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Feature Extraction Of Modulated Signal Based on Swarm Optimization and Random Forest classifier

A Research
Submitted to the Department of Computer Science\ College of Sciences\ University of Diyala in a Partial Fulfillment of the Requirements for the Degree of Master in Computer Science

By

Batool Abd Al Hadi Sultan

Supervised By

Dr. Taha M. Hassan
Assistant Professor

Hadi A. Hamed
Assistant Professor

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بِسۡمِ ٱللَّهِ ٱلرَّحۡمَٰنِ ٱلرَّحِيمِ

﴿ٱقْرَأْ وَرَبُّكَ ٱلْأَكْرَمُ(٣) ٱلَّذِي عَلَّمَ بِٱلْقَلَمِ (٤)
عَلَّمَ ٱلْإِنسَانَ مَا لَمْ يَعْلَمْ (٥) ﴾

صدق الله العلي العظيم

العلق– الآية (٣,٤,٥)

Dedication

To...

My family

My dear parents

My dear husband

My children Husain & Mohammed

All our distinguished teachers those who paved the way for our science and knowledge

Batool Abd AL hadi

Acknowledgment

First of all, praise is to GOD, the lord of the whole creation, on all the blessing was the help in achieving this research to its end.

I wish to express my thanks to my supervisors, Assist. Prof Dr. Taha Mohammad Hassan and Assist.prof. Hadi Ahmed for supervising this research and for the generosity, patience and continuous guidance throughout the work. It has been my good fortune to have the advice and guidance from them.

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Batool –Abd AL hadi

Supervisor's Certification

*We certify that this thesis entitled "**Feature Extraction Of Modulated Signal Based on Swarm Optimization and Random Forest classifier**" was prepared under my supervision at Department of Computer Science\ College of Sciences\ University of Diyala in a partial fulfillment of the requirements for the degree of **Master of Science in Computer Science.***

Signature:

Name: Asst. Prof. Dr. Taha Mohammad Hassan

Date: / /2020

Signature:

Name: Asst. Prof. Dr. Hadi Athab. Hamed

***Date*: / / 2020**

Approved by the Department of Computer Science at University of Diyala

Signature:

Name: Asst. Prof. Dr. Taha Mohammad Hassan

***Date*: / / 2020**

(Head of Computer Science Department)

Linguistic Certification

I certify that this thesis entitled **"*Feature Extraction Of Modulated Signal Based on Swarm Optimization and Random Forest classifier*"** *was prepared* ***by Batool Abdel Hadi Sultan*** *And was reviewed linguistically. Its language was amended to meet the style of English language.*

Signature :

Name: ***Asst. Prof*. Dr Alia Maan Abdul Hamid**

Date : / **/2020**

Examination Committee Certification

We certify that we have read the thesis entitled ***"Feature Extraction Of Modulated Signal Based on Swarm Optimization and Random Forest classifier"*** *and as examination committee, examined the student* ***"Batool Abdel Hadi Sultan"*** *in the thesis content and that in our opinion, it is adequate as fulfill the requirement for the Degree of Master in Computer Science at the Computer Science Department, University of Diyala.*

(Chairman)

Signature:

Name: Prof. Naji Mutar Sahib

Date: / /2020

(Member)

Signature:

Name: Asst. Prof. Dr. Firas .M. Aswad

Date: / /2020

(Member)

Signature:

Name: Asst. Prof. *Dr.Ahmed. K .Abdullah*

Date: / /2020

(Member\ Supervisor)

Signature:

Name:Asst. Prof. Dr. *Taha .M. Hassan*

Date: / /2020

(Member\ Supervisor)

Signature:

Name :Asst. Prof. Dr. Hadi Athab Hamed

Date: / /2020

Approved by the Dean of College of Science Computer , University of Diyala

(The Dean)

Signature:

Name: Prof. Dr. Tahseen Hussein Mubarak

Date: / /2020

(Head of Computer Science Department**)**

Abstract

The applications of digitally modulated signals are still in progress and expansion. Automatic Modulation Identification (AMI) is important to classify the digitally modulated signals of arbitrary modulation schemes. AMI is crucial in military applications, like electronic surveillance, and interference recognition. In civil applications, AMI can be employed in Software Defined Radio (SDR), signal monitoring, intelligent modems, Cognitive Radio (CR), etc.To get better results of the system suggested optimization the features to discard weak or irrelevant features in the system and keep only strong relevant features, Thus increasing the accuracy of the system in identifying the modified signals.In this work, present hybrid intelligent system for the recognition related to the digitally modulated signals where used , which include 3 major modules: optimization module, classifier module, as well as feature extraction module. The proposed (AMI) had been built to classify ten most popular schemes of digitally modulated signals, namely (2ASK, , 2PSK, 4PSK, 8PSK, 8QAM,16QAM ,32QAM, 64 QAM, 128QAM, and 256QAM), with the signal to noise ratio ranging from (-2 to 20) dB. High-order cumulants (HOCs) as well as high-order moments (HOMs) were utilized. The parameters of features extraction were minimized by decreasing the numbers of HOMs and HOCs, in order to reduce the complexity and training time of the AMI systems using modified optimization techniques .In this thesis used two optimization algorithms Chicken Swarm Optimization (CSO) , Bat Swarm Optimization (BA) to optmize.The Random Forest (RF) classifier was introduced for the first time In this thesis. Simulation results of the System proposed , under additive white Gaussian noise channel show that when used (RF-CSO)

have 95 % success rate for SNR between (20-13)dB and the a Classification accuracy of (94%) for the SNR ranging from (6-12) dB for the low SNR values (5≥ SNR) .The classification accuracy (90%) dB .While algorithm (BA Swarm Optimization) for the modulated signals obtained a classification accuracy of around 90% for the SNR between (20-13) dB and the a classification accuracy of (92%) for the SNR classification from (6-12) dB for the low SNR values(5≥SNR) The classification accuracy (89%) . A fair comparison was carried out between the two system proposed to feature extraction optimization and with the best classifier under the same circumstances. The comparison clearly showed that the used (RF -CSO) have higher success rate than those of the (RF-BA).

Contents

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List of Abbreviations

Abbreviations	Meaning
ABC	Artificial Bee Colony
ACO	Ant Colony Optimization
AI	Artificial Intelligence
AM	Amplitude Modulation
AMC	Automatic Modulation Classification
AMR	Automatic Modulation Recognition
ASK	Amplitude Shift Keying
Avg	Average
AWGN	Additive Wight Gassing Noise
BA	Bat Algorithm
CDMA	Code Division Multiple Access
COMINT	Communication Intelligence
CS	Cuckoo Search
CSO	.Chicken Swarm Optimization
DSPS	Digital Signal Processors
DT	Decision Theoretic
DVB-S	Digital Video Broadcasting –Satellite
DWT	Discrete wavelet transform
ECCM	Electronic Counter- Counter Measures
ECM	Electronic Counter Measures
EPSO	Enhanced Particle Swarm Optimization
ESM	Electronic Support Measures
EW	Electronic warfare,
FA	Firefly Algorithm
FBA	Flower Pollination Algorithm
FDM	Frequency-Division Multiplexing
FM	Frequency Modulation
FP	False Positive
FSA	Fish Swarm Algorithm
FSK	Frequency Shift Keying
GA	Genetic Algorithm
HOCs	High-Order Cumulants
HOMs	Highly Ordered Moments
IWO	Invasive weed Colonization
KH	krill Herd
MA	Monkey Algorithm
MABC	Modified Artificial Bee Colony
MABC	Modified Artificial Bee Colony
ML	Machine Learning
PM	Phase Modulation
PNN	probabilistic neural networks
PR	Pattern Recognition

PSK	Phase Shift Keying
PSO	Practical swarm optimization
QAM	Quadrature Amplitude Modulation
RF	Random forest
RMS	Root Mean Square
ROC	Receiver Operating Characteristic
SDR	Software defined radio
SNR	Signal To Noise Ratio
SVM	Support Vector Machine
TDM	Time Division Multiplexing
TP	True Positive

Symbols Table

Symbol	Meaning
*	Multiplication operation
+	Addition operation
/	Division operation
-	Subtraction operation
=	Equality sign
Θ	Theta
∑	Summation - sum of all values in range of series
Log	Logarithm
μ	Mean Value
σ	Standard Deviation
%	Percent sign
Sin	Sin function
Cos	Cos function
Θ	Circled minus /ominus
√	Square root
(a,b)	Ordered pair, collection of 2 elements
( )	Parentheses, calculate expression inside first

List Algorithms

Chapter One

General Introduction

Chapter one

Introduction

1.1 Over view

Base-band signals might not be always appropriate to be used for the transmission over a given channel. These signals are modified to facilitate transmission. Parameters related to high-frequency carrier will be varied according to the variation of baseband signal. Shifting the range regarding the frequency spectrum of the signal is defined as modulation to gain several advantages: The long wavelength of baseband signal will need an impractically large antenna, and transmitting different modulated signals simultaneously as Frequency-Division Multiplexing (FDM) and Time Division Multiplexing (TDM). The digital and the analog modulations transform baseband signals into modulated band pass signals [1]. In conventional communication of digital communication system, the modulation formats include, modulation type, symbol rate, carrier frequency and so on. Technologies are rapidly moving toward secure and advanced communications. Rapid grow was achieved in terms of developing highly intelligent systems of communication. These systems could be vital for military and civilian applications, in which various systems of modulations are needed for securing communications. Automatic modulation classification (AMC) can be considered as in-between phase between detecting information that is carried through signals and its de-modulation provide simplicity in handling various standards of communications. Single receiver circuit could be used for the purpose of recognizing various systems of modulation, and after that de-modulate those in the coming signals that were transmitted through the use of various standards. AMC can also be used in spectrum management, interference identification, and signal confirmation.

Authorities related to civilians might want to look over their transmission so as to have a control over them in addition to monitoring and detecting the non-licensed transmitters [2] For military purposes its applications can be electronic warfare (EW), threat analysis and surveillance. Applications such as the systems of electronic support measures (ESM) are of high importance as an information source that is required for conducting target acquisition, warning, electronic counter measures (ECM), and the electronic counter-counter measures (ECCM) [3] . Automatic modulation classification (AMC) work on the basis of one the 2 methods: Pattern Recognition (PR) method or the Decision Theoretic (DT) method[4]. Probabilistic hypothesis testing arguments are used by the DT approach for the purpose of formulating recognition problem. The absence of robustness with regard to model mismatch as well as the complicated computations are the main disadvantages of DT methods. Also, because of the limitations of DT methods, they lack efficiency in the case when encountering various types related to the digital signals. With regard to PR methods, they have two major sub-systems: classifier sub-systems as well as the feature extraction sub-systems. The first one determines the signal's membership while the second will be extracting the features, also they do not require particular handling, thus they can be implemented easily. Many modulation recognition methods were stated in literature[5]. Another method was used in this thesis to identify the formation is (a Random forest). This approach is divided into four steps: signal generation and extraction features, phase improvement features, training phase for adjusting work-book structure (for determining biases and weights), and test phase, where the network performance is determined. In this thesis we used the second approach(PR) because it need less memory, simple and faster than the other techniques. More details about this approach will be discussed in later chapters.

1.2 Literature Survey

A comprehensive review of literature regarding automatic modulation techniques is presented. After improving the parameters of the signals included to increase the accuracy of the classification. In the presented chapter, brief review of different techniques for classification of modulation formats is presented.

- ***Amudha, Karthik, & Sivakumari, 2015*** [6]- A hybrid algorithm has been suggested by the authors for integrating modified artificial bee colony (MABC) with an enhanced particle swarm (EPSO) for the purpose of predicting the infiltration detection. Such algorithms have been combined for the purpose of achieving improved results of optimization, also the classification precision will be achieved via 10-folds verification approach. The results show that when a dataset is categorized with all features, the average resolution of hybrid approaches is suggested. The ABC and MABC-EPSO accuracy rate were significantly increased to 94.36%.
- **HL & Shrinivasan, 2015** [7]- Suggested anovel algorithm for distinguishing six types of digital modulation approaches (ASK-2, FSK-2, PSK-2, ASK-4, FSK-4 and PSK-4). High resolution results for new algorithms have been demonstrated even when SNR = 4dB.
- **M Hamee & Wadi, 2015** [8]- In this study, the researchers investigated a method of classification of digital MFSK signals without prior information using the modified heterogeneity method. This method used for account features to form a FSK is sensitive with the FSK forming indicator although the signal-to-noise ratio (SNR) varies. Using a single-to-all SVM-OAA rating vector performance algorithm, a rating of 6 digitally modified signals has been achieved, with a rating accuracy of 85.85 at SNR =15Db.

