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Spectrum Sensing using NMLMF algorithm in Cognitive Radio Networks for Health Care Monitoring Applications

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ABSTRACT

To use unlicensed version of cognitive radio spectrum without any interference spectrum sensing method is used. Energy detection is mostly used technique for sensing spectrum because it does not need any prior information of primary input. Spectrum sensing performance is good by using multiple antennas. Performance is low for noise uncertainty values at selecting threshold point and for low SNR values. Detection probability is improved by using dynamic threshold point, but there is noise present at the receiver output. To avoid this noisy output proposed an adaptive filter algorithm i.e., Maximum Normalized Least Mean Fourth (MNLMF) algorithm. By the proposed algorithm, noisy outputs are decreased, also variable step size considered in weight update equation of NMLMF for better estimation of error estimates. Then we get better probability detection performance for decreased false alarm probability and for various values of signal to noise ratio values. Performance is measured in terms of convergence, get the better results for sign regressor based algorithm when compared to other two variants of MN LMF algorithm.

Key words: Cognitive radio, Energy detection, Threshold, Signal to noise ratio

1. INTRODUCTION

Usage of wireless communications and their frequency spectrum allocations are increasing day by day. But available frequency spectrum allocated to particular user and particular band, but federal communication commission (FCC) studies states that licensed frequencies are highly utilized. To avoid this problems FCC introduced the unlicensed users for avoiding interference to licensed users of allocated bands. For avoiding this interference problems, in wireless communications IEEE group is formed to improve spectrum utilization bands particularly in cognitive radios bands i.e., IEEE 802.22. Here unlicensed users (secondary users) are temporarily accessed by primary licensed users, to identify this free availability of spectrum. For avoiding this interference problems, spectrum sensing is mostly used method in cognitive radio systems. In the radio frequency spectrum having some crucial problems in wireless communication to give the main preference to high user, in this problem to rectify the Energy detection we used [1]-[3]. In the cognitive radio we added the full-duplex with spectrum sensing is utilized, while we use energy detection in cognitive radio of frequency spectrum sensing have more simplest methods. In the cognitive radio to improve the energy consumption and improving energy efficiency in wireless communication, for the cognitive radio networks to improve the spectrum sharing scheme and adaptive spectrum sharing scheme are in half and full duplex methods [4]. The cognitive radio is more interference in primary user (PU is Licensed user) and it is verifying the what the available spectrum is having and it is used to solve the problem in cognitive radio networks for spectrum sensing. In this cognitive radio network is only for who are granted but the unused licensed user (is primary user) the spectrum sensing without harming for any interference of licensed users.

The energy detection is for what the probabilities and how to calculate the performance of cognitive radio networks[5].The cognitive radio of spectrum sensing is have to supporting the cognitive user(is secondary user) and it is improves the energy detection based spectrum sensing, For the licensed user(is known as Primary User) has communication channel we have to determine is occupy or not then the cognitive radio is to step forward in to vacant channel(or leaving channel) without any interference of licensed user(is known as Primary User)[6]. The energy detection in cognitive radio where it is a wireless communication it can transmit(Tx) and receiver(Rx)the signal called transceiver and it can also detect the channels which are used and which are not used channels and it will go into which are not used channels by primary users and it will be used by secondary users[7]. Spectrum sensing with full duplex and Listening before talk are two types of spectrum sensing are considered, secondary user has only sensing and it have quiet period to transmit and switch to transmission only for particular period only. If primary user is active means there is no allow for secondary users to use spectrum until primary user gets in active ones the primary user gets inactive secondary user can use spectrum freely and safely therefore this is the best method to increase the spectrum utilization [8]-[11]. Energy detection doesn't need any previous data for primary user signal characteristics, but it didn't separate signal from noise using spectrum sensing.

