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An Automatic Modulation Classifier for signals based on Fuzzy System

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Abstract - Automatic modulation classification has attracted a lot of interests in the research community in recent years. Automatic modulation classification is a procedure performed at the receiver based on the received signal before demodulation when the modulation format is not known to the receiver. This paper presents a method for the automatic classification of digital modulations without a priori knowledge of the signal parameters. This method can recognize classical single carrier modulations such as phase-shift keying, frequency-shift keying, amplitude-shift keying, as well as analog modulations such as amplitude modulation, phase modulation and frequency modulation from the classifier based on Fuzzy System. After identification of the modulation type, the method automatically estimates some parameters characterizing the modulation. To evaluate the method performance, several simulations have been carried out in different operating conditions that should be particularly critical by varying the values of signal to-noise ratio[17]. To validate the assumption that is made, experimental tests have been performed.

Keywords – Modulation Classifier, AMC, Fuzzy system, Analog Modulation, Digital Modulation, AWGN Channel

I. INTRODUCTION

An automatic modulation classifier is a system that automatically identifies the modulation type of the received signal without the preventive knowledge of some parameters. Such a system could play an important role in electronic surveillance systems, military communications, emitter interception, signal verification, and interference identification. In particular, great interest is achieved to the development of an automatic system that is able to characterize the signaling quality whichever digital or analog modulation is used.

In this paper, we try to conduct research in automatic modulation classification through instantaneous features such as instantaneous amplitude, phase and frequency parameters [12]. As a direct result, we have been able to classify more modulation types. Specifically, we are able to classify six commonly used modulation types: ASK, FSK, PSK as well as AM, FM and PM. Simulations over different signal to noise ratios confirm the effectiveness of the algorithm and the choice of thresholds.

In this paper, we propose a new pattern recognition approach based on various features of the signal amplitude, phase, and frequency. Proposed classifier is composed of two subsystems. First one extracts useful information from the observed data and can be viewed as a mapping observation space into a chosen feature space. Second one is a pattern recognizer subsystem which indicates the membership of the modulation type [1]. Based on this classification modulation scheme is identified.

II. PROBLEM STATEMENT

In coherent technique, the receiver has prior knowledge about modulation scheme used at receiver side. But in non-coherent technique, receiver is unaware of which modulation scheme is used. So at that time we cannot get the exact data of which modulation scheme is used.

To overcome the problem automatic modulation scheme detection technique should be . Thus AMC can be used to demodulate the received signal and further classify it. So there should be some technique that can be used to determine the modulation scheme without much knowledge of signal parameters.

III. PROPOSED SOLUTION

The first idea about the solution is that develop an algorithm such as it can include more certainty about the difference between various schemes. Then try to make a code simpler that it can reduce complexity. For this solution I will use MATLAB platform. Here various parameters of the modulation is classified.

Different parameters are frequency, amplitude and phase. From these we can classify ASK,PSK and FSK. For this we use fuzzy logic classifier, which can be made in fuzzy logic toolbox of MATLAB. The fuzzy classifier has two phases:

(1) Classifier Training Phase
(2) Classifier Testing Phase

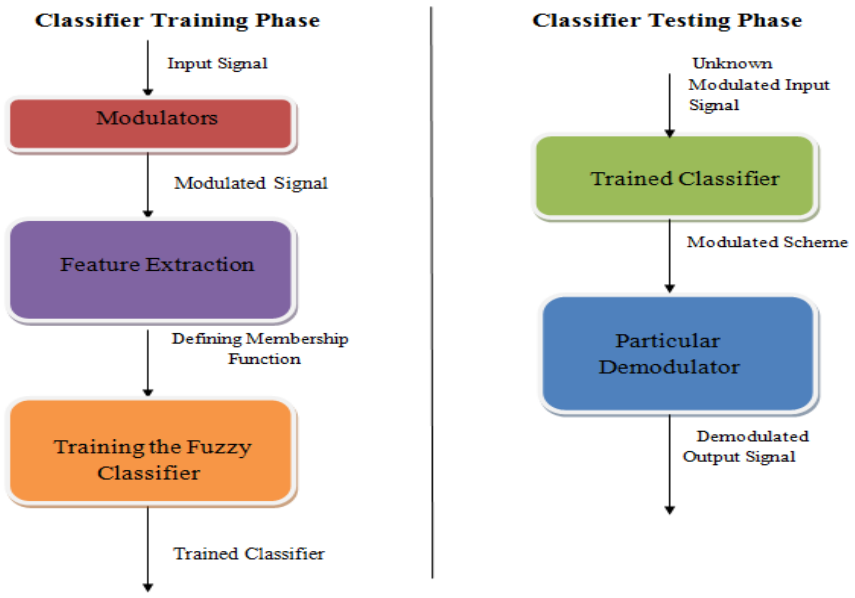

Fig.1 Block Diagram of proposed work

(1) Classifier Training Phase :

In classifier training phase, input signal is given to modulators and then the modulated signal is given to feature extraction block by defining membership function which trains the classifier.