- **Hakimi and Ebrahimzadeh, 2015[9] -** In this research, the researchers used a smart hybrid system to identify digital signal types. The system consists of three main units: the unit of extracting parameters, the classification using probabilistic neural networks (PNN), and the optimization using the bee algorithm. The proposed system gave high ratings accuracy results even when signal-to-noise ratio (SNRs) was low. Where the workbook achieved a success rate of about 91% for SNR> 0 dB.
- **Hassanpour, Pezeshk, & Behnia, 2016 [10] -** The researchers proposed a new algorithm to identify the configuration (AMR) based on pattern recognition for the purpose of determining the digital modulation systems. There are certain types of modulation such as: BASK, BFSK, BPSK, 4-ASK, 4-FSK, QPSK, 16-QAM, and AWGN that considered a channel. Features will be extracted from received signals that are considered in time, wavelets and frequency bands, To overcome the multi-layer problem, hierarchical structure will be examined on the basis of bilateral SVMs. Simulations will demonstrate the effectiveness related to the proposed features have been digitally separated. The modified signals in an extremely noisy environments with values of SNR are extremely low; Thus, it was indicated that the optimum selection is -5 dB, while the final accuracy ratio of 98.15 has been achieved at -10 dB.
- **Kanisha & Balarishnanan, 2016 [11]-** The researchers used the speech signal as input to the content recognition, where the signal processing involved three stages :pre-processing, extraction of features, and SVM. They used different optimization algorithms, including APSO. They extracted optimal features such as triple spectral, peak signal and separate waveform (DWT). These optimized features are used as an input to the SVM demonstrated results, that optimize

algorithm (APSO) has higher accuracy compared to the current SVM linear kernel technology.

- **Almaspour & Moniri, 2016 [12] .** In this study, the researchers selected suitable features for the modified input signal and used the neural network algorithm, choosing 10 modified signals (2ASK, 4ASK, 2FSK, 4FSK, 2PSK, 4PSK, 4QAM, 16QAM, 64QAM). The presence of Gaussian noise -5 dB to 20 dB .The results showed that the use of the NN algorithm led to a significant increase in the accuracy of recognition of the type of modification.
- **Liu, Proietti, Zhang, Lu, & Yoo, 2017 [13]-** The researchers proposed a method to determine the MFI format that provides high resolution even in a low-light signal system of less than 10 dB that uses peak detection and non-linear power conversion. The proposed method can specify the type of signal modulation format: BPSK, QPSK, 8-PSK, and QAM. The experimental results showed that the proposed MFI can achieve high accuracy even when SNR is 7 dB.
- **Wang, Guo, Dou, & Lin, 2018[14]** -The study aimed the complication to identify adjustments in SNR decline. According to entropy's information features and Dempster-Shafer manual theory, new automatic adjustment recognition approaches were suggested in this paper. First, Renee Interoperability and Single Entropy have been applied for obtaining adjustment features. Second, according to standard test theory, the new basic probability assignment function (BPAF) has been introduced. Finally, Dempster-Shafer has been applied as profiler. The results of the study suggest that the novel method has the ability of obtain high degree to recognition in the lower SNR rate .
- **Rajendran et al., 2018[15]-**They studied the classification problem of the distribution wireless spectrum sensor network. They proposed a data-based model to classify the AMC automatic adjustment

and based on LSTM long-term memory. They used the time-based capacitance model and stage information from the configuration diagrams contained in the training data without relying on expert features such as periodic top order moments. The results was averaged 90% accuracy in varying SNR ranging from 0dB to 20d.

- **Kurniansyah, Wijanto, & Suratman, 2018 [16]-** In this research, extracting the executed parameters is a statistical advantage of high ranking in time domain. Order 4 is the applied statistical order. The signals information have been transmitted on transmission channel with the existence of AWGN noise interference with variable signal quality that ranged from zero to forty dB. ANN has been utilized for classifying the modification. AMC has ability of distinguishing between AM, LSB, USB, BPSK and QPSK, and 8PSK modulation. The accuracy rate related to the system in modulation classification process without using non-linear conversions is 65.5 percent on signal quality of ten dB. After that, AMC accuracy through the use of non-linear transformations on incoming signal reached 88.8 percent on signal quality ten dB.
- ***Sun et al., 2019 [17]*** This paper proposed a method for determining the format of blind modification using the decision tree dual-carrier bus system support has been trained on features extracted from the high-order stacking tool. The results suggested that the average Accuracy of the identification of optical format coordination signals can be achieved more than 94% when SNR is -5 dB.

in fact, Paper submitted by Hakimi and Ebrahimzadeh, 2015 **[9]**under title "Digital modulation classification using the bees algorithm and probabilistic neural network based on higher order statistics" The closest research with our study , have used the same type of signal and same kind of features, But in this research were used two algorithms to improve system performance (CSO & BA) and Random Forest for

classifying the signal. .the researcher depended on bee algorithm to improve system performance and the classification using probabilistic neural networks (PNN) where better results were obtained.

1.3 Thesis Contribution

The main contributions of this thesis are:

1-Utilization of Random Forest (RF) as a classifier for identification digitally modulate signal was introduced at the first time by this Thesis.

2-The improved the performance the proposed classifier Random Forest (RF)is presented based on Statistical features. by Chicken swarm optimization and Bat swarm optimization was introduced at the This technique first time by this Thesis.

1.4. The Aim of Thesis

The purpose of this study is to design and implementation an intelligent system able to get better results of Via optimization the features to discard weak or irrelevant features in the system and keep only strong relevant features using developed optimization techniques this reduces the complications of time and cost , thus increasing the accuracy of the system in identifying the modified and detect digitally modulated signals, without prior knowledge of the transmitted signal thus investing it within its applications each type according to its use, using MATLAB and JAVA programs.

The objectives this thesis are as follows:

1- Develop optimization methods to extract the main features of the received signals that could be used to distinguish the different between communication signals.

2- Develop algorithms to improve the characteristics of the signal extracted from the vertical to strength the parameters and increase the accuracy of their classification

3 - Develop algorithms to define the configuration based on the main features extracted from the signal after improve them using Random forest.

1.5. Thesis Layout

Furthermore, the other parts of the presented thesis consist :

Chapter Two: Theoretical and Background

Digital modulation signals and feature extraction present an extensive overview optimization feature extraction of signal moduled and classification two features extraction techniques are given.

Chapter Three: The Proposed modulation Recognition System

Chapter three introduces the steps of the suggested system, describes the developed algorithms to execute the system

Chapter Four: The Experimental Result and Test

This chapter presents the experiments and the results which are obtained from the system running and performance measures related to tested results

Chapter Five: Conclusions and Suggestions for Future Work

Chapter five provide conclusions list that is derived from the results related to the current work and few future works with suggestions.

Chapter Two

Theoretical Background

Chapter Two

Theoretical Background

2.1 Introduction

The presented chapter discus detailed explanation of the types of digitally modulated signals That is generated in a language MATLAB , Statistical feature extraction (Cumulants (HOCs) , and Moments (HOMs)) for modulated signals, provided intelligent swarm optimization algorithms such as swarm optimization algorithms (Chicken(CSO), Bat (BA)) That mimic the life behaviors of some organisms in nature intelligent swarm optimization algorithms have certain advantages such as high accuracy, rapid convergence rate, optimum stability, also they have the ability of obtaining precise solution or estimated solution related to the large-scale optimum problems with less consumed time,, and classification of signals by (Random Forest) combine tree predictors in a way that each of these trees depends on random vector values that have been independently sampled and with the same distributions as all forest trees. . This algorithm works effectively on large databases that can handle large amounts of input variables without deleting. It provides an assessment regarding the important variables in the classification, and performance evaluation criteria.

2.2 Modulation

Original messages or signals (referred to as the base-band signals) are not always adequate to be transmitted over channels for a lot of reasons. For the purpose of facilitating the transmission process, the base-band signals will be adjusted.

Carrier signals that are defined as high-frequency sinusoid are applied for this aim. Modulation is specified as: adjusting at least one property related to carrier signals through base-band signals. Properties that are changed through base-band signals might be phase, frequency, amplitude, and so on, corresponding modulations will be referred to as amplitude modulation (AM), phase modulation (PM), and frequency modulation (FM). The signal which has been modulated, as soon as being received at receiver, should be de-modulated prior to being utilized. Some of the advantages provided by modulation are:

1. To have effective transmission, the radiating antenna's size must be one in ten of the radiated signal's wave-length. The frequency that related to the majority of base-band signals is considered to be relatively low and led to unpractical huge dimension for radiating antenna. One can ensure that the antenna size is within a practical limits through use of a high frequency carriers.

2. The base-band signals which are being transmitted with similar frequencies and might interfere with each other.

3.To use carrier signals that have frequencies with certain distance between them for various base-band signals might result in translating each one of the base-band signals to distinctive frequency range, and avoid interference. Frequency division multiplexing (FDM) is the approach that is used to translate the signals to different frequency bands [1], Figure(2.1) represent modulation block diagram .

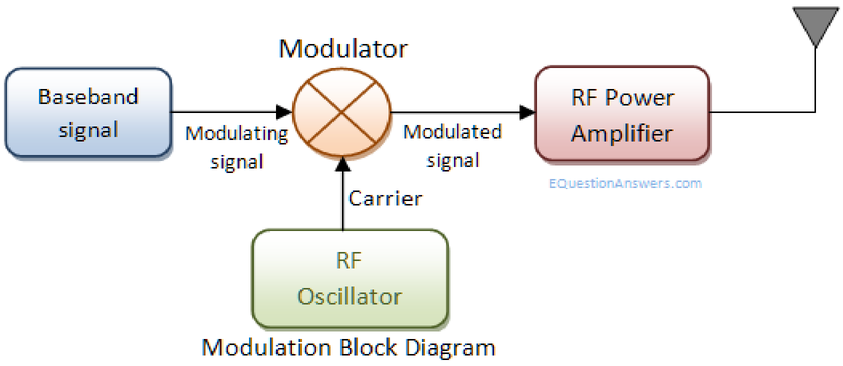


Figure.*(2.1) modulation block diagram*[1]

2.3 Modulation types

Modulations can be categorized into two main categories: digital modulation and analog modulation. Figure(2.2) that display the modulation types and the subtypes related to digital modulation and analog modulation

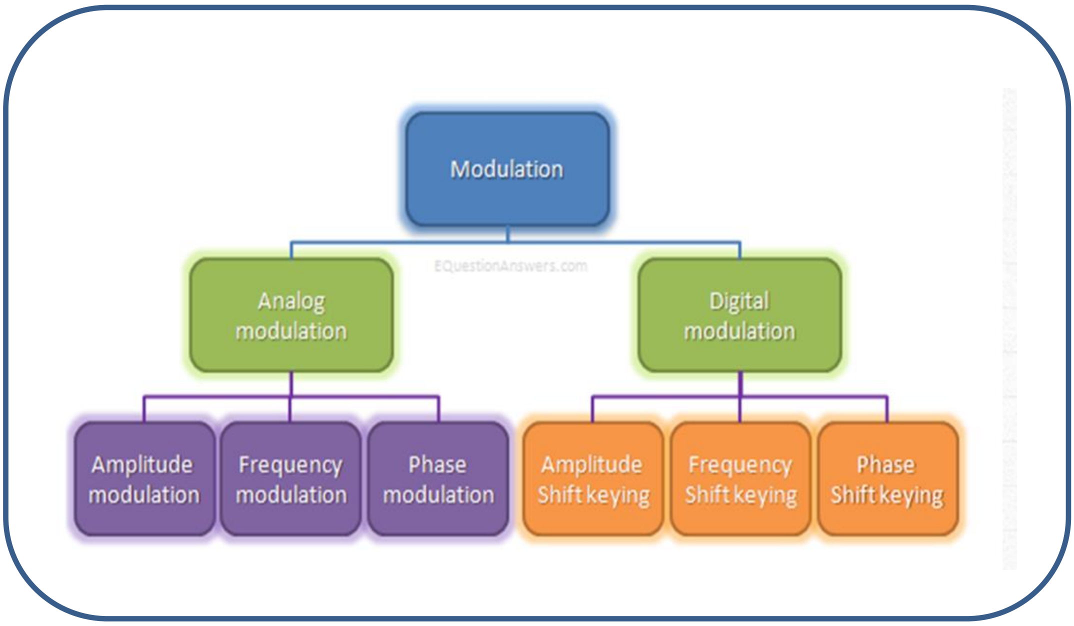


Figure.*(2.2) type of modulation*[1]

2.3.1 Analog Modulation Techniques

There are basically three techniques related to analog modulations (AM, FM, PM); in which there is a variation of

different characteristics like phase, frequency, and amplitude. The analog modulation techniques are the [2] **,** Figure(2.3) represent Analogue Communication System .