High data rates, short range wireless applications used in ultra-wide band radio connectivity with spectrum range of 3.1-10.6 GHz is allowed for federal communication range (FCC). It solves the noise variance like unknown noise variance in input signal problems by using of energy detection. Noise uncertainty problems are increasing in output signal, without knowledge to accurate noise variance parameters, so that it leads to decrease of energy detection performance. But by using the primary and secondary users, particularly with use of secondary use, network is implemented without causing interference to primary user sensing spectrum id done in practical considerations also. We are using the least means square algorithm for energy detection for the secondary user to utilize the spectrum slot which is unused slot.

Primary user bands are identified by identifying weak signals at primary transmitter of cognitive radios. For transmitter feature detection, matched filter detection, wavelet detection, detection using covariance and energy detection techniques are used. Among all energy detection is mostly used method, because it is easy to implement and did not previous data to licensed user. Whereas the other methods need information of unlicensed user information to primary user, it needs large algorithms may lead to additional power consumptions and then computational complexity is also increased. Hence, we preferred energy detection method when compared to other methods. Energy detection method mainly depending with signal to noise ratio (SNR) received of cognitive radios, but it does not work well for low SNR values. Practically, cognitive users are suffering with hidden primary signal problems at receiver may lead to fading and shadowing problems, these problems are recovered by cooperative spectrum sensing, but there are some noise uncertainty problems and accuracy estimation problems. For enhancing energy detection performance have to concentrate on problems of selection of threshold, noise uncertainty problems. Various adaptive algorithms are studied in [12]-[17]. To reduce noise uncertainty problems on performance of signal detection proposed an adaptive filter-based method for spectrum sensing i.e., Maximized Normalized LMF (MN LMF) to get error free outputs and better convergence by reducing computational complexity and this concept is used in remote health care applications.

2. SPECTRUM SENSING USING NM LMF

Energy detection is basically used method in spectrum sensing, because it its computational complexity is low and their implementation is also simple so it is used for identifying unused frequency holes of cognitive radio system. It is a non-Coherent detection method used for identifying primary user signal (Licensed user signal). For identifying the licensed user, probability is considered on particular frequency band then identified the primary user vacancy in allocated band, without effecting false detection probability licensed user is identified even though primary user transmitted actually.

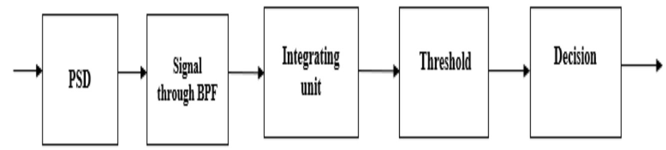

Figure 1: Spectrum sensing using Energy detection

Energy detection block diagram is shown in the Figure 1. MATLAB tool is used for the analysis of energy detection spectrum sensing. Energy detection it helps us to determine whether the signal is available or not. without using any data of the licensed users. This method uses a threshold value. It considers the primary signal [18]-[25] as noise and then detect signal is being. Input signal is passed through energy detection block diagram of band pass filter it is having frequency bandwidth 'w' over a particular interval of time, as the input signal is passing through band pass filter for filtering the noise signals present in input signal then noise is removed, initially band pass filter is used for measuring power spectral density signals for measuring energy signal, then output of BPF signal is convolving with matched filter and this filter response is same like reference signal. Comparison of matched filter and band pass filter considered for identifying the primary user is present or not. Performance of spectrum is compared with individual spectrums for identifying cooperation between primary user and secondary user then to show a same channel environment between different users are considered. Received signal energy and their variances are calculated for input signal. This will be approach has some disadvantages. This spectrum sensing concept is used in medical telemetry networks by allocating frequency bands to every patient and then data is considered from patient and further treatment is given to patient by allocating doctor to that patient. It gives poor results for if threshold point and signal to noise ratio (SNR) values are not considered well, then it may lead to give interference problems for primary users and their noise performance [26]-[29] will limit performance.

