Automatic Modulation Detection Technique using IWO

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Abstract - In the present scenario, various methods are used to recognize the modulation types. There are two types of method used for the modulation classification likelihood and feature based. The likelihood-based method does not provide accurate classification so we select features based approach. The features based scheme follow three main steps feature extraction, features selection and classification. . We take an OFDM model having four modulated signal BPSK, QPSK, 8PSK and 16PSK. The noise signal added to the modulated signal. We extract 12 features from the simulated signal. These features belong to the spectral and statistical based category. We proposed a new approach called IWO (Invasive Weeds Optimization to select the features from extracted twelve features. The selected features further used to train the neural network. The modulation classification performs on the basic testing data. The evaluation parameter is the accuracy of predict modulation. The proposed algorithm IWO selected features are provided higher accuracy of modulation signal reorganization than the all selected features.

Keywords - OFDMA BPSK QPSK 8PSK NN IWO

I. INTRODUCTION

In the present scenario, wireless communication is an important term of modern communication. The Modulation classification is a process between signal detection and demodulation. The modulation classification finds various applications like military and civilian. The modulation algorithm varies according to the carrier frequency of the modulated signal. The modulation classification system has three main steps, signal processing, feature selection and selection of modulation algorithm. In preprocessing step some parameters of signal calculated like SNR and symbol period, symbol synchronization and noise reduction. The neural network performed well in terms of feature extraction like the picture and audio quality of the modulated signal. The classification accuracy improved with the NN trained modulation classification mode. Two classes of recognition algorithms available The development of modulation methods obtains due to the wireless communication system. The communication signals travel in space with different frequencies and modulation types. The main function of the modulation classification module is to recognize the modulation types with no or minimum information of the signal. : Likelihood-based and Features based recognition. There are two parameters could be important recognition time and classification accuracy. The mathematic expression of the received baseband complex envelope describe by equation 1.1

$$r(t) = s(t; u_i) + n(t) \qquad (1.1)$$

$$s(t; u_i) = a_i e^{j2\pi\Delta f t} e^{j\theta} \sum_{k=1}^{K} e^{j\phi_k} s_k^{(i)}\, g(t-(k-1)T-\varepsilon T), \qquad 0 \le t \le KT \qquad (1.2)$$

Equation 1.2 represents the noise-free condition of the baseband complex envelope received signal.

Likelihood-based methods for AMR-This method discussed by the various authors which are based on the hypothesis testing. The calculation of the likelihood of the hypothesis uses the probability density function of the estimated wave conditioned on the intercepted signal. The classification error minimizes with Bayesian sense by which threshold optimal value fixed. This process is also defined as the likelihood ratio test because it provides the ratio between two likehood functions

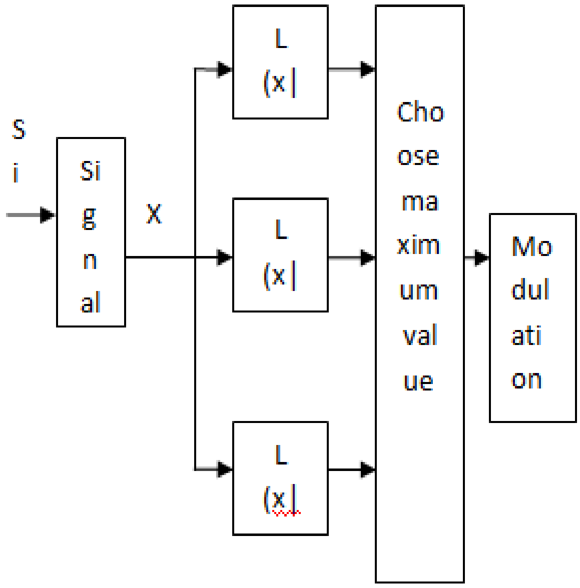


Figure 1: likehood based diagram

The likelihood-based method is developed completely on a theoretical basis, derives the theoretical curve of the reorganization process, and provided optimal classification results with the less Bayesian cost. If the parameters are not estimated clearly in start the accuracy affected directly. The performance of LB goes down due to low prior information estimation, so it does not match the real-time channel characteristics. The computational complexity of the LB approach is very high. To overcome these disadvantages we used the feature-based method.