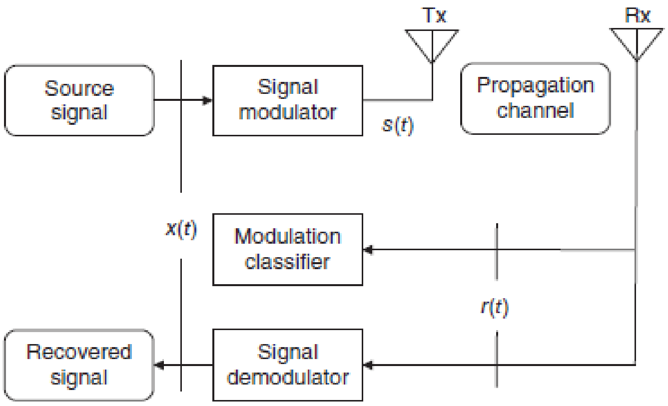


Figure***.(2.3)*** Analogue Communication System[3].

2.3.1.1.Amplitude Modulation(AM)

AM. carrier signals will be modulated for the purpose of its amplitude differ with changing amplitudes that are related signal frequency and phase , frequency of carrier remains. AM is shown in figure (2.4) ,AM process involves changing peak amplitude that is related to high-frequency carrier signals in relation to instantaneous amplitude that is related to the modulating signals [4] **.**

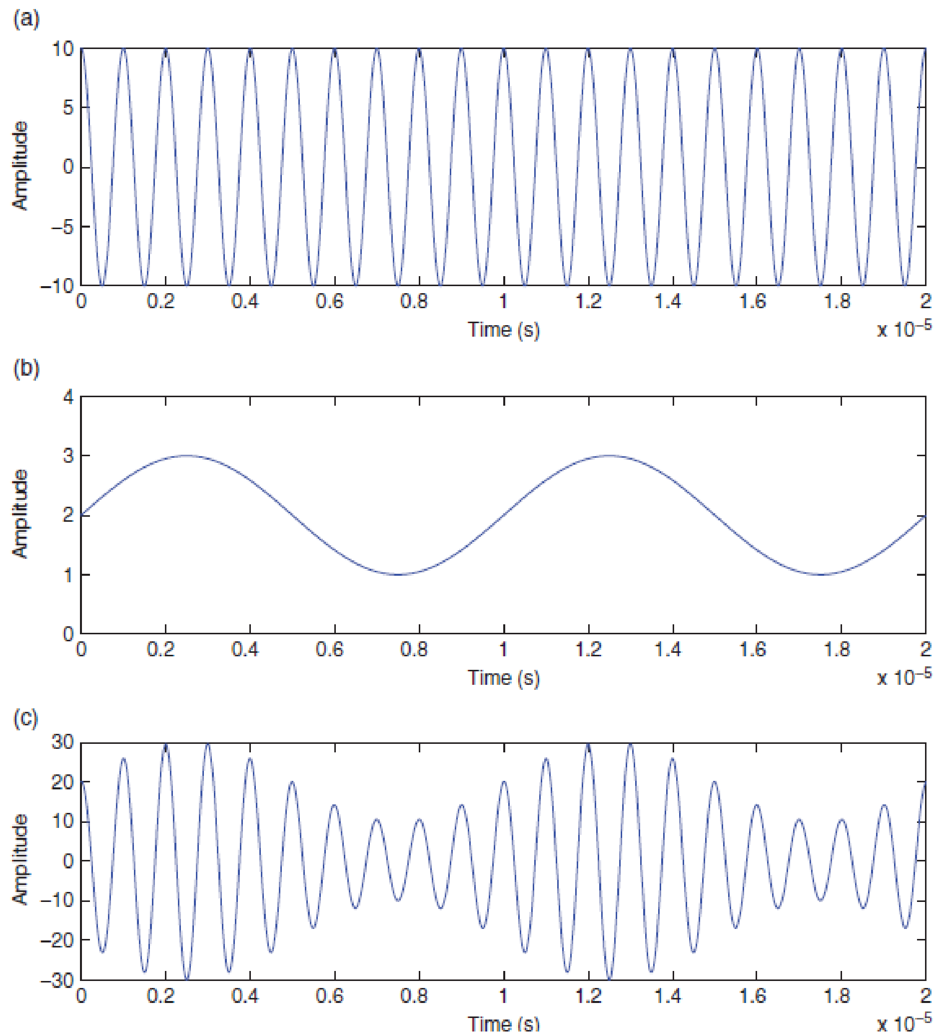


Figure ***(2. 4).(a)*** **Carrier signal, (b) source signal and (c) AM signal** [3]

2.3.1.2.Frequency Modulation(FM)

FM. the carrier's frequency will be changing in relation to the modulating signal's amplitude. The carrier signal's amplitude will remain constant. FM is shown in figure (2.5)

FM is considered to be type that related to the angle modulation where instantaneous frequency will be changing with message or modulating signal [4].

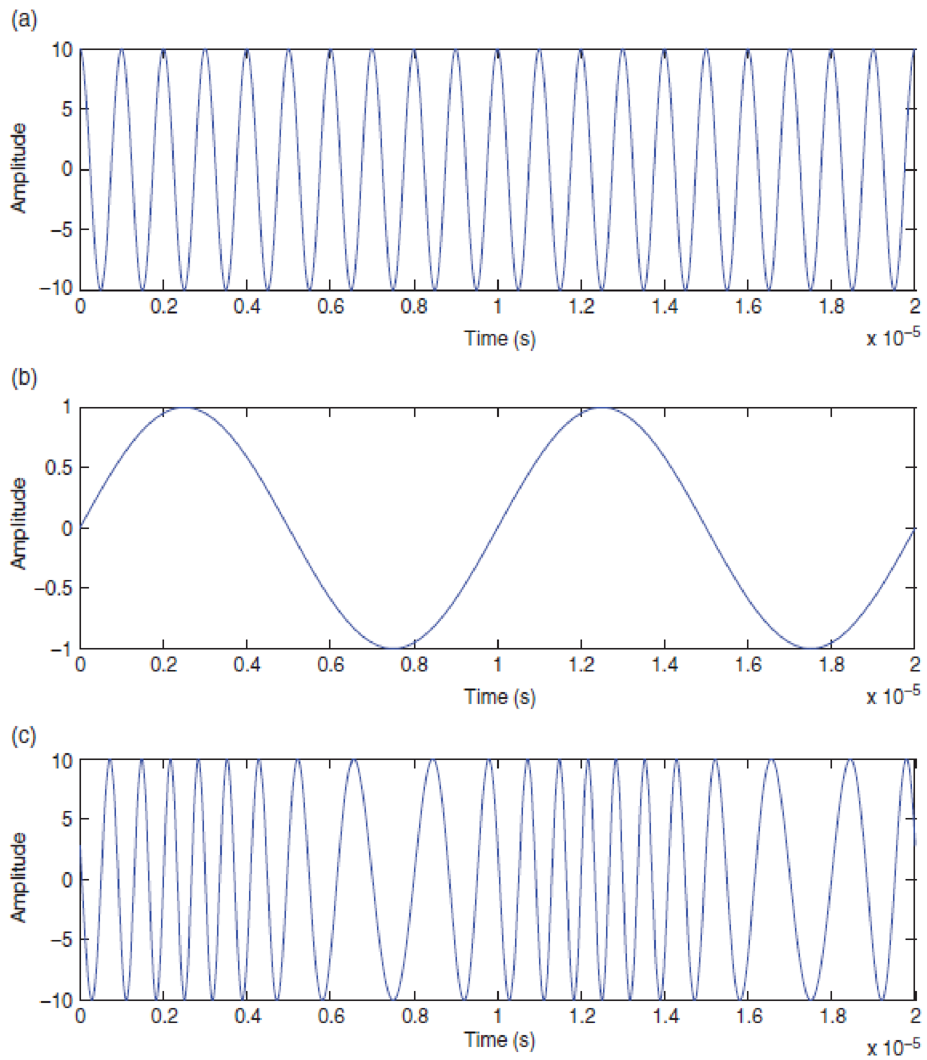


Figure *(2.5)* (a) Carrier signal, (b) source signal and (c) FM signal .[3]

2.3.1.3. Phase Modulation (PM)

PM. the carrier signal's phase will be changing in relation to the modulating signal's amplitude. The carrier's amplitude will remain constant. With regard to PM transmission, the carrier signal's phase will be modulated for the purpose of following the varying voltage levels that are related to modulating signal. Peak amplitude and frequency related to the carrier signal will remain constant [1]. Figure(2.6) represent that the phase of modulating signal changes with carrier wave. Phase of signal lags during positive half and leads during negative half .

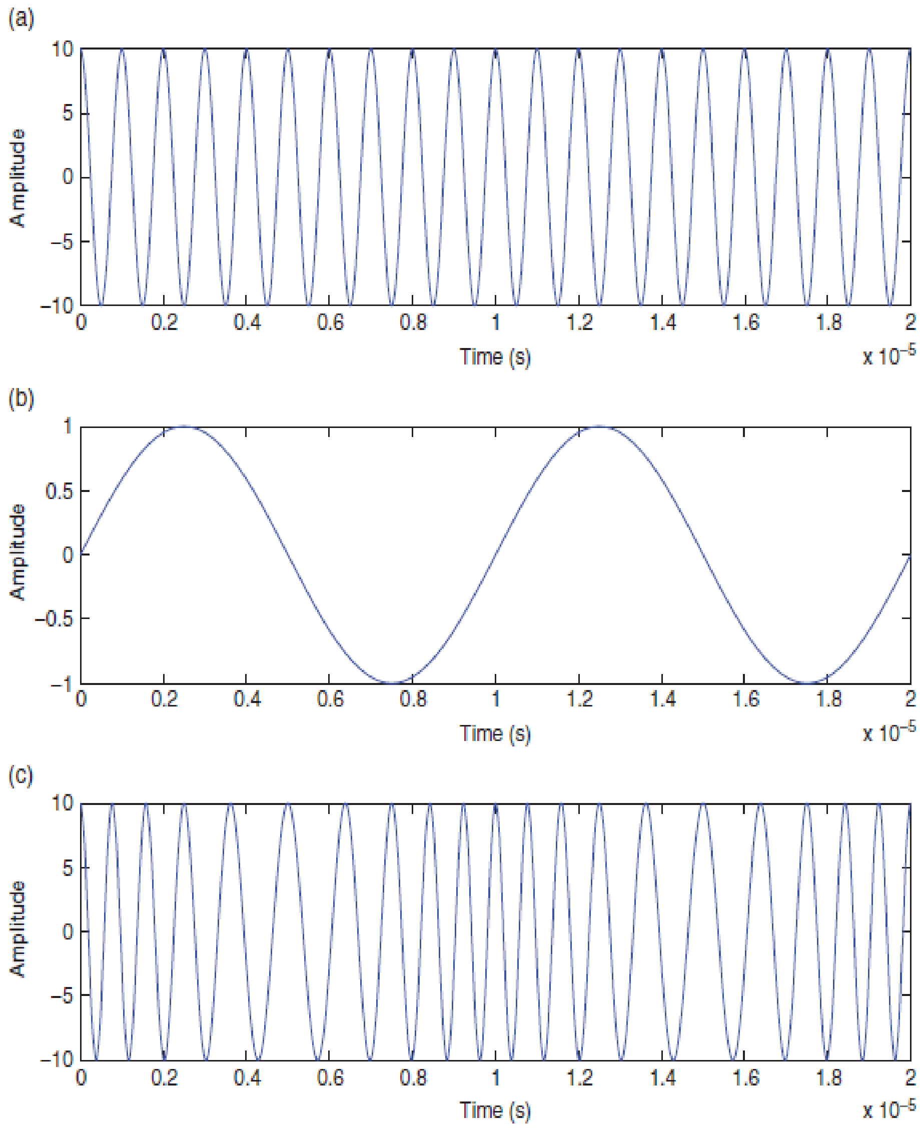


Figure *(2.6)*. (a) Carrier signal, (b) source signal and (c) PM signal [3]