(2) Classifier Testing Phase:

In classifier testing phase, unknown modulated signal is given to trained classifier which at the output side gives the particular modulation scheme and using that demodulator can be selected to obtain demodulated signal.

Parameters Extracted:

The list of parameters used for extraction of input modulated signal based on training phase are listed below:

Table 1: Parameter Extraction

Sr No.	Parameter	Mathematical Expression
1)	Instantaneous amplitude of analytic signal :	a(i)=abs(fft(x(i)))
2)	Instantaneous frequency of analytic signal	f(i)=fft(x)
3)	Instantaneous phase of analytic signal	ϕ(i)=180*angle(x)/pi

IV. SIMULATION RESULTS

In Membership function editor of Fuzzy interface system, input signal is given which maybe amplitude ,Phase and frequency for which output membership function will give the type of modulation scheme like ASK,FSK or PSK.

Analog Modulation Results :

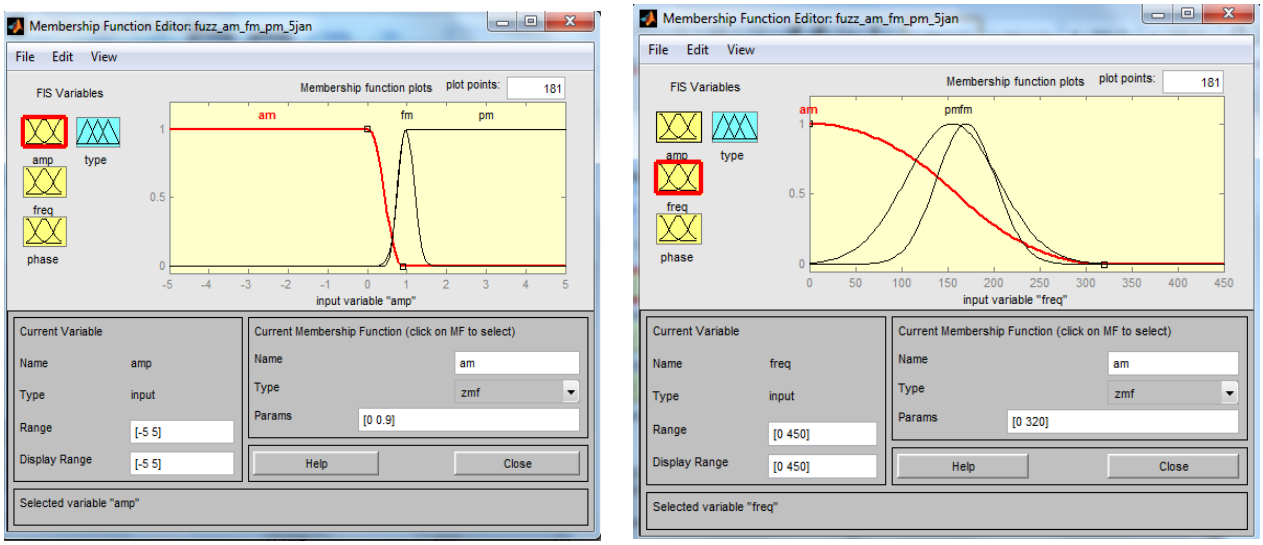

Fig. 2(a) Membership function for amplitude (b) Membership function for Frequency