Feature-based method: The feature-based (FB) approach also provides the same performance as LB approach, but the computational complexity is lesser than LB. There are two stages follows; feature extraction from the input signal and decision making by classifiers.

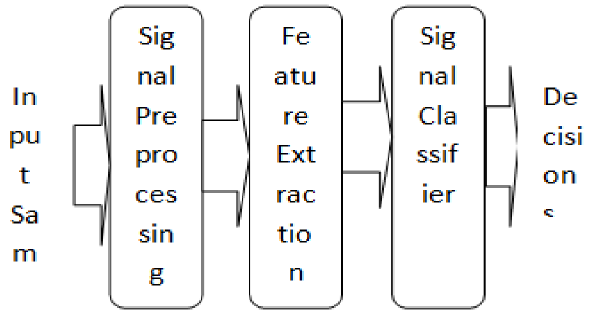


Figure 2: General Steps of Modulation classification process [1]

The complete process of the feature-based approach shown in figure 1.2. The input samples filter out using the pre-processing step. In pre-processing the samples amplified and convert it into binary form. After the pre-processing the key features extracted from the suitable signal. The features related to the frequency, amplitude and phase parameters of the signal.

Spectrum based classification method: The spectrum analyzing means detected the modulation types from the received modulated signal. For example, in MFSK (Multiple Frequency Shift Keying) the information is conveying through the carrier frequencies which spectrum is always higher than the unused frequency. Similarly, in MPSK, the phase spectrum estimates the number of phases which used to modulate the baseband signal. Both spectrum frequency and phase cannot distinguish all of the modulation types, and their performance increased from one group to another group. The fast Fourier transform used for the identification of modulation.

Wavelet Transform: FFT is used to study different modulation type signal in the frequency domain. It provides the information regarding the signal that the signal is fixed and their spectrum is time invariant. For not stationary signal the wavelet transform is used as the general solution to investigate signal in both frequency and time domain. The wavelet transform also reduces the effect of noise on the transmitted signal. The signal is processed through the high pass and low pass for the calculation of the wavelet transform. The low pass filter suppresses the high-frequency components while passing the low-frequency components of the signal. The high pass filter passes the high-frequency component and suppresses the low-frequency component. Figure 1.3 shows the decomposition of the wavelet method. The received signal first applied to the High pass filter (HPF) and Low pass filter (LPF), determine the coefficients of the signal. The output of HPF and LPF again applied to the HPF and LPF with a different cut of frequencies as used in the first stage. The output is another details coefficient of the signal. The final output of 3-level wavelet transformed obtained by $D_1, D_{2,} D_3$ and A_3 as shown in the figure. The classification features can be extracted from the decomposed components and provided to the classifier which distinguishes the modulation types of signal.

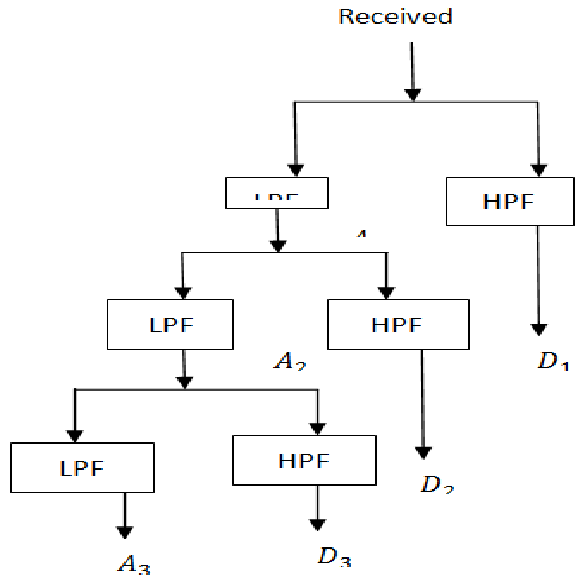


Figure 3

Clustering Algorithms: These algorithms are used to form the group of received signal symbols of the undefined signals into clusters. The number of clusters and their centroid location are used to identify the types of modulation. The process is explained with an example- let 4-QAM modulation has four different states. If the signal is transmitted through the noisy channel, then the received signals will reach the receiver scattered around their original position. The scattered symbols are grouped by using the clustering algorithm. They are resulting in four distribution cluster which identified the modulation type's 4-QAM.