2.3.2. Digital Modulation Techniques

Almost all modern communication systems, digital communication techniques have replaced the analog modulation techniques because of many advantages, some of them are: easier multiplexing, easier error correction and detection, better spectral efficiency, better data encryption, better noise and fade rejection [5]. The choice of a digital modulation technique depends on certain aspects: A necessary digital modulation system exhibits

low bit error rates at low received SNRs, has a good performance in fading and multipath conditions, provides minimum band-width, also it can be implemented easily. The digitally modulated schemes do not meet all requirements, then a trade-off can be made to select a digital modulation scheme depending on the requirement of the system applications [6] . In digital modulation, the basic is to identify efficient modulation schemes taking M different symbols, such techniques are called M-ary modulation. The number of binary digits or bits transmitted by an M-ary is:

$$m=log_2 M \qquad (2.1)$$

Thus, the rate of information can be increased by increasing M,

$$C=Blog_2\left(1+\frac{S}{N}\right) \qquad \text{bit/ sec} \qquad (2.2)$$

where C is the maximum achievable bit- but the transmitted power is increased , B can be defined as the channel's band-width in Hz, S can be defined as average signal power over band-width, and N represent the noise's average power. The transmission band width does not depend on pulse amplitudes but depends on the pulse rate. The relation between the signal power, bandwidth, and information rate can be specified according to the Shannon-Hartley theorem that indicated the fact that: rate, that denotes the capacity of the channel in bits for each second,. M-ary signals can be developed through modifying the carrier's amplitude, frequency, and phase in the M discrete, and therefore there are M-ary PSK, M-ary FSK, M-ary ASK, and M-ary QAM. Communication systems which use a large number of digitally modulated signals, [7]. The methods of digital modulation can be categorized into 2 types (non-linear or linear). With regard to the linear modulation, the modulated signal's amplitude will be

linearly changed with the message signal. Due to the fact that the modulated signal's frequency in the linear modulation in constant, thus it can be considered as band-width efficient. Recently, the band-width efficient is the main necessity for all systems due to the fact that the users are increasing rapidly. Available spectrum is considered to be constant all the time, also the necessity for such spectrum is growing always, thus, systems with not as much of band-width requirement is needed. In similar way to the analog signals, the digital signals are storing information in phase, frequency, or amplitude, therefore, the same key feature extraction approach can be applied for classifying the digital signal[8] . Figure (2.7) digital modulation types.

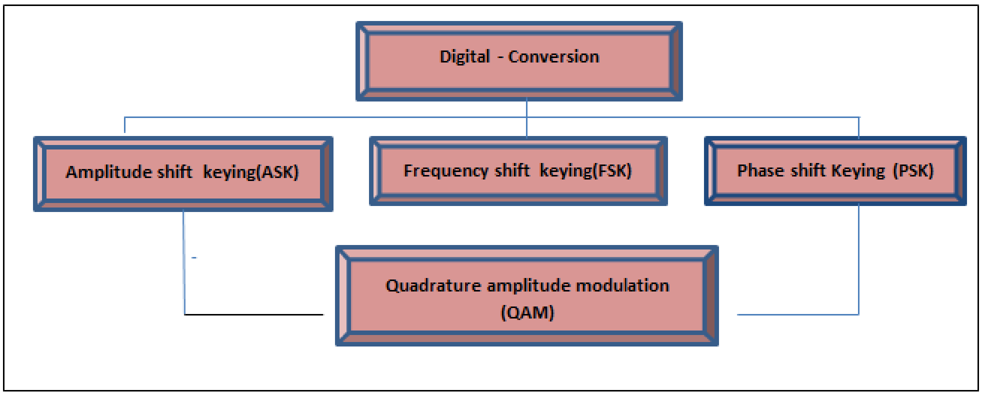


Figure.*(2.7)* Digital modulation types

2.3.2.1 Amplitude Shift Keying (ASK)

In ASK, two different carrier signal's amplitudes are used for representing binary digits (0 or 1), one of the digits will be signified through constant amplitude that is related to the carrier signal whereas the other one will be acquired through the carrier signal's absence. Phase and frequency remain constant. The transmitted signal is:

$$S_{ASK}(t)\begin{cases} A \ \ \cos(2\pi f_c t) & \text{binary 1} \\ 0 & \text{binary 0} \end{cases} \quad (2.3)$$

The general expression for M-ary ASK or MASK is:

$$S_{MASKi}\,(t) = \sqrt{\frac{2E_{i(t)}}{T}}\ \ cos(2\pi f_c t + \phi) \quad (2.4)$$

where:

i=1, 2, ..., M, 0≤ t≤ T, E_i represent symbol energy, T represent time of signal Theta, $\emptyset$ is the phase, f_c represent the carrier's frequency, and M represent the number of symbols. ASK is extremely susceptible to sudden gain changes and to noise, thus ASK can be considered as ineffective modulation method**.** Figure (2.8) show the generation of signals 2ASK [7].

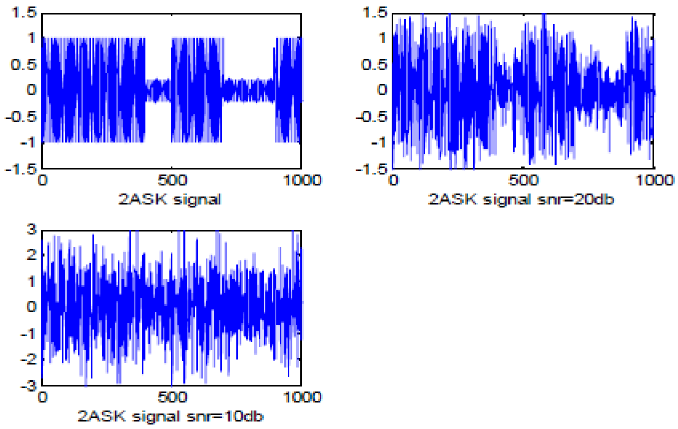


Figure (2.8) 2ASK signal with and without AWGN nois*e*

2.3.2.2 Frequency Shift Keying (FSK)

The majority applied type of FSK is the binary FSK, the carrier frequency is varied to represent the two binary values 1 or 0, amplitude and phase remain constant. The transmitted binary FSK signal is:

$$S_{FSK(t)} = \begin{cases} Acos\ (2\pi f_1\ t) & \text{binary 1} \\ Acos\ (2\pi f_2\ t) & \text{binary 0} \end{cases} \quad (2.5)$$

ASK have more susceptibility to error and noise than FSK, yet in FSK more band-width is requested for transmission. In M- ary FSK, M possible sinusoidal waveforms are used, but differ in frequency by a certain amount. The general expression of MFSK signal can be defined by:

$$S_{MFSK_i(t)} = A\cos(2\pi f_i\, t + \emptyset) \quad (2.6)$$

where $0 \leq t \leq T$, i=1, 2, ..., M, $\emptyset$ is the phase, f_i is the transmitted frequency of M possible sinusoidal signals and can be represented by:

$f_i = \frac{n_{c+i}}{2T}$, n_c is a fixed integer, T is the transmitted signal duration. The separation of the individual frequencies is by $\frac{1}{2T}$ Hertz [9] Figure (2.9) show the generation of signals 2FSK.

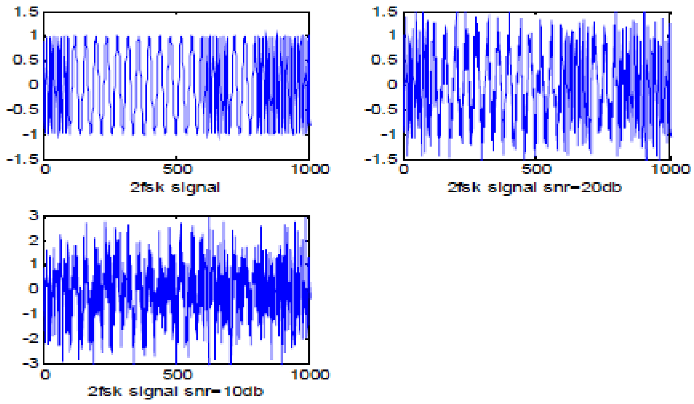


Figure (2.9) 2FSK signal with and without AWGN noise

2.3.2 .3 Phase Shift Keying (PSK)

In PSK, the data is transmitted through shifting the carrier signal's phase. The plainest type of PSK is binary phase shift keying BPSK, transmitted signal will be defined as follows:

$$S_{BPSK}(t) = \sqrt{\frac{2E_{i(t)}}{T}} \; \cos(2\pi f_c t + \phi)$$

$$S_{BPSK} = \begin{cases} A\cos\ (2\pi f_c t) & \text{binary 1} \\ A\cos(2\pi f_c t + \pi) & \text{binary 0} \end{cases} \qquad (2.7)$$

The phase shift that is related to π can be considered as corresponding to sinusoidal wave multiplied by (-1). M-ary PSK, gives higher data rate and the bandwidth is more efficient than MFSK. Each signal unit represents two bits or more. One of the possible values of M is taken by the carrier phase, the general expression of the MPSK is:

$$S_{MPSK}\ (t) = Acos\big[\big(2\pi f_c t + \theta_{i(t)}\big)\big] \qquad (2.8)$$

where:

$S_{BPSK}\ (t)\ A = \sqrt{\frac{2E}{T}}\ , \theta_{i(t)} \frac{2\pi}{M}\ \ (i-1)$ i=1, 2, ..., M, T is the duration of signaling interval, E is the signal energy per symbol. The MPSK signal may be expanded to:

$$S_{MPSK_i}\ (t) = Acos\left[\frac{2\pi}{M}\quad (i-1)\right] cos(2\pi f_c\ t)$$
$$-Asin\left[\frac{2\pi}{M}\quad (i-1)\right] sin(2\pi f_c\ t) \qquad (2.9)$$

The expansion of the MPSK signal contains pair of quadrature carriers, then the signal constellation is two dimensional [10] MPSK is widely used in commercial communication system and military applications. It is applied broadly in applications such as cellular services, Code Division Multiple Access(CDMA), Digital Video Broadcasting-Satellite(DVB-S), wireless local loop, and iridium (voice/data satellite system). figure (2.10) show the generation of signals PSK.

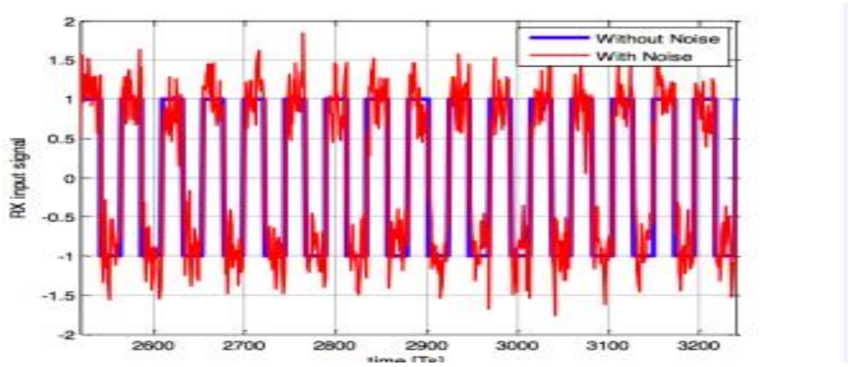


Figure (2.10) PSK signal with and without AWGN noise

2.3.2.4 Quadrature Amplitude Modulation (QAM)

QAM technique is hybrid in nature that represents a combination of PSK and ASK. Two separate signals are transmitted independently using the same carrier frequency with two quadrature carriers. QAM structure allows for M amplitude levels. The general expression for QAM signal can be described by:

$$S_{QAM_j}(t) = \sqrt{\frac{2E_0}{T}}\ a_j cos(2\pi f_c t) - \sqrt{\frac{2E_0}{T}}\ b_j\ sin(2\pi f_c t) \quad (2.10)$$

where 0≤ t≤ T, j=1, 2, ..., M, E_0 represent the energy regarding the lowest amplitude signal, a_j and b_j can be defined as the pair of in-dependent integers for all the j selected on the basis of location of specific signal point, a_j represent the in-phase component, and b_j is defined as the quadrature-component. The QAM signal has 2 phase quadrature carriers, each one has been modulated through discrete amplitudes depending on the number of symbols M Constellation diagram represents a graphical distribution of each symbol state for complex envelope, the complex envelope in-phase component has been signified through x-axis, whereas the y-axis has been applied to represent the quadrature component. The bit error probability is affected by

distance between adjacent signals on constellation, then the modulated signal with densely packed constellation is lower energy efficient than the modulated signal with low densely constellation **[5]** . Figure (2.11) shows the generation of signals 16 QAM.