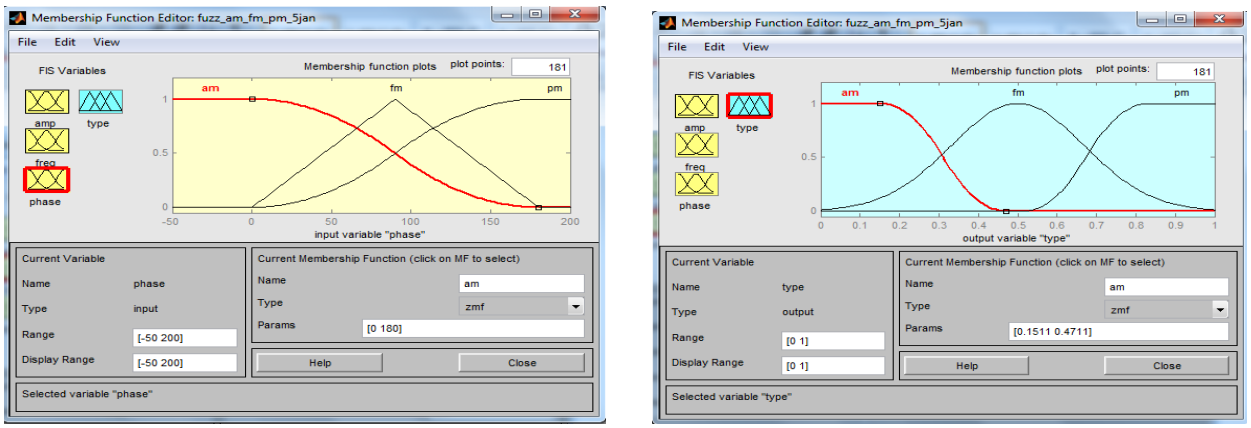

Fig. 3 (a) Membership function for phase (b) output (modulation type)

Digital Modulation Results :

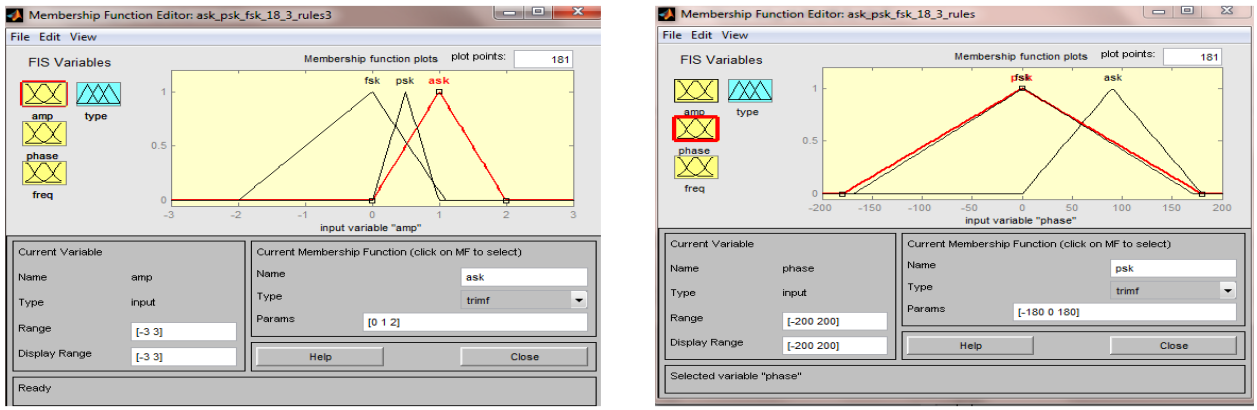

Fig. 4(a) Membership function for amplitude (b) Membership function for phase

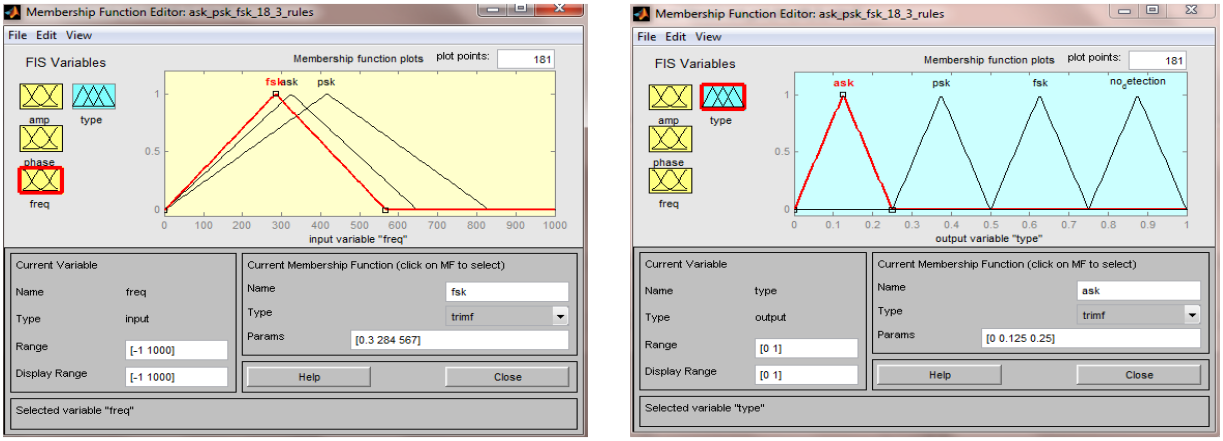

Fig. 5 (a) Membership function for frequency (b) output (modulation type)

