuzzy neural methodology with Bayesian detection.

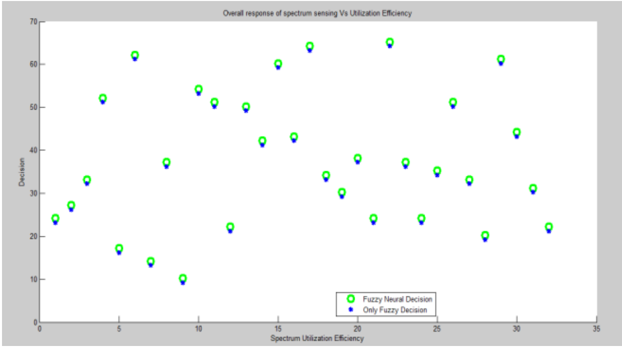

Fig. 6 Decision Vs Spectrum utilization efficiency.

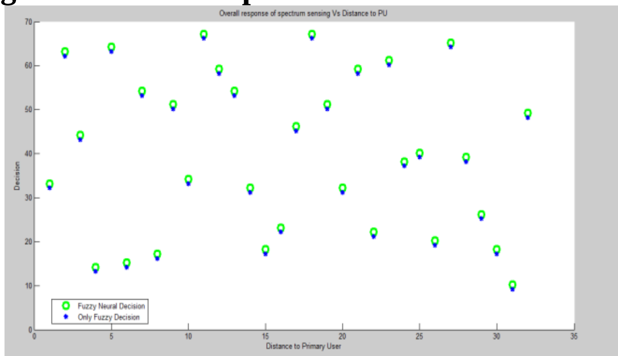

Fig. 7 Decision Vs Distance to PU.

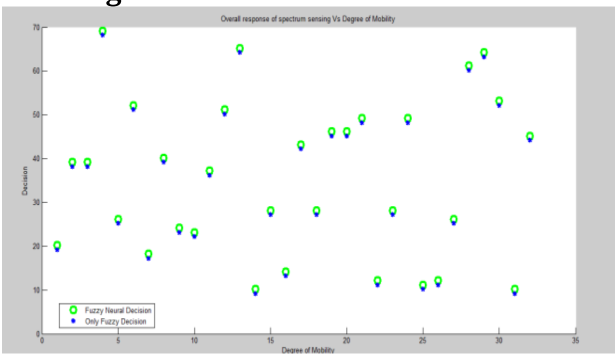

Fig. 8 Decision Vs Degree of mobility.

6. Conclusion

A novel methodology is proposed utilizing the fuzzy neural approach with Bayesian identifier for the deft range access in CR systems. The SU is chosen taking into account of three descriptors, i.e., user range proficiency of the SU, its level of portability likelihood discovery and its separation to the PU. In first stage, the utilization of Bayesian detection the likelihood of recognition gets enhanced in both low and high estimation of SNR .In next stage, mamdani fuzzy derivation framework depends on encounters from the gathering of system, so that a satisfactory choice can be developed. Subsequently, we declare the shrewd range access choice surface. Range access choice is recreated to approve next two stage approaches. The reenactment results are contrasted and fuzzy choice making plan for dissecting change in detecting exactness because of criticism in neural system. Accordingly, proposed detecting method higher likelihood of discovery and low false alerts in subjective client. From recreation results, it is clear that, the possibility of choice increments in the separation of the middle authorized and unlicensed client is low and the speed of the SU is more. It is essential to explore a few answers to keep a few clients from utilizing range wastefully and take care of the versatility administration issue so as to keep a high QoS of CR's

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