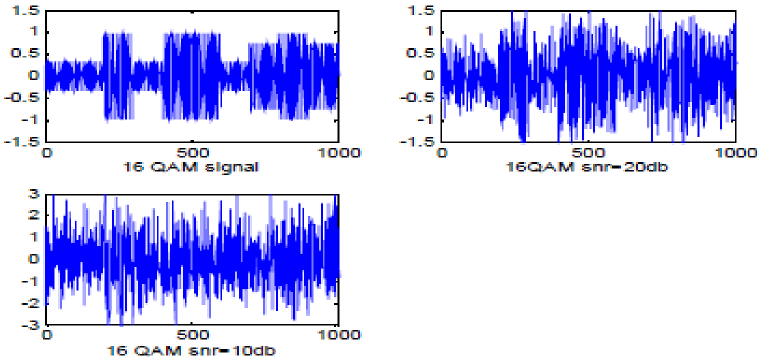


Figure (2.11) 16 QAM **signal with and without AWGN noise**

2.4. Application

. There are a lot of civilian and military applications related to Communication Intelligence, a few of these applications are:

A. Civilian Applications

- Spectrums management
- Cognitive radios
- Monitoring and transmission control
- Software defined radios
- Interference identification

B. Military Applications

- E-warfare
- Homing
- Threat analysis and surveillance

• Jamming

• Target acquisition

the frequency spectrum will be divided between various licensed users. (COMINT) could be applied for the purpose of finding out whether users are outside or within their allocated spectrum (spectrum management). If the users go outside their assigned spectrum, this will lead to certain interference with the other users, such interference could be detected through the use of communication intelligence. Interference identification and the spectrum management related to the communication intelligence could be utilized for the purpose of controlling and monitoring the signal's transmission. Software defined radio (SDR) is considered to be one of the evolving AMC's applications. Lately, a lot of focus was directed towards the digitizing of radio frequency signals to use the Digital Signal Processors (DSPs) for replacing the analogue components. Replacing or minimizing the systems of communications has led to the development of SDRs. SDRs are considered to be simple communication devices which have the ability of handling many modulation systems. As the SDRs have evolved lately, there was a lot of focus on AMCs. AMCs have been applied at the SDR's front end for the purpose of classifying the modulation type related to the incoming signals. In such manner, many modulations can be handled through single SDR, also the cognitive radios are considered to be as one of the evolving technologies for the dynamic spectrum access[11, 12]. The major concept regarding the cognitive radios is enabling secondary users to share or re-use the radio spectrums initially assigned to the primary users in the case when it is underutilized via primary users. With regard to public safety applications and

military applications, no information is provided regarding the signal's modulation type. Thus, the cognitive radios are requiring precise information related to the modulation type of signal utilized through the primary users to de-modulate it. Therefore, cognitive radio's performance could be improved through the use of consistent modulation classification system for these applications. Communication intelligence could be applied in e-warfare to detect the signals applied through enemies in specific spectrums and taking suitable actions for the purpose of negating it (target acquisition). According to the energy related to signal utilized through enemies, the threat attached to it can be detected. Communication intelligence have the ability of providing thorough information about the enemy signals which can be used for jamming. Another use of COMINT is to intercept the radar signals as well as detecting their locations (homing).

2.5 Feature Extraction

All objects which could be classified, have certain distinctive features that distinguish between the object and the other ones. Such features are referred to as features in Pattern Recognition (PR) problems. With regard to certain PR problems, the actual features are represented through the collected data, also there is no necessity for extracting the features explicitly. There are three major categories related to the features (mathematical, structural, and physical). The object's material, color, or odor are included in the physical features. The structural features are representing the object's structural features such as width, weight, and height. The major significant features in the presented context are the mathematical features which are used for

representing the object's mathematical features . The dimension of raw data is reduced before the classifier processing. These new reduced data are represented as a feature extraction . In features extraction the useful information with discriminative characteristics that differentiates between the modulated signals is extracted from the raw data to be pertinent for classification. Features extraction stage is prerequisite for identification processes because of limited computation times and memory, the desired features are the features that can be extracted easily, unchanging to certain irrelevant transformations, not sensitive to noise, and suitable to discriminate between the objects of distinctive groups. Due to the fact that the features that have been extracted are going to be used later through classifier for classification, perfect feature must produce information which make the task of the classifiers as simple as feasible, that imply that examples from same class must have comparable feature values, while the examples from different class must have different feature values. Choice and number of features needed is defined as problem dependent. Typically, for real-world problems, single feature is not sufficient for differentiating between the objects of various categories. Many features signifying same object have been ordered into feature vectors, also set of all features will be referred to as the feature space. In the presented study, each feature's occurrence will be referred to as instance, for example, in the case when each column in a matrix represent feature, then the row is going to be referred to as instance [13]**.**There is a variety of extracted features, and no precise rule for choosing the proper feature parameters for specific identification processes, the main challenge behind the

feature extraction is to perform the identification processes with smaller datasets. The size of feature extraction parameters is necessarily reduced because of the following:

1. Storage capacity
2. Ineffective processing caused by redundant features.
3. The identification performance is degraded due to weak features.

Some elementary feature extraction parameters are: time domain features [14], statistical features [15], cyclostationary [16], wavelet[17], zero-crossing [18], and temporal feature [19]. More details about features extraction are presented in references [13]. In this theses the extracted features are statistical features are implemented,

2.5.1 High Order Statistics (HOSs)

High Order Statistic (HOS) is used for features extraction of Pattern-Recognition approaches to recognize the modulation schemes of digitally modulated signals. HOS is a field of statistical signal processing. Statistical moments and cumulants are the parameters related to HOS which grants the distinguishing features of data. These statistical features are possibly employed to classify the modulation schemes of noisy signals in the identification task [20]. High Order Moment (HOM) and High Order Cumulant (HOC) are described next.

2.5.1.1 High Order Moments (HOMs)

The statistical moments are a concept of expected value, and define the characteristic of probability density function. For

digital signals the ith order moment for a finite length is given by [21]:

$$\mu_i = \sum_{K=1}^{N} (S_K - \mu)^i \ f\ (s_k) = 1 \qquad (2.11)$$

where N is the data length, S_K is the random variable, subscript (k) is an integer- valued variable, μ is mean value of random variable. Let the signal have a zero mean (μ=0), thus equation (2.11) becomes:

$$\mu_i = \sum_{K=1}^{N} (S_K)^i \ f\ (s_k) \qquad (2.12)$$

The auto-moment of the random variable is:

$$E_{S,P+q,p} = E[s^p \ (s^*)^q \ ] \qquad (2.13)$$

the (p) represent number of the non-conjugated terms, (q) represents the number of conjugated terms, (p+q) represents moment order, and (S) is discrete random variable, S* represents the complex conjugation of S [22] .If the baseband signal sequence is considered in the complex form:

$$S_K = a_k + jb_k \qquad (2.14)$$

Then the second order moment, $E_{S,2,1}$ can be calculated as an example using equation (2.13):

$$E_{s,2,1} = E[(a + jb)(a - jb)] = E[a^2 \ - b^2]$$

Different expressions of moments can be easily derived.

Table (2.1) Display the most important moments.

Table (2.1): Statistical moment

Moment Order 2	$E_{S,2,2}$	E$[a^2 - b^2]$
	$E_{S,2,1}$	E$[a^2 + b^2]$
Moment Order 4	$E_{S,4,4}$	E$[a^4 - 6a^2\ b^2 + b^4]$
	$E_{S,4,3}$	E$[a^4 - b^{24}]$
	$E_{S,4,2}$	E$[a^4 + 2a^2\ b^2 + b^4]$
Moment Order 6	$E_{S,6,6}$	E$[a^6 + 15a^2\, b^4 - 15a^4\, b^2 - b^6]$
	$E_{S,6,5}$	E$[a^6$-5$a^2\ b^4$-5$a^4\ b^2$+$b^6]$
	$E_{S,6,4}$	E$[a^6$-$a^2\ b^4$+$a^4\ b^2$-$b^6]$
	$E_{S,6,3}$	E$[a^6$+$a^2\ b^4$+3$a^4\ b^2$+$b^6]$
Moment Order 8	$E_{S,8,8}$	E$[a^8$- 28$a^2\ b^6$-28$a^6\ b^2$+70 $b^4 b^4 + b^8]$
	$E_{S,8,7}$	E$[a^8$+ 14$a^2\ b^6$-14$a^6\ b^2$- $b^8]$
	$E_{S,8,6}$	E$[a^8$- 4$a^2\ b^6$-4$a^6\ b^2$- 10$a^4 b^4 + b^8]$
	$E_{S,8,5}$	E$[a^8$-2 $a^2\ b^6$-4$a^6\ b^2$-$b^8]$
	$E_{S,8,4}$	E$[a^8$+4 $a^2\ b^6$+4$a^6\ b^2$+6$a^4 b^4$+ $b^8]$

2.5.1.2 High Order Cumulants (HOCs)

Cumulants, are also statistical features. If the characteristic equation of a random variable S with zero mean is:

$$f(t) = E\left[e^{jts}\right] \qquad (2.15)$$

Expanding the Logarithm of equation (2.15) by applying a Taylor series,

$$log[f(t)] = k_1(jt)+\frac{k_2(jt)^2}{2} + \cdots + \frac{k_r(jt)^r}{r!}!+\cdots \quad (2.16)$$

where(k_r) is called the cumulant, (t) is time. The nth order cumulant is similar to the n^{th} order moment, thus

$$c_{s,p+q,p} = cum\left[\underbrace{s, \ldots \ldots s}_{p\ terms}, \underbrace{s^*, \ldots \ldots s^*}_{q\ terms}\right] \quad (2.17)$$

The cumulant is a function of moments, then the cumulants may be derived in term of moments [23]. The derivations are given in appendix A, some of the important expressions of cumulants are given as follows which show the relationships between cumulants and moments:

$$C_{s,2,1} = E_{s,2,1} \quad (2.18)$$

$$C_{s,4,4} = E_{s,4,4} - 3E_{s,2,2^2} \quad (2.19)$$

$$C_{s,6,5} = E_{s,6,5} - 10E_{s,2,2}\ E_{s,4,3} - 5E_{s,2,1}\ E_{s,4,4} + 30E_{s,2,2^2}\ E_{s,2,1} \quad (2.20)$$

$$C_{s,8,8} = E_{s,8,8} + 420E_{s,2,2^2}\ E_{s,4,4} - 35E_{s,4,4^2} - 630E_{s,2,2^4} \quad (2.12)$$

$$C_{s,8,8}E_{s,8,4} + 96E_{s,4,3}\ E_{s,2,2}\ E_{s,2,1}\ 9635E_{s,4,3}E_{s,2,1}\ E_{s,2,2}\ 72E_{s,4,2}E_{s,2,2^2}$$
$$+144\ E_{s,4,2}E_{s,2,1^2} + 12E_{s,4,4}E_{s,2,2^2} - 432E_{s,2,2^2}$$
$$-16\ E_{s,4,3^2} - 18E_{s,4,2^2} - E_{s,4,4^2} - 54E_{s,2,2^4} - 144E_{s,2,1^4} \quad (2.22)$$

2.6. Signal to Noise Ratio (SNR)

SNR can be defined as a measure that is applied in engineering and science, it put comparison to the levels related to the required signals to the levels related to the background noise, also it can be specified as the signal power's ratio to the noise power's ratio, regularly stated in dB. More signal than noise is indicated through the ratio that is higher than 1:1 (greater than 0 dB). As the signal to noise ratio is usually quoted for the

electrical signals, yet it could be used to any signal form. Sometimes, SNR is applied metaphorically to denote ratio related to the significant information to unrelated or false data in exchange or conversation. For instance, with regard to the online communities and the online discussion forums, spams and the off-topic posts can be considered as "noise" which interfere with "signal" of suitable discussion. SNR will be specified as the ratio related to the signal power (meaningful information) to background noise's power (undesirable signal):

SNR=P(signal)/p(noise)

In which the average power is denoted as P. The noise and signal power should be estimated at equivalent or same points in the system, also within same system bandwidth. According to a signal is a constant (s) or random variable (S), SNR for random noise N with expected value of 0 is as follows:

$$SNR = \frac{S^2}{N^{\sigma^2}}$$

SNR, band-width, as well as the channel capacity related to the communication channel will be connected through Shannon–Hartley theorem

$$(\text{SNR})dB = 10\ log_{10}\left[\frac{Total\ transmited\ signal\ power}{Total\ \ additine\ Gaussian\ noise\ power}\right]$$ [24].