II. IMESIVE WEED OPTIMIZATION (IWO)

Optimization is the process of finding the best value for the variables of a particular formulation to maximize or minimize an objective function called as an optimization. Optimization used in the various fields of research. There is two basic need of the optimization process, the parameters of the problem are identified by their nature (problem can be analog or digital), and constraints which applied to the parameters have to be recognized. The objective function of the given problem should be identified, which can be classified as a single objective and multi-objective. Therefore the parameters selection, constraint recognition, and objective investigation employed to resolve the problem.

Classification of Optimization Problems Optimization issues may be categorized primarily based on the type of constraints, nature of layout variables, nature of the equations involved, and a kind & a wide variety of goal capabilities. These classifications are briefly mentioned under. Based on the existence of constraints. A hassle is called constrained optimization problem if it is a situation to 1 or greater constraints in any other case it's far referred to as unconstrained

The solution for Optimization Problems The desire of suitable optimization approach relies upon the type of optimization problem. Various classical strategies have been there to clear up such troubles. The fundamental advances in optimization came about best after the development of speedy virtual computers. Nowadays, numerous advanced optimization techniques are used to remedy the layout and operation related nuclear reactor troubles.

Linear programming methods: The objective function and constraints both are linear in case of linear programming method. Simplex technique provides optima in a very green manner for linear programming issues. In the simplex technique, an outside (slack) variable is delivered to convert the inequality constraints into equality constraints. The simple solution for m linear equations with n unknowns is advanced by putting n-m variables to 0, and solving the m equations for m ultimate unknowns. The 0 variables are formally known as no primary variables, whereas the closing m variables are called primary variables. If all the simple variables are non-bad, the result is known as a basic viable answer. The most efficient will be one in all of them.

Interior factor methods The indoors factor techniques have been popular in the course of Nineteen Sixties for solving nonlinearly limited optimization issues due to the total dominance of the simplex approach for linear programming problems. After the Karmarkar's fast indoors method for linear programming, interior techniques are gambling a growing position in the observe of all type of optimization troubles. Based on the character of the equations concerned Based on the nature of equations for the objective feature and the restrictions, optimization troubles can be labeled as linear and nonlinear programming trouble.

Iwo parameter The process of IWO algorithm depends on the various parameters. Before implementing the IWO algorithm, the key terms are to be considered .

Agent or individual- it is the set of containing the value of each optimization variable, which is also called a seed. Every seed grow a flower in the colony.

Fitness- the value reflecting the goodness of the solution for each seed.

Plant-it is the value of one individual or seeds after estimating its fitness value.

Colony- it is the complete group of agent or individual.

Population Size- total number of plants present in the colony.

A maximum number of plants- the plants which allow producing new seeds in the colony.

III. PROPOSED WORK

The automatic modulation classification is a new technology which applied into the communication receiver to automatically recognize the modulation type of a received signal. In this work, we develop a new automatic modulation reorganization system that maintains a simple structure and provides higher accuracy. Different types of modulated signal simulated by using the OFDM (Orthogonal Frequency Division Multiplexing). The modulated signal like QPSK, BPSK, 8PSK, and 16PSK are used for classification. There are three phases of our proposed work; features extraction features selection and modulation classification. In the first step, the OFDM signal is simulated and observes the various modulation signals from them. We extract twelve features from the simulated signal and select the optimal of them by optimization process IWO. We use a neural network as a classifier; it receives selected features as input which trains the NN model. Further NN provides the classification of modulation types by IWO [9], and IWO selected features. It is in best of our knowledge that the IWO has never been proposed and used in modulation selection work earlier. The optimization algorithms play an important role in modulation classification. IWO proposed for the feature selection routine