Primary user signal sensing is based on hypothesis decision given as follows

$$r(t) = \begin{cases} e(t), & h_0 \\ p(t) + e(t), & h_1 \end{cases}$$

where r(t) is received signal of secondary user, p(t) is signal at primary user, e(t) is error signal and here h_o represents when the signal is absent, h_1 is primary user signal presence. Probability of detection P_{od} and false alarm probability P_{ofa} are calculated based noise variance present in received signal for improving performance [30]-[32] and their parameter equations for energy detection can be given as follows

$$P_{od} = Q\left(\frac{\delta - S(\sigma_{pt}^2 + \sigma_{rt}^2)}{\sqrt{S(\sigma_{pt}^2 + \sigma_{rt}^2)}}\right)$$

$$P_{ofa} = Q\left(\frac{\delta - S\sigma_{rt}^2}{\sqrt{2S\,\sigma_{rt}^4}}\right)$$

Where δ is threshold point, Q is Gaussian probability function

For constant probability false alarm, threshold value is given as

$$\delta_{p_{ofa}} = (Q^{-1}(P_{ofa})\sqrt{2S} + S)\sigma_{rt}^2$$

For probability of detection, threshold is given as

$$\delta_{P_{od}} = (Q^{-1}(P_{od})\sqrt{2S} + S)(\sigma_{pt}^2 + \sigma_{rt}^2)$$

Here S is number of samples, σ_{pt}^2 is noise variance at input of antenna, σ_{rt}^2 is noise variance at receiver antenna.

To use primary users in better way, probability of detection method is used, also usage of secondary user also increased by fixed threshold point and false alarm as constant and there is a good trade-off between P_{od} and P_{ofa}