2.7. Pattern Recognition

Pattern Recognition can be defined as the process that has the aim of classifying objects to many classes or categories. [11] The pattern recognition process has a lot of applications in various subjects. For example, machine vision is applied for analyzing and determining the type of the captured images, such as in manufacturing industry for determining if certain product

can be considered as flawed or not. The Bio-medical applications enable the physicians to diagnose various diseases, while the character recognition is applied for identifying the written texts such as numbers and letters which could be applied in identifying signatures in the banks, or the price checkers in super-markets.

With regard to the pattern recognition, identifying various patterns has been decided via their distinctive features. The applicability related to such method is on the basis of discriminating power regarding selected features (classification features) as well as the efficiency related to the used classifiers. There are three major categories in pattern recognition: Supervised Learning Algorithms in which the machine learning classifiers are trained through using labeled data from identified classes; Un-supervised Learning Algorithms where the class identity that is related to training data is not provided at classifiers, and that can be solved with extra complexity; and lastly the Semi-Supervised Learning Algorithms, that is considered to be as a hybrid classification type where part of training data has been labeled and other part is not. The input data which is typically the raw data such as human voice (speech recognition problems), images (image processing problems), or the modulated received signals (automatic modulation classification problems). The stage of pre-processing is applied for cleaning patterns of interest, and typically data normalization, noise filtering, and data smoothing will be achieved in this stage. Then, the chosen discriminant features will be extracted from processed input data for the purpose of forming actual input to machine learning classifier. [25].

2.8.Swarm Optimization

Business management and science are considered as global optimum problems. Time consumption via the conventional computation methods which are used to solve the large-scale optimization problems is increasing rapidly. Thus, such method does not have the ability of meeting the real-world necessities. For the purpose of solving such problems, a lot of researchers, simulated the life behaviors of some living beings in nature, provided intelligent swarm optimization algorithms such as particle swarm optimization [26], ant colony optimization (ACO) [27], artificial bee colony (ABC) [28], invasive weed colonization optimization (IWO) [4], firefly algorithm (FA) [28], cuckoo search (CS) algorithm [29],fish swarm algorithm (FSA)[30], bat algorithm (BA) [29],monkey algorithm (MA)[30], krill herd (KH) algorithm, and flower pollination algorithm(FPA) [29]; all the above-mentioned approaches have shown promising results. As novel type of burgeoning metaheuristic algorithm, intelligent swarm optimization algorithms have certain advantages such as high accuracy, rapid convergence rate, optimum stability, also they have the ability of obtaining precise solution or estimated solution related to the large-scale optimum problems with less consumed time. The algorithm of chicken swarm optimization (CSO) can be defined as novel bionic algorithm that is suggested via Meng et al. [31] in the year 2014. CSO simulate the hierarchy of the chicken's swarms as well as their behavior when they search for food. The chicken swarm is divided into chick swarm, hen swarm, and cock swarm. The cock swarm is the chickens that have the maximum fitness value, the chick swarm is the chickens that have the minimum fitness values, the rest of the chickens are

considered as hen swarm. In the case of solving optimization problems, each swarm chicken corresponds to solution. Various strategies for searching have been used for various sub-swarms depending on different populations. In comparison to the bat algorithm, differential evolution, and the standard PSO, CSO has improved searching accuracy or higher convergence rate[32]. With regard to simple CSO, random search plan on the basis of Gaussian distribution has been implemented for cock swarm's particles. With regard to the particles of hen swarm, search is carried out as the cocks are guiding their population as well as other populations, that will enable the hen particles close to the global optimum.

2.8.1Chicken Swarm Algorithm

CSO is an algorithm that suggested on the basis of different cocks, hens, and chick's behavior as they search for food. In CSO, the chicken swarm in the searching space will be mapped as certain particle individual. The particle swarms of hens, chicks, and cocks will be sorted depending on the particle's fitness value, different searching mode is used by each sub-swarm [33] .In CSO, the cock swarm will consist of the particles with optimum fitness, that is provided via

$$X_{i,j}^{t+1} = X_{i,j}^{t} + randn(0,\sigma^2)\,.X_{i,j}^{t} \quad (2.23)$$

where $X_{i,j}^{t+1}$ and $X_{i,j}^{t}$ represent position regarding the jth dimension of particle i in t+1 and t iterations, respectively, and randn (0, σ^2) represent random number related to Gaussian distribution that has a variance σ^2.The parameter σ^2 could be estimated via

$$\sigma^2 = \begin{cases} 1, & fit_i < fit_k \\ \exp\left(\frac{(fit_k - fit_i)}{(|fit_i| + \xi)}\right), & fit_i \geq fit_k \end{cases} \quad (2.24)$$

where $i, k \in [1, r$ size] and $i \neq k$. r size represent the number of the cock swarms. $fit_i$and fit_k represent the fitness values regarding the cock particle i and k, respectively; ξ represent a number that is adequately small. Furthermore, the majority of particles with decent fitness will be chosen as hen swarm. Its random search will be achieved through cocks of population of hen and that of others, that could be defined as

$$X_{i,j}^{t+1} = X_{i,j}^{t} + s1 * randn(X_{r1,j}^{t}, X_{i,j}^{t}) + s2 * rand * (X_{r2,j}^{t}, X_{i,j}^{t}) \quad (2.25)$$

where $X_{r1,j}^{t}$ and $X_{r2,j}^{t}$ denote the position regarding cock individual $r1$ in the population of hen x_i and cock individual $r2$ in the other population, respectively. rand denote the uniform random number over [0, 1]. $S1$ and $S2$ denote the weight calculated through

$$S1=exp\left(\frac{(fit_{i-fit_{r1}})}{(|fit_i|+\xi)}\right)$$

$$S2= exp(fit_{r2} - fit_i)$$

where $fit_{r1}$and $fit_{r2}$are the fitness value of cock individual $r1$ in the population of hen $x_i$and cock individual $r2$ in the other population. All individuals, except for cock swarm and hen swarm ,are defined as chick swarm. Its search mode follows that of hen swarm, which is given by

$$X_{i,j}^{t+1} = X_{i,j}^{t} + FL.\left(X_{m,j}^{t} - X_{i,j}^{t}\right), FL \in [0,2] \quad (2.26)$$

where FL stands for a parameter, meaning that the chick would follow its mother to forage for food. $X_{m,j}^{t}$ represents the position of the ith chick's mother ($m \in [1,N]$) [30] .

. The following describes the execution steps of the Chicken algorithm :

Step 1: Form the initial generation that is related to the chickens in random approach regarding limits of search space. Each chicken swarm can be considered as a vector related to all the control variables, i.e.

Step 2: Running NR load flow to calculate the optimum values regarding all chicken solution. The values of the control variable that is taken through different rooster will be incorporated in system data and load flow will be run. For each chicken, the total generation costs will be estimated.

Step 3: Selecting the optimum hens that has global optimum searching food approach fitness value through the use of equation. Roosters, hens and chicks will be organized in ascending order their (sound echoes), the first hen is going to be a candidate with optimum food searching approach (minimum cost) and provide optimum global index value.

Step 4: Generating new roosters around global best swarm through adding/subtracting normal random number based on equation. It must be guaranteed that control variables will be within their limits or else adjust the ‟and α‟‟the.,, values of chicken swarm group.

Step 5: Hens , roosters ,chicks which one is provided with the best global fitness value until the procedure is achieved with number of iterations. Repeating the steps two-for until stopping criteria is not accomplished [34]. figure (2.12) show the flaw chart of CSO algorithm.

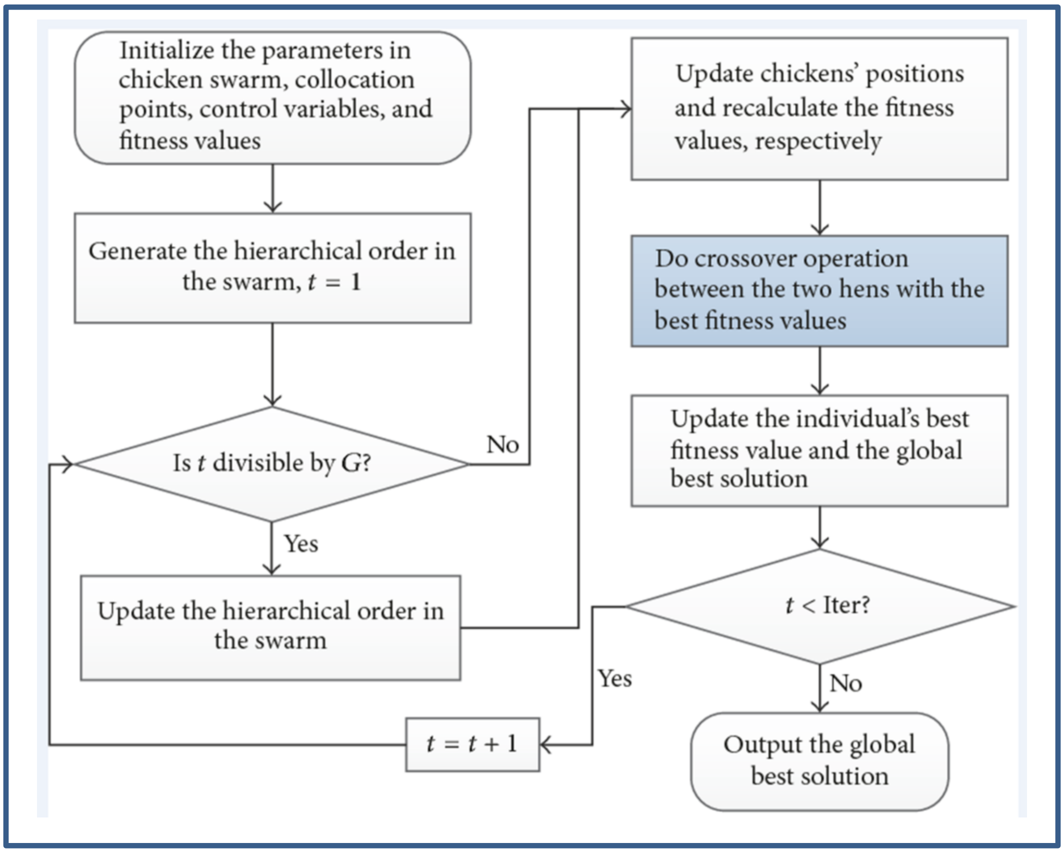


Figure (2.12) flaw chart of CSO algorithm

2.8.2 Bat Algorithm (BA)

BA is also suggested as swarm intelligence-based algorithm, based on the microbats' echo-location behavior. In the case when they fly and hunt, the bats will be emitting certain ultra-sonic, short pulses to environment and list to their echoes. The researches have indicated that information from taken from echoes will allow the bat to develop adequate image regarding their environment as well as accurately determining the shapes, distance of the prey. The echo-location capability of micro-bats is very interesting since the bats have the ability of finding their pry and distinguish a lot of insect's types in total. Previous studies have indicated that bat algorithm have the ability of solving constrained and un-constrained optimization problems with a lot of effectiveness and robustness in comparison to PSO and

GA.[35] Bats usually use echolocation to find food. During removal, bats usually send out short pulses, however, when they encounter food, their pulse send out rates increase and the frequency goes up. The increase in frequency means frequency-tuning, which shortens the echolocations' time and increases the location accuracy .In the standard bat algorithm, each individual i has a defined position X_i (t) and velocity v_i (t) in the search space, which will be updated as the number of iterations increases. The new positions X_i (t) and velocities v_i (t) can be calculated as follows:

$$X_i(t+1) = X_i(t) + v_i(t+1) \quad (2.27)$$

$$v_i(t+1) = v_i(t) + \big(X_i(t) - P(t)\big).f_i \quad (2.28)$$

$$f_i = f_{min} + (f_{max} + f_{min}) \; .\beta \quad (2.29)$$

where β is random vector with uniform distribution, range of which is [0, 1]. $p(t)$ is the current global optimal solution and f_{min}=0, f_{max}=1.