Features Selection using IWO : There is a large number of features extracted from the simulated signal which makes the computational complexity. To overcome this problem, we use IWO optimization process to select the optimal features. We need the uniformly distributed value of optimally selected features, so we normalized them as:

$$normalised\ attribute = \sum_{i=1}^{n} \frac{f_i - \min(f)}{\max(f) - \min(f)}$$

Where 'n' is the total number of samples in an attribute, f_i is the sample value of the ith feature. For that purpose, we opted the novel optimization algorithm based on invasive weed optimization. This optimization is known as IWO and discussed in the the previous chapter. when a large data is provided by using the more number of feature the predictive model take a lot of times in making training model. After that more time is consumed in the testing and classification.

The IWO is an iterative type of algorithm which can maximize and minimize any objective function. The principle of IWO (Invasive weed optimization) [9] explained in the previous chapter. The invasive weed optimization algorithm follows the rule of plant growth which is not affetced by the weeds. The invade weeds affect the plant seeds more and reproduction seeds also affetcted badly as studied in previous chapter-3. A block diagram representing their communication is shown in figure 4.

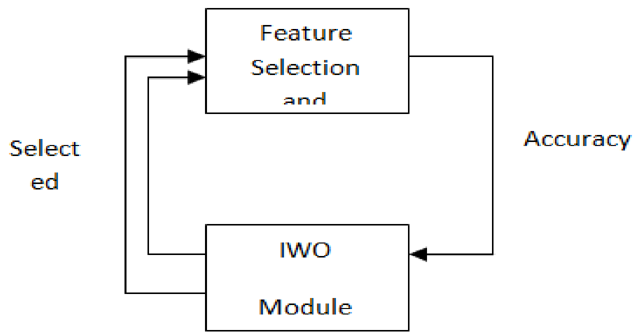


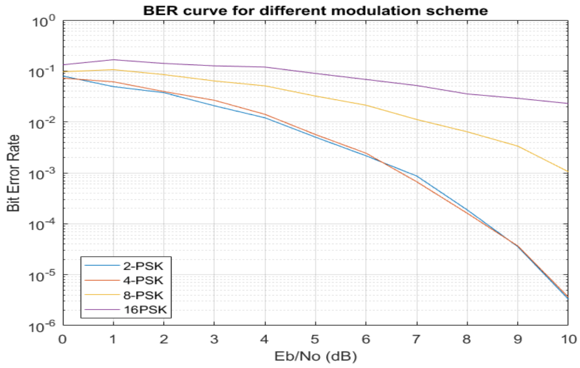
Figure 4: Relation between feature selection and IWO optimization

The process of optimization selects the optimal features to form the extracted features. We consider 20 generated weeds which search for best population member in 100 iterations. The position of generated seeds is considered as the index of selected features amongst12 features of the received signal. The feature which is selected is assigned a value 1 at its index else 0. For every whale's position, the modulation accuracy is calculated using NN classification as described in the next section.

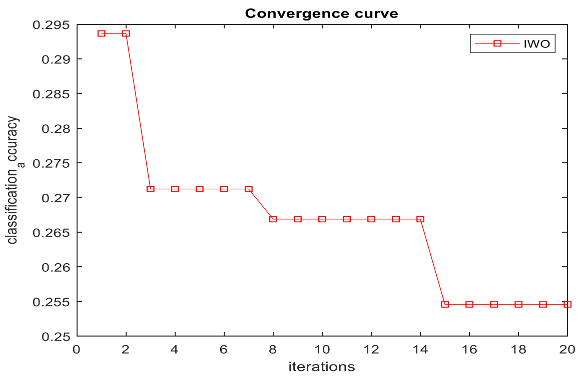
IV. RESULT AND DISCUSION

We proposed the IWO optimization to select the features from simulated OFDM signal dataset. The selected features are used to train the neural network which provided the classification of modulation types. All the codes are a module in the MATLAB with their specific name, and the Main script is also generated which calls the entire module in their code. All the functions which are designed in the MATLAB only calls in the main script; the user does not need to call them separately.