Following are rules for this classifier.

If (amplitude is ask) and (freq is ask) and (phase is ask) then (type is ask)

If (amplitude is psk) and (freq is psk) and (phase is psk) then (type is psk)

If (amplitude is fsk) and (freq is fsk) and (phase is fsk) then (type is fsk)

If (amplitude is ask) and (freq is ask) and (phase is psk) then (type is ask)

If (amplitude is psk) and (freq is psk) and (phase is fsk) then (type is psk)…

Likewise futher 27 rules can be defined for different combinations of ASK,FSK & PSK as shown below.

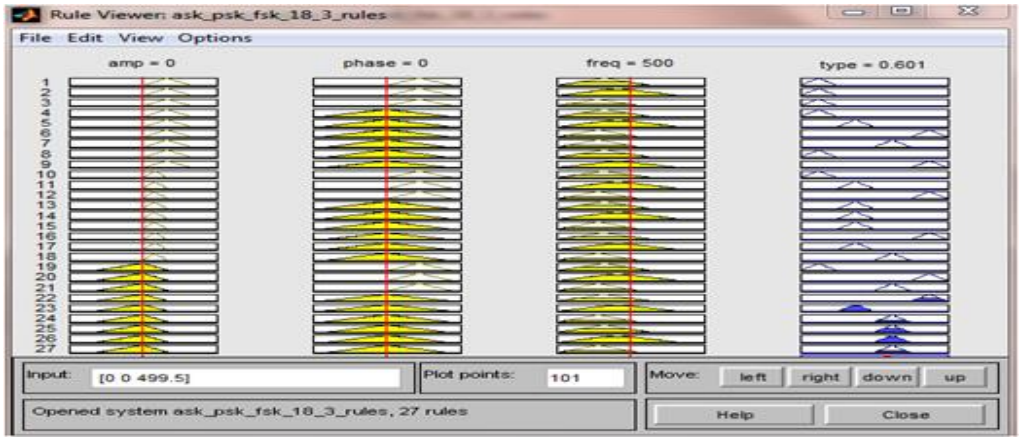

Fig.6 Fuzzy Rule Viewer

Detection Accuracy Measurement:

For various modulation schemes like ASK,PSK & FSK , Using different values of SNR , Accuracy is measured. For various values of SNR, number of iterations are varied and for that output accuracy is measured. It can be seen that for higher values of SNR , accuracy increases.

Table 1: ASK Performance Evaluation

Modulation Scheme : ASK									
SNR	5 dB			10 dB			20 dB		
No of iterations	100	1000	5000	100	1000	5000	100	1000	5000
Measured Value	87%	82%	81%	95%	90%	85%	99%	98%	99%

Table 2: FSK Performance Evaluation

Modulation Scheme : FSK									
SNR	5 dB			10 dB			20 dB		
No of iterations	100	1000	5000	100	1000	5000	100	1000	5000
Measured Value	82%	80%	80%	100%	89%	97%	100%	100%	100%

Table 3: PSK Performance Evaluation

Modulation Scheme : PSK									
SNR	5 dB			10 dB			20 dB		
No of iterations	100	1000	5000	100	1000	5000	100	1000	5000
Measured Value	70%	76%	83%	81%	85%	93%	99%	98%	99%

V. CONCLUSION

Automatic modulation scheme classification is the method to recognize the modulation type. This method requires no prior knowledge of different signal parameters and it gives output with less or no knowledge input modulated signal. Also, based in results, it is observed that with increase in SNR value, accuracy of AMC is increased. Simulation results proved that the elaborated algorithm, using proposed set of the features is very strong with respect to SNR. For non-coherent techniques, Modulation Schemes can be automatically detected effectively. This method allows to create intelligent radio links, efficient monitoring, methods of signal transmission and various control systems.

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