Survey on Automatic Modulation classifications

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***Abstract*: Wireless communication is an important term of modern communication. Modulation is a process to give strength to signal so that signal can travel long distance. The Modulation classification is a process between signal detection and demodulation. The modulation classification finds various applications like military and civilian. The terms automatic is used as opposed to the initial implementation of manual modulation classification where signal is processed by engineer and processing equipment. 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. The main function of the modulation classification module is to recognize the modulation types with no or minimum information of the signal. Two classes of recognition algorithms available: Likelihood-based and Features based recognition. In this survey paper we have discuss various technique used for automatic signal detection and iwo algorithms..**

***Keywords*: WC ASD AL**

Introduction: 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 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. Two classes of recognition algorithms available: Likelihood-based and Features based recognition.

Likelihood-based methods for AMR: 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 likelihood function

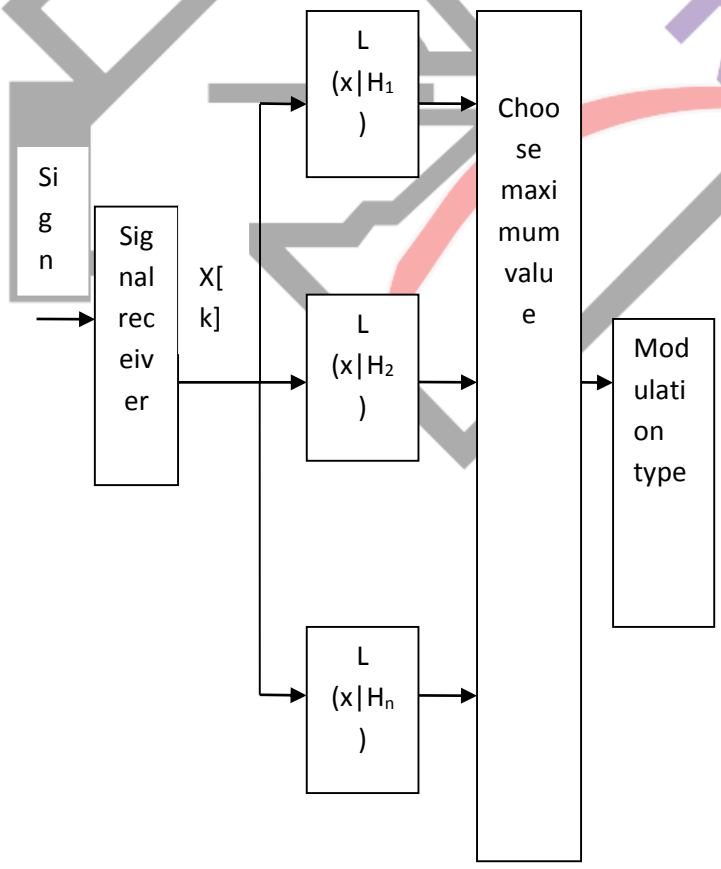

Figure 1.1 likelihood based MC

Figure 1.1 describes the steps of the LB AMR method, and the receiver measures the observed value of the input signal after that likelihood value determined under the different modulation hypothesis H.

$$\Lambda_A^{(i)}[r(t)] = \int \Lambda[r(t)|v_i, H_i]p(v_i|H_i)dv_i \qquad (1.5)$$

$\Lambda[r(t)|v_i, H_i]$ is the conditional likelihood function of the given H_i, and $p(v_i|H_i)dv_i$ is the prior probability density function. The signal parameters like, SNR, symbol rate and carrier frequency are considered as the recognizer.

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.

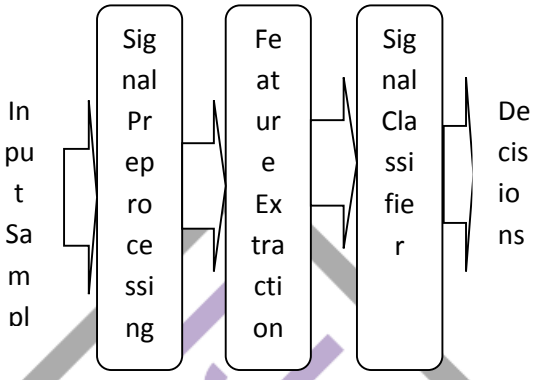

Figure 1.2 General Steps of Modulation classification process

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

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.

Invasive 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. The basic inspiration of invasive weeds optimization algorithm depends on the colonization of weeds in nature, which depend on the biology and ecology of the weed of the system. The phenomena of invade weeds in the cropping fields are to find the space between the crops. The weeds collect the unused resources present in the crop field and grow new flowering weeds, which further produce the new weeds. The fitness of flowering weed in the colony affects the number of production of new weeds from each flower weed. The weeds which compatible with the atmosphere condition and take the resource more from the field are growing faster and produce a large number of seeds. The process of weeds production spread all around the field until the maximum number of flowering weeds produce in the crop field. The weeds which have better fitness survive for a long time and produced a large number of weeds corresponding limited resources. Based on these weeds flowering production process, an optimization algorithm developed, which is called Invasive Weeds Optimization .

Literature Survey

1.Jagannath et al. (2018)- developed a practical Automatic Modulation Classification system (AMC) which provided a robust performance in a real-time situation system. The features from the modulated signal serve a better performance to AMC.

2. **H.L. Punith et al. (2017)-** proposed a new algorithm which analyzes the five different modulation signals. The FSK, BPSK, QPSK, ASK-2, and ASK-4 were classified through the algorithm. The algorithm extracts the features from received modulated signal then tests them along with preset threshold value. This process determines the type of modulation from the received signal. The proposed method improves the performance of the AMR system.