Classification and results The data set of OFDM contains four types of modulated signal. We collected the features for these modulation techniques at various SNR values. We compared the bit error rate for those modulation scheme for different SNR too as shown in figure 5.1. As the modulation type increases, the BER decreases. Higher the BER, higher is the modulation scheme.



reflects the convergence curve of IWO algorithm. The optimization curve must be increasing for initial iterations and must settle down to a maximum fixed MSE for after little iteration. As soon as it settles, better is the optimization. In our comparison case, IWO selected features trained NN is settled to a higher value than all selected features trained NN.



The classification accuracy of IWO is better than all selected BPNN features. A comparison of IWO and all features optimization for our work shown in figure 5.5

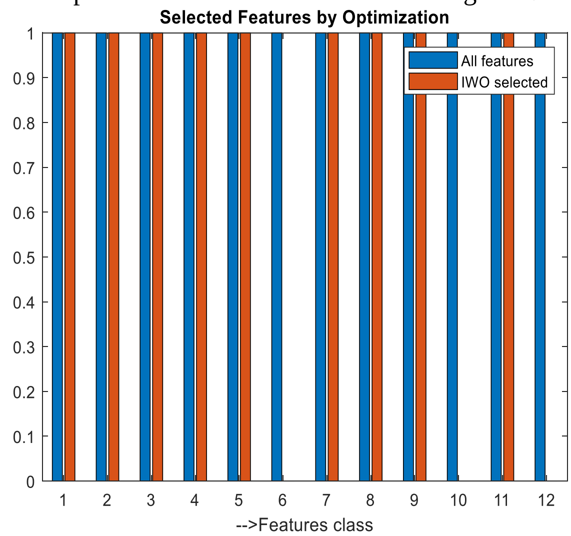


Figure 5: selected features comparison among IWO and All features

Figure 5 shows the features selection curve in which all features and IWO selected features are represented. There are twelve features extracted from the modulated signal. The optimization process is used to select the features. The IWO algorithm selected only 9 and all features are counted as 12.

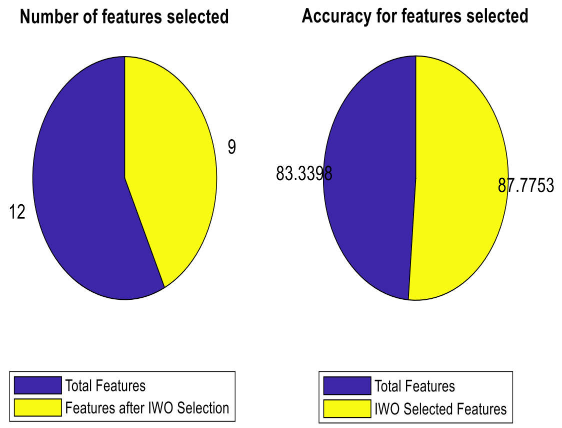


Figure 6: Pie chart of selected features by IWO and All features

Figure 6 shows the pie chart among the features selection and accuracy after selected features. The comparison is on behalf of all features and IWO selected features. The IWO selected features provided a higher accuracy than the all selected features. The figure reflects the number of features selected through the optimization and accuracy as per selected features.

Figure 5.7 represents the bar diagram of classification modulation accuracy of all features and IWO optimized selected features. Accuracy comparison curve provided the results that IWO optimization provided better performance. The modulation type classification accuracy through IWO is

87.77% and better results provided. The IWO algorithm selects the 9 features from the extracted features set and improved the frequency than all selected features.