As we also know, whether BA has global and local search capabilities depends on its parameters; therefore, it is necessary to achieve a balance between global search and local search abilities by adopting adaptive parameters. The formula for the local search strategy is as follows:

$$X_{i\,(t+1)} = \vec{p}(t) + \varepsilon \bar{A}\,(t) \quad (2.30)$$

where ε represent random number from [−1, 1], $\overline{A}\,(t)$ is the population's average loudness. In addition, it achieves global search by controlling loudness A_i (t+1) and pulse rate r_i (t+1).

$$A_i(t+1) = \alpha A_i(t) \quad (2.31)$$

$$r_i(t+1) = r_i(0)[1 - exp(-\gamma t)] \qquad (2.32)$$

where α and γ are constants and α>0,γ>0. A_i (0) and r_i (0) are initial values of loudness and pulse rate, respectively .

[36]. figure (2.13) show the flaw chart of BA algorithm.

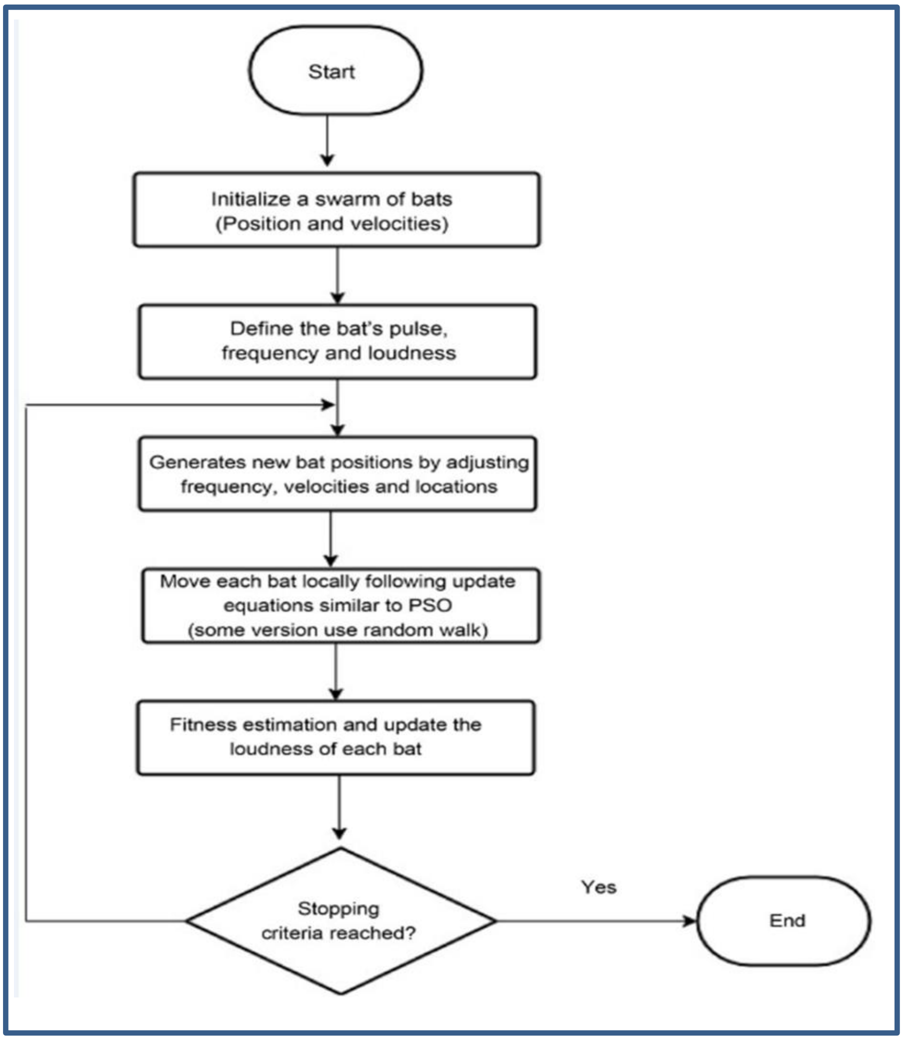


figure (2.13) show the flaw chart of BA algorithm.

2.9. The Random Forest Algorithm

Random forest can be defined as collection of classifiers that include various decision trees and provides the class which is the class's output mode by individual trees[40]. This term originally comes from the random decision forests which were initially suggested by [41] This approach combines Breiman's "bagging"

concept with random feature selection, independently proposed by Ho, Geman, and Amit for the sake of constructing a collection of decision trees that have controlled variation. Random forests combine tree predictors in a way that every one of the trees is dependent on random vector values which were sampled independently and with same distributions for all the forest's trees. Generalization error related to the forest of tree classifiers is on the basis of strength of forest's individual trees and correlation between such trees . The discussed algorithm operates effectively on large databases that can handle large volumes of input variables with no deletion. It offers assessment regarding considerable variables in classification. This algorithm is considered to be unbiased toward assessment related to generalized error throughout forest formation. Furthermore, it can efficiently estimate the missing data and keep accuracy with approaches provided for balancing errors in the unbalanced class population datasets. It provides information regarding the association between classification and variables. It operates effectively for outlier detection, to label unsupervised clustering and data views[42] to resampled independently and with same distribution for all the forest's trees. Each one of the trees depend on collection of random variables. More formally, for a p-dimensional random vector $X = (X_1, \ldots, X_P)^T$ representing the real-valued input or predictor variables and a random variable Y representing the real-valued response, we assume an unknown joint distribution P_{XY} (X,Y). The goal is to find a prediction function f (X) for predicting Y. The function of prediction is found by a loss function L(Y, f (X)) and characterized for minimizing the expected loss value:

$$P_{XY} = \left(L\left(Y, f(X)\right)\right) \quad (2.33)$$

Where subscripts represent expectations according to X's and Y's joint distributions. Whereas subscripts represent expectations according to X and Y's joint distributions. Naturally, L(Y, f (X)) is measures the closeness between f (X) and Y; it penalizes f (X) values which are a far from Y. Usual L choices are zero-one loss for classification and squared error loss L(Y, f (X)) $=(Y - f(X))^2$ for regression:

$$L(Y,f(X))=I(Y\neq f(X))=\begin{cases}0 & \text{if } Y = f(X)\\ 1 & \text{otherwise}\end{cases} \quad (2.34)$$

It turns that the minimization of E_{XY}(L(Y, f (X))) for squared error loss provides conditional expectation

$$f(x)=E(Y|X=x) \quad (2.35)$$

which is otherwise referred to as regression function. In case of classification, considering that the possible values set of Y is represented as Y minimizing $E_{XY}\left(L\left(Y, f(X)\right)\right)$ for zero-one loss results in:

$$f(x)= \operatorname{argmax}_{y\epsilon y}\, p\left(\frac{y}{x} = x\right) \quad (2.36)$$

also referred to as Bayes rule. Ensembles produce f based on a set of what is known as the "base learners" h1(x), . . . ,hJ(x) which are combined for giving "ensemble predictor" f (x). In regression, base learners are averaged:

$$f(x) = \frac{1}{j}\sum_{j=1}^{J} h_j(x) \quad (2.37)$$

whereas in classification, f (x) can be considered as the most often expected class (i.e. "voting")

$$f(x) = \text{argmax}_{y \epsilon y} \frac{1}{j} \sum_{j=1}^{J} I \left(Y = h_j (x) \right) \quad .(2.38)$$

In Random Forests jth base learner is a tree which is represented by $hj(X,\Theta j)$, where Θj represents a set of arbitrary variables and Θj's are independent. for $j = 1, . . . , J$. even though Random Forest definition is quite general. For the sake of understanding the algorithm of Random Forest, there is an importance for having basic knowledge about types of trees which are utilized as base learners [43]. The error of generalization of a tree classifiers forest is dependent on how strong individual trees in a forest are and the association amongst those trees. Tree formation includes several steps, as follows:

Considering to have S cases in the training dataset, S cases which are arbitrarily sampled with deviating from the original data. The generated sample would afterwards be considered to be a training dataset for tree growth. At every one of the nodes, p variables need to be arbitrarily chosen, in a way that p <<P out of all P input variables .Out of every potential split on p variables, the optimal split is utilized for splitting the node. Throughout forest growth, the p value is taken as a constant. every one of the trees grows to the maximum possible degree. There isn't any pruning. Streaming Random Forest learning Algorithm includes the following steps:

Step1: Assuming that S is the number of training samples, whereas P is the number of variables in a classifier.

Step2: assuming that *p* is the number of input variables which are utilized for determining decisions at tree nodes where *p* must be considerably < P.

Step3: choose a training dataset for a specific tree via choosing *S* times with replacement from every *S* available training case. With predicting classes, the remaining samples are utilized for the estimation of tree error.

Step4: in order to make a decision at one of the nodes, arbitrarily choose p variables for every one of the tree nodes. Calculate the optimal split in training dataset according to the *p* variables.

Step 5: every one of the trees will grow at the maximum possible level in a way that there isn't any more pruning.

Those steps work effectively on large databases that are capable of managing large input variable volumes with no deleting. It offers estimating about important variables in a classification.

This algorithm is not biased toward estimating generalized error throughout growing the forest. The algorithm of random forest is as well considered efficiently approximating missing data and preserving precision with approaches that are available to balance errors in the unbalanced datasets of class population. Resulting forests are also capable of being considered as inputs to future datasets. It provides information on the correlation between classification and variables. It operates quite sufficiently for the detection of outliers, as well as labeling unsupervised clustering

show in figure (2.14) the flaw chart of **FR** algorithm[44].

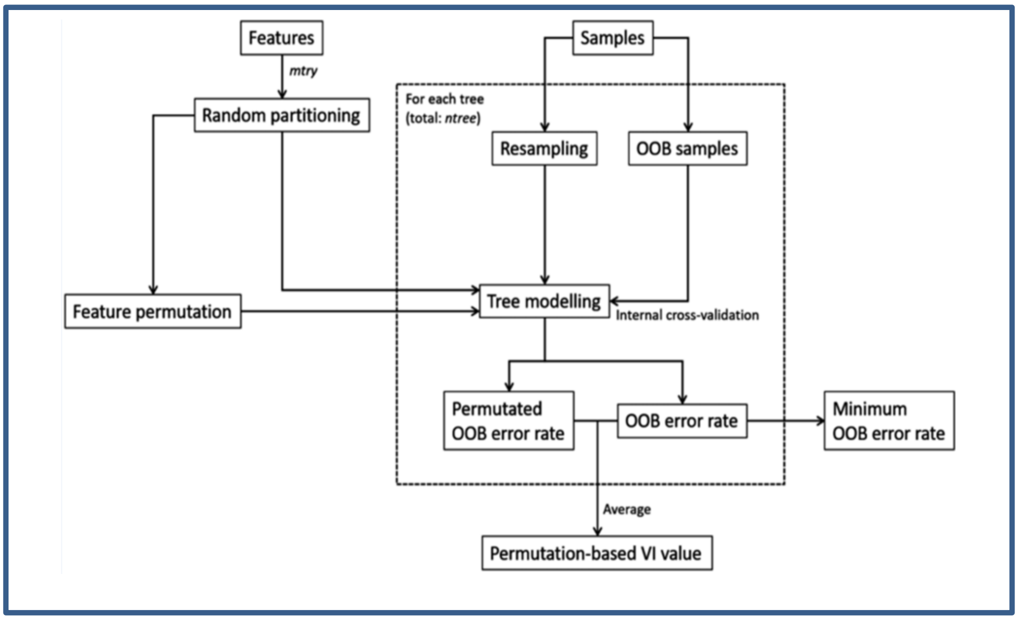


figure (2.14) the flaw chart of RF algorithm.