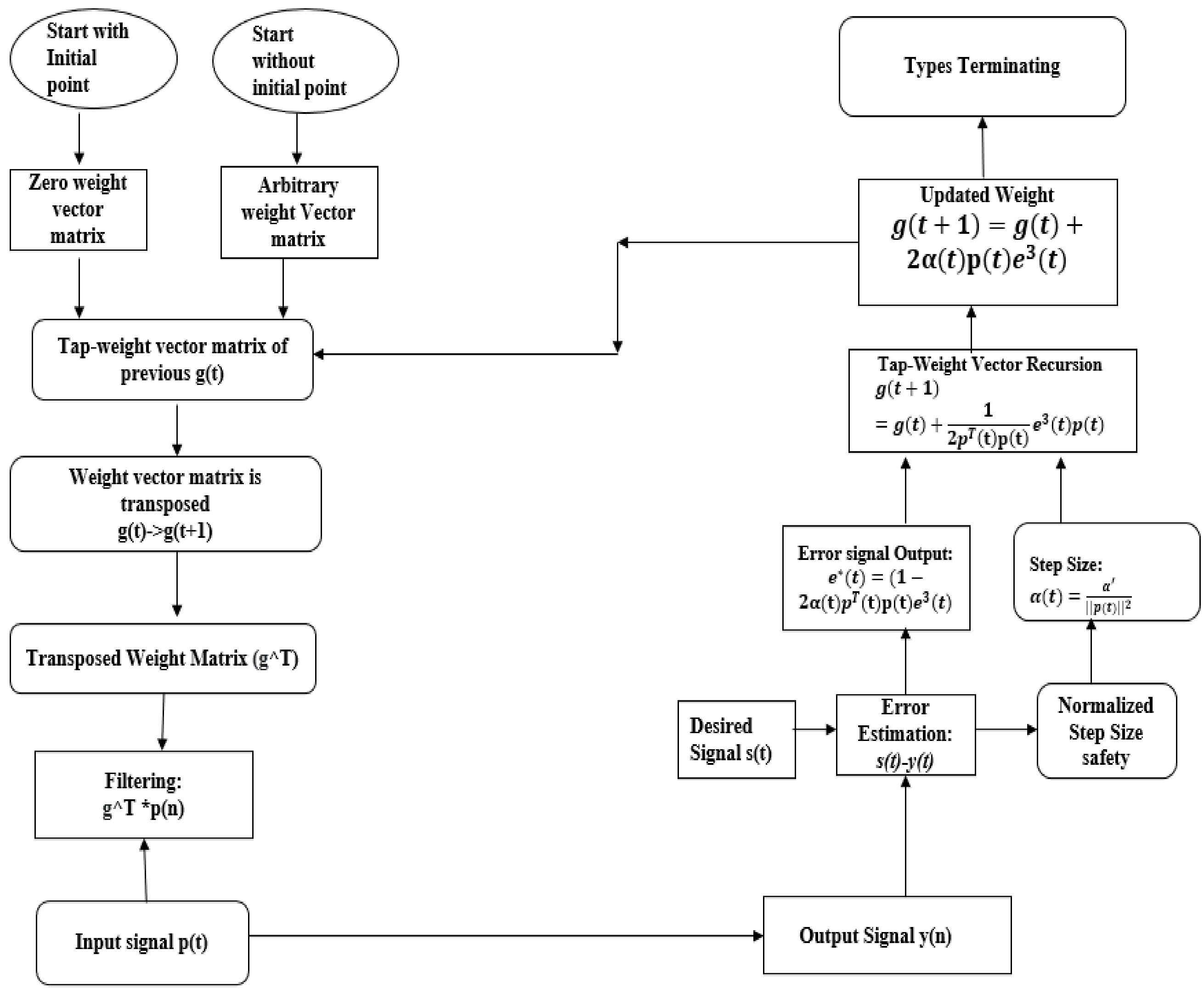

Figure 2: Flowchart of MN LMF for Spectrum Sensing

Adaptive filters are used in wireless communication techniques like cognitive radios for avaoiding noise uncertainity problems at output of receiver. Because they are simple and their robustness. Basic LMS is considered for removing errors present at output of receiver signal, but initially we are choosing step size parameter for stability and convergence of before given input to LMS filter. Input levels of unknown information is generallay known before going to adaptation process and its information of input is proportioanl to weight update process, also step size is fixed and its flowchart is shown in figure 2. Adaptive filters must low computatioanl complexity at output of signal, to reduce this complexity clipping function is used at input signal.

Let p(t) is input signal, r(t) is output signal acquires as result of adaptive filter, e(t) is error signal give to feedback for altering weights, 'F' is length of filter. Step size parameter 'α', is estimated for every weight estimated based on present weight esimator and their weight coefficinet is given as g(t). weight update expression of LMS is given as

$$g(t+1) = g(t) + \alpha p(t) e(t)$$

By applying clipping function to input primary signal, computational complexity is reduced, three forms of clipped version of input signal is given as

$$C\{p(t)\} = \begin{Bmatrix} 1 : p(t) > 0 \\ 0 : p(t) = 0 \\ -1 : p(t) < 0 \end{Bmatrix}$$

These clipped versions are used to reduce LMS computational complexity. By using this clipped version LMS has more computational compared to clipped versions. Data clipped version is used for LMS as altering primary input, then the mean values of C[p(t)] substituted for input p(t), where sign function is used based on the basis of input p(t). Then the clipped version of LMS is expressed as

$$g(t+1) = g(t) + \alpha\, C\{p(t)\}\, e(t)$$

By changing e(t) using sign version, weight update equation remains unchanged and is given as

$$g(t+1) = w(n) + \alpha\, p(t)\, C\{e(t)\}$$

weight update equation by changing p(t) and e(t) with sign function is given as

$$g(t+1) = g(t) + \alpha C\{p(t)\}\, C\{e(t)\}$$

To avoid problems in real time applications by using adaptive filter, tap coefficients are updated if there any changes occurred input and output signals. For big input data signals, this LMS technique has some issues in terms of gradient noise amplification. To avoid such problems like gradient noise amplification, weight drift and low convergence studied another adaptive filter algorithm i.e., Normalized least mean fourth (NLMF) algorithm. Estimated error is minimized with fourth order. By using Normalized LMF (NLMF) disadvantages of LMS recovered, its efficiency of using adaptive filter also increased, increased convergence when compared to LMS. To increase efficiency of cognitive radios, Maximum NMLF is used and to use in real time applications like cognitive radios. It also reduces, ability mean square error of adaptive filter. Sign functions of MNLMF also used to reduce computational complexity, three versions of MNLMS are sign regressor, sign algorithm and sign sign algorithm

Let 'G' is filter length, α is step size parameter, input signal is p(t) then data of input vector is given as
$[p(t), p(t-1), \ldots\ldots p(t-F+1)]^T$

Then s(t) is desired response at time 't', α' is step size parameter constant, e(t) is error signal.