3. **Ettefagh et al. (2017)-** provided the Artificial neural network (ANN) approach for the Automatic Modulation Recognition (AMR). The overall process dived into two parts, features extraction, and trained neural network. Two feature sets were extracted from the received modulation signal. The spectral based features set and statistically based features combined to obtain the accurate classification of modulation types.

4. **Bahloul et al. (2017)**-proposed the spectrum sensing modulation classification method for the cognitive radio systems. In this work, the critical review also provided to the present spectrum sensing methods.

5. **Moniri et al. (2016)**- Recognized ten modulated signal by using features extraction based classifier. The key features were selected from the input modulated signal which further provided to the ANN for classification purpose.

6. **Ameen et al. (2016)-** proposed the Hierarchical Polynomial (HP) to the automatic detection of M-PSK and M-QAM signals in noise (Additive White Gaussian Noise (AWGN)) and slow fading atmosphere. In this scheme, the higher order cumulants (HOC) of the received modulated signal were used to detect the difference between types of the modulation signal. This scheme divides the complete modulation classification into much hierarchical binary subclassification.

7. **Hassan et al. (2016)**-proposed the pattern recognition method to obtained automatic modulation recognition (AMR). The main part of this scheme was feature extraction, and some new features were introduced to recognize the digital modulated signals. The modulation types were, BPSK, BFSK, BASK, 4-FSK, QPSK, 4-ASK, 16 QAM- with the channel Adaptive White Gaussian Noise (AWGN).

8. **S. Karimkashi (2010)-** proposed an optimization algorithm called Invasive weed optimization (IWO). It is nature inspired Meta heuristic type optimization algorithm, which mimics the nature of weeds produce with the plants. The IWO method of optimization is very competitive than previous methods and conventional methods.

9. **Wei Su et al. (2015)**-proposed two features base method called single variable and multivariable modulation for the automatic modulation recognition (AMR) of weak communication signals. These schemes used for the single input and multi-output signal sensing channels. These methods achieved better performance than the previously used methods of modulation recognition.

10. **Liu et al. (2014)-** proposed BPNN (Back Propagation Neural Network) for the Automatic Modulation Recognition (AMR). The BPNN system faces many problems which can be improved by the optimization process. The PSO method was used to optimize the value of weights and biases of the ANN. PSO is a locally based optimization method which improved the performance of ANN by tuning the weights and biases. The proposed method provided a higher accuracy than the other classifier

11. **Subbarao et al. (2013)**-provided a new method of automatic recognition of digital modulation signals with the help of signal representation known as Modulation Model. The modulation model was achieved by autoregressive spectrum modeling. The modulation model easily calculates the modulation parameters. Modulation model estimated the carrier frequency, bit rate, and modulation types. This method also performs very well in case of the low carrier to noise ratio (CNR) condition.

12. Sherme et al. (2012)-developed an accurate Automatic modulation recognition system. There were two stages present in the AMR system. In the first stage, various set of features were extracted from the received modulated signals. Generally, three features sets, spectral-based features set, wavelet-based feature set, and statistically based features set extracted. Then a classifier was used to classify the modulation types. Extracted features sets trained the classifier. The combination of these features sets was used to trained the Multi-Layer Perceptron (MLP) Neural Network and hierarchal based SVM.

13. **Bhawna et al. (2012)**-proposed the digital modulation recognition scheme for M-ary signal detection. The digital modulation signals had wide applications. The parameters of the digital modulation signal are statistically based so statistical features were extracted from the received modulated signal. There are two approaches applied for the recognition of the digital received modulated signal. The pattern recognition approach (PRA) and maximum likelihood approach (MLA) are the two categories of the recognition process.

14. **Hou et al. (2011)**-provided Wavelet transform and Neural Network based automatic modulation detection scheme for the digital modulation signal. The SNR plays a vital role in the identification of the modulated signal. In this scheme, the input signal features were extracted by the Wavelet Transform. The combination of extracted features formalizes into the singular binary matrix. This binary matrix provided as the input to the neural network. The supervised training provided to each BPNN for obtaining classification

15. **Wang et al. (2010)**-proposed the rough set theory and neural network based scheme for the classification of the digital modulation classification process. The method followed by the features selection and training process. The spectral based features were estimated from the modulated signal. The six modulation types were identified from the received modulated signal. The 2ASK, 2PSK, 2FSK, 4ASK, 4PSK, and 4FSK modulation types were tested through the proposed scheme.

16. **Nandi et al. (2003)**-proposed a new method called statistical features set for automatic recognition of digital modulation signal. The QAM16, QAM64, V29 signals were examined through this scheme. Two algorithms were used for the training purpose, backpropagation with momentum for multilayer perceptron (MLP) and Adaptive learning rate investigated.

17. Yaqin et al. (2003)- proposed the modified structure of ANN for detection of carrier signal modulation types. The adaptive white Gaussian noise (AWGN) also present in the carrier signal. Five key features were extracted from the digital modulated signal and 3- node output layer ANN network train by them. In this method, seven types of modulated signals were classified. The structure of the ANN was simple and had low computational complexity. The seven modulated signals FSK, ASK, PSK, 2FSK, 2ASK, 2PSK, and 16 QAM were recognized through the proposed methodology.

Conclusion

In this survey paper we have discussed various techniques implemented by researchers for getting optimal solution in automatic modulation technique .it is found that The optimization algorithms play an important role in modulation classification.

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