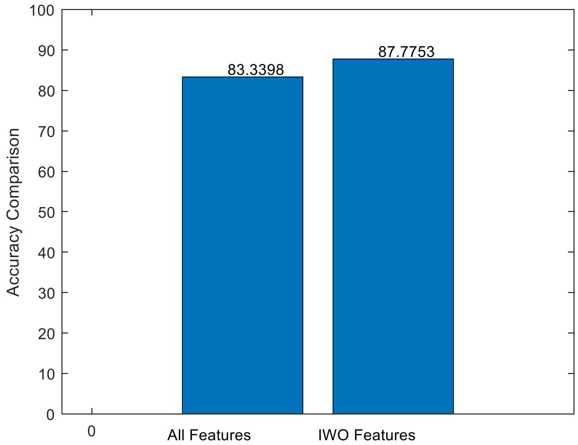


Figure 7: Accuracy comparison of IWO and All features

We also tested the proposed method with different division (70:30 and 60:40 ratio) of dataset. The results are shown in the table 5.3 with accuracy comparison.

Table 1: Different division of dataset with accuracy comparison

Data ratio	All features Accuracy	IWO Accuracy
80:20	83.33	87.77
70:30	83.89	84.03
60:40	83.81	85.47

V. REFERENCES

[1]. Jagannath, Jithin & Polosky, Nicholas & O'Connor, Daniel & N. Theagarajan, Lakshmi & Sheaffer, Brendan & Foulke, Svetlana & Varshney, P.K, "Artificial Neural Network Based Automatic Modulation Classification over a Software Defined Radio Testbed.". pp1-6, 2018.

[2]. Punith Kumar H.L., Shrinivasan L, "Automatic Digital Modulation Recognition System Using Feature Extraction," vol 394. Springer, Singapore, pp 201-208, 2017.

[3]. Y. Ettefagh, M. H. Moghaddam and S. Eghbalian, "An adaptive neural network approach for automatic modulation recognition," 51st Annual Conference on Information Sciences and Systems (CISS), Baltimore, MD, pp. 1-5,2017.

[4]. Mohammad Rida Bahloul, Mohd Zuki Yusoff, Abdel-Haleem Abdel-Aty, M. Naufal M. Saad and Lamis Kudsi, 'Spectrum Sensing for Cognitive Radio Systems Using Modulation Classification: A Review' Appl. Math. Inf. Sci. 11, No. 3,pp-857-865, 2017.

[5]. H. Wang and L. Guo, "A new method of automatic modulation recognition based on dimension reduction," Forum on Cooperative Positioning and Service (CPGPS, Harbin, pp. 316-320, 2017.

[6]. Shahnaz Almaspour, M. R. Moniri, 'Automatic modulation recognition and classification for digital modulated signals based on ANN algorithms' Journal of Multidisciplinary Engineering Science and Technology (JMEST) Vol. 3 Issue 12, pp-6230-6235, December – 2016.

[7]. A. Abdelmutalab, K. Assaleh, M. El-Tarhuni, Automatic modulation classification based on high order cumulants and hierarchical polynomial classifiers, Physical Communication, pp-1-25, 2016.

[8]. S. Hassanpour, A. M. Pezeshk and F. Behnia, "Automatic Digital Modulation Recognition Based on Novel Features and Support Vector Machine," 12th International Conference on Signal-Image Technology & Internet-Based Systems (SITIS), Naples, pp. 172-177, 2016.

[9]. S. Karimkashi and A. A. Kishk, "Invasive Weed Optimization and its Features in Electromagnetics," in *IEEE Transactions on Antennas and Propagation*, vol. 58, no. 4, pp. 1269-1278, April 2010.

[10]. W. Su, "Modulation Classification of Single-Input Multiple-Output Signals Using Asynchronous Sensors," in IEEE Sensors Journal, vol. 15, no. 1, pp. 346-357, Jan. 2015.

[11]. Li Cheng and Jin Liu "An Optimized Neural Network Classifier for Automatic Modulation Recognition," TELKOMNIKA Indonesian Journal of Electrical Engineering, Vol.12, No.2, pp. 1343 - 1352, February 2014.

[12]. Subbarao et.al, "A Novel Technique for Automatic Modulation Classification and Time-Frequency Analysis of Digitally Modulated Signals," International Journal of Signal Processing, Image Processing and Pattern Recognition. Vol.-6. No.-2, pp- 1-14, 2013.

[13]. M. H. Valipour, M. M. Homayounpour and M. A. Mehralian, "Automatic digital modulation