Weight update estimate of t+1 is g(t+1)

Linear estimation solution wiener filter is given as

$$s(t) = g_0^T p(t) + e_0(t)$$

LMS weight update equation is written as

$$g(t+1) = g(t) + 2\alpha(t) p(t) e^3(t)$$

Then error e(t) for variable step size parameter is written as

$$e^*(t) = (1 - 2\alpha(t) p^T(t) p(t) e^3(t)$$

Then the weight update equation is

$$g(t+1) = g(t) + \frac{1}{2p^T(t)p(t)} e^3(t)\, p(t)$$

Then the varying step size parameter set as

$$\alpha(t) = \frac{\alpha'}{p^T(t)p(t)} = \frac{\alpha'}{||p(t)||^2}$$

A small positive parameter € is added to denominator to get low value and then it is expressed as

$$\alpha(t) = \frac{\alpha'}{€ + ||p(t)||^2}$$

Then the updated NLMF equation is represented as

$$g(t+1) = g(t) + \frac{\alpha'}{€ + ||p(t)||^2} e^3(t)\, p(t)$$

For maximized NLMF equation, weight update equation is expressed as

$$g(t+1) = g(t) + \frac{\alpha'}{€ + \max||p(t)||^2} e^3(t)\, p(t)$$

Sign function is used to reduce computational complexity, then three simplified versions of MNLMF are MN SRLMF, MN SLMF, and MN SSLMF algorithms are expressed as

$$g(t+1) = g(t) + \frac{\alpha'}{\varepsilon + max(||x(n)||)^2} e^3(t)\; C[p(t)]$$

$$g(t+1) = g(t) + \frac{\alpha'}{\varepsilon + max(||p(t)||)^2}\; C[e^3(t)]\; [p(t)]$$

$$g(t+1) = g(t) + \frac{\alpha'}{\varepsilon + max(||p(t)||)^2}\; C[e^3(t)]\; C[p(t)]$$

By using Normalized versions of LMS and its sign versions computational complexity is reduced. In these three versions, sign regressor version gives better results when compared to sign algorithm (MNSLMF) and sign sign algorithm (MN SSLMF). Cognitive frequency ranges are used in medical telemetry by placing sensors to patient body then information is updated to doctors by using wireless communication networks like Wi-Fi, Bluetooth etc., then further treatment is done to patients.

3. RESULTS AND DISCUSSIONS

Analysis of spectrum sensing is done using energy detection method for spectrum band results in cognitive radio. Then adaptive filter-based spectrum sensing is used for removing noise variances from output of received signal. While using proposed adaptive filter, initially we have to select threshold point, then calculated probability false alarm and detection probability for low SNR values. Based on parameters of detection probability and false alarm values hypothesis parameter decision are considered as primary user absent (h_o) or presence of primary user (h_1). Also updated weight equations of proposed maximum normalized LMF equations, step size parameter considered as variable to get maximized output at adaptive filter. Simulations are considered for 1000 samples; false alarm probability value is fixed as 0.01. Then simulations results are plotted between probability detection and signal to noise ratio for fixed false alarm probability. It gives better results for fixed threshold and low SNR values in terms of better performance of spectrum sensing. For fixed number of samples, varying SNR values probability detection is plotted and it gives better results for low threshold and SNR values. Performance of probability detection is given in terms of SNR values and false alarm probability. For a particular false alarm value, we are getting corresponding probability detection value. For different values of SNR corresponding different probability detection values are obtained. By selecting threshold value for noise estimation, it improves the detection performance for the increased detection probability. By the proposed maximum normalized median LMF algorithm for energy detection, to increase probability detection and for reducing false alarm probability used a dynamic threshold point by measuring noisy signal at output of receiver. Then noise values are measured and their corresponding noise variance are also calculated and their results shows that it increases detection probability performance for decreased false alarm probability for dynamic threshold point values and their improved performance is given in terms of convergence of proposed LMF algorithm.

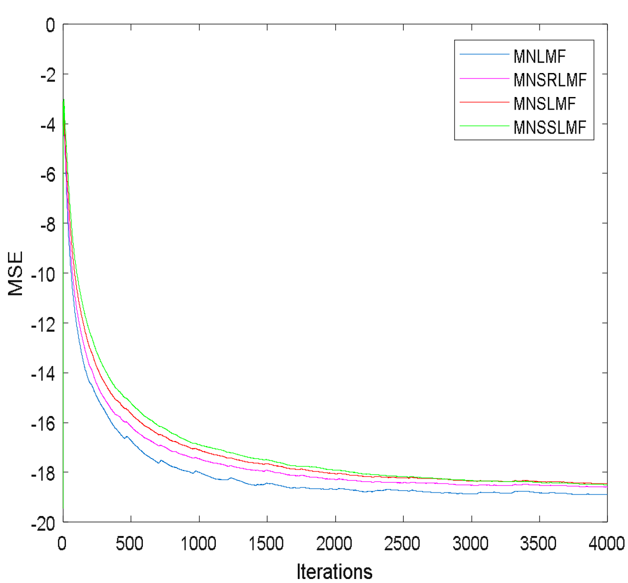

Figure 3. Convergence Curves of MN LMF Algorithm and its signed versions.

Probability detection performance is explained in this paper in terms of computational complexity and convergence curves. While calculating computational complexity, for estimating and to compare adaptive filter algorithm number of multiplications are required are calculated. Calculation of computational analysis is not based precise analysis; it depends on evaluation calculations of Maximum Normalized LMF algorithm. It also depends on sign versions, even without multiple calculations for real time applications. ‘F+1’ multiplications are required for LMS for updating weight equation also one addition is required. It requires ‘2F+1’ multiplications for sign regressor based MNLMF i.e., ‘S e(t)’. Whereas it requires ‘2F+1’ multiplications to other signed versions. In MN SRLMF it needs only few multiplications compared to other LMF based algorithms and also low computational complexity for sign regressor based algorithms. By the proposed adaptive filter algorithm, it has less computational complexities and good convergence so these adaptive algorithms are used in cognitive radios at receiver for removing noise signals from output signal. MNLMF convergence curve and their sign version convergences are shown in figure 3.

Table I. Computations Required for LMS and Various MNLMF Based Sign Versions

S.No.	Algorithm	Multiplications	Additions
1	LMS	F+1	F+1
2	MN LMF	F+3	F+1
3	MN SRLMF	5	F+1
4	MN SLMF	F+1	F+1
5	MN SSLMF	1	2

All these sign versions of MN LMF give good convergence curves when compared to LMS alone. Based on computational complexities and their convergence curves, it gives better results for sign regressor based NMLF i.e., MN SR LMF. So, it is clear that MN SR LMF converges faster when compared to MN SLMF and MN SSLMF. Its frequency concept is used in health care applications for providing treatment to remote health care patients by allocating frequencies to input signal. This cognitive radio concept is used in telemetry networks for providing treatment for patients who are away from hospital.

4. CONCLUSION

In this paper, we studied about usage of spectrum bands in cognitive radios using spectrum sensing. Later we discussed about energy detection-based spectrum sensing for identifying spectrum holes and to use of secondary user without causing interference to primary user. There are noisy signals present at the output of secondary user receiver. For avoiding these errors, proposed a normalized median LMF algorithm. By using proposed method, error is estimated for every estimation in adaptive filter and it is updated in weight equation of LMF equations. Signum function is considered in input signal for avoiding computational complexity of filter. Three version of signum functions are considered in input signal of weight update equation. But sign regressor based NM LMF gives better results in terms of convergence and reduced computational complexity.

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