2.10 Performance Evaluation Methods

2.10.1 k-fold cross-validation

The approach of K-fold cross-validation for assessment of the proposed algorithm's efficiency, quite a popular k-fold cross-validation, method is utilized. In this cross validation, a dataset is divided to k mutually exclusive sub-sets that are almost equally sized and the approach is done k times (folds). Every time, one sub-set is utilized as a testing set and the rest of the k–1 sub-sets are combined together for creating a training dataset. After that, the average precision across every k trial is calculated. In the present work, k =10 has been considered for every experiment while attempting to eliminate the time of calculation and the number of experiments as well as the reduction of estimator variance. The option of number of folds (k) is dependent on the dataset size. For the experimental datasets that

have been used in this study, the 10-fold cross validation has been found sufficient [45].

2.10.2.Details accuracy

The evaluating of the suggested system was executed depending on accuracy, recall, precision, and F-measure tests which use the true negative (t_n), true positive (t_p), false negative (f_n), false positive (f_p) and these criteria are computed as follows [46] .(2.39), (2.40) and (2.41), (2.42).

$$\text{Accuracy} = \frac{t_p + t_n}{t_p + f_p + f_n + t_n} \quad (2.39)$$

$$F_{measure} = \frac{2 * t_p * precision}{t_p + precision} \quad (2.40)$$

$$precision = \frac{t_p}{t_p + f_p} \quad (2.41)$$

$$recall = \frac{t_p}{t_p + f_n} \quad (2.42)$$

2.11.Role of Soft Computing:

The methods of soft computing (rough sets, NNs, fuzzy sets, and genetic algorithms GAs) are majorly utilized in data mining. The fuzzy sets offer natural frameworks for the process in handling uncertainty. Rough sets and NNs are applied for rule generation as well as for classification. GAs are used in different search and optimization processes, such as template selection and query optimization. There are other methods such as decision trees and case-based reasoning are applied for solving data mining problems. Lately, different soft computing methods were utilized for handling various obstacles presented in data mining. The major constituents regarding the soft computing, at such juncture,

consist of GAs, NNs, rough sets, and fuzzy logic. Each one of these methods contribute unique approach to address the challenges in such domain. This can be achieved in cooperative, instead of competitive, approach. The result will me more robust and more intelligent systems which provide human-interpretable, low costs, approximate solutions, in comparison to conventional approaches. Initially, the importance and roles of individual soft computing tools as well as their hybridizations will described, and then the different system created to handle various functional aspects related to the field of data mining. Adequate preference standard will be optimized throughout mining process. It could be indicated that there is no generally optimum data mining approach; selecting particular soft computing tool(s) or certain combination with conventional approaches is totally on the basis of certain application and need human interaction for deciding appropriateness of the method [47]. The figure(2.15) shows the role of the Soft Computing as the machinery for handling challenges which are out of scope of the more conventional Hard Computing methods[48].

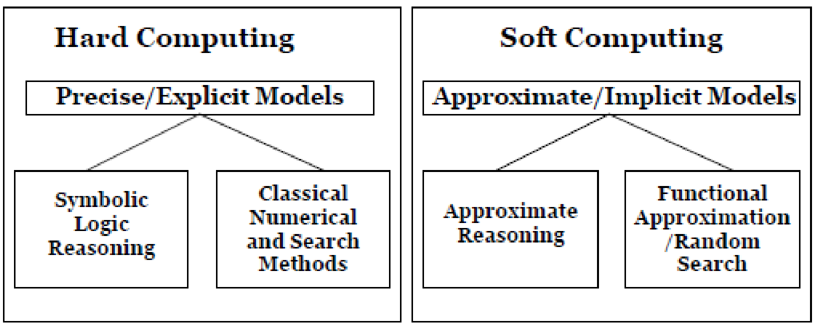


Fig.(2.15)Soft computing and Hard computing

Chapter Three

Implementation Of The Proposed System

Chapter Three

Design and Implementation Of The Proposed System

3.1 Introduction:

Given that the signals during their passage through the atmosphere are subject to some reflections and refractions and some influencing factors such as noise, distortion and attenuation, and the effect of noise on the signal abounded, the researchers discussed it in several researches, and the use of signals in many applications focused on the importance of classification of signals and because the signals have a set of feature including Weak and unrelated, including strong ones, therefore the characteristics of the signals are improved to strengthen them and thus increase the accuracy of classification and this we will apply our research by In this chapter the proposed system .The signals are generated within a range of SNR (-2,.....20) for optimization of features extraction of signal Modulating, By two swarm optimization (CSO & BA)algorithms and classified using random forest algorithm.

3.2 Data Set:

Many types of signal generated using MATLAB to work with these signals in the proposed system.

The generated signal is split up to three main categories:

- Quadrature amplitude modulation (M QAM) : the digital family that is mainly used to transfer data in telecommunication with its different size (8,16,32,64,128,256) .
- Phase-shift keying (M PSK): that convey the data via changing (modulating) phase related to constant frequency reference signal (carrier wave) with size (2, 4 and 8).

- **Amplitude Shift Keying** (ASK2): transmit the digital data via varying amplitude of sin wave. Both phase and frequency still constant while the amplitude changes with size (2, 4, 8).

This dataset consist of three parts each part represents generated signals which will treated as a dedicated level which easier refer to as (SNR signal to noise ratio).

3.3 Proposed System:

In this system a new modeling for signals feature extraction optimized using swarm techniques (BA and CSO) algorithm and data optimized will Classified using random forest classification algorithm Present Figure shows (3.1) proposed system layout .

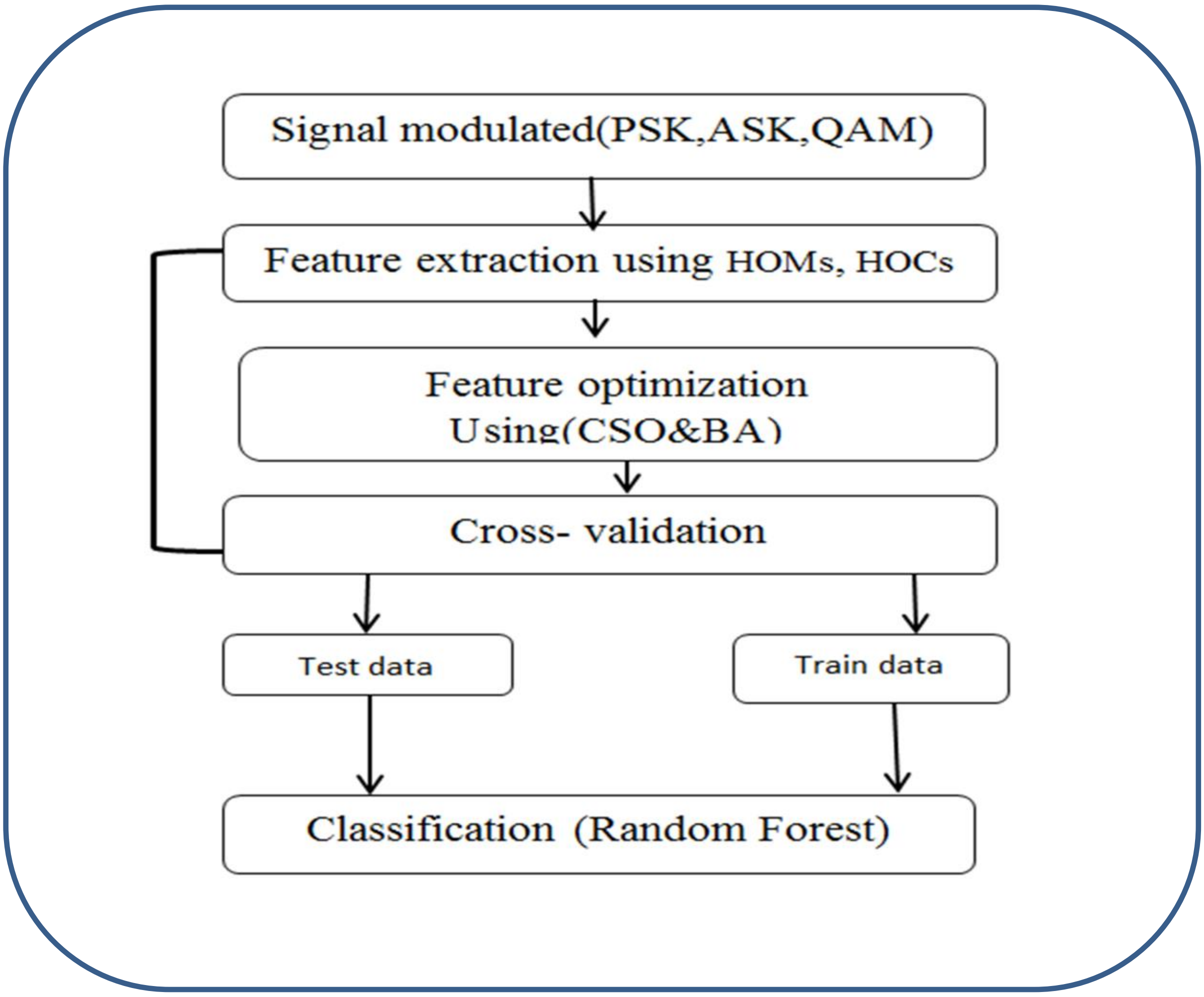


Figure shows (3.1) proposed system layout .

System Architecture

System mainly consists of three main phases:

1. **Data generation and preprocessing phase:** this phase is consist of many internal steps which is :
   - **Signal generation:** This is done via using MATLAB signal generator to generate three types of signals (QAM, PSK, and ASK2).
   - **Feature extraction:** this is done via extracted feature the statistic HOMs, HOCs by calculating the mean where each time .
   - **Dataset preparation:** this is done by group the data set to three (signal to noise ratio) (SNR) each one is represent all types of signal which is enter the cross validation step, the cross-validation method use K=10 to mix the data and split it up to train and test to guarantee that all the data is take the role as train and test.
2. **Feature optimization phase:** the number of features extracted from the feature extraction still huge and need to be optimized by discard the weak or inconsistency features which is done via (BA or CSO).
3. **Classification phase:** the classification is done in this phase via random forest algorithm to classify the features to main classes.

The classification is done using six scenarios:

- Classify test features using Random Forest.
- Classify train features using Random Forest.
- Classify test features optimized using BA feature optimization algorithm using Random Forest.

- Classify train features optimized using BA Swarm optimization algorithm using Random Forest.
- Classify train features optimized using chicken Swarm optimization algorithm using Random Forest.
- Classify test features optimized using chicken Swarm optimization algorithm using Random Forest.

Discussion about results obtained from the system is discussed in Chapter four.

3.4.Data generation and preprocessing phase:

Generating the signals in proposed system by MATLAB Proram:

As examples of this.

QAM Signal generation using MATLAB Program
Input: matrix (array) integer values Output: signals
Start Step1: define the base-band modulator Step2: define channel (AWGN channel) Step3: generate M-array QAM is done via generate the data Symbols In column vector using the qam mod function. Step4: SNR is used for different values from (-2,-1,……20) dB. End

PSK Signal generation using MATLAB Program
Input: matrix (array) integer values Output: signals
Start Step1: define the base-band modulator Step2: define channel (AWGN channel) Step3: modulates input signal, x, utilizing PSK with modulation order M. where M could be the modulation number. Via y = PSK mod(x,M) Step4: specify initial phase of PSK-modulated signal. Via y = PSK mod(x,M,ini_phase) Step5: specify symbol order of PSK-modulated signal. Via y = pskmod(x,M,ini_phase,symorder) Step 6: SNR is used for different values from (-2,-1,……20) dB. **End**

ASK Signal generation using MATLAB Program

Input: matrix (array) integer values

Output: signals

Start

Step1: define the base-band modulator

Step2: define channel (AWGN channel)

Step3: Step5: i=1;

```
while i<nx+1
     t = i:0.001:i+1;
    if x(i)==1
       ask2=sin(2*pi*f*t);
    else
        ask=0;
       end
    subplot(3,1,1);
    plot(t, ask);
```

Step4 :SNR is used for different values from (-2,-1,……20) dB.

End

3.4.1 Dataset Preparation:

Three levels of SNR is calculated for all the signals

A .SNR1 with 8 numbers (integers number) generated for all signals with values (-2,-1,0,1,2,3,4,5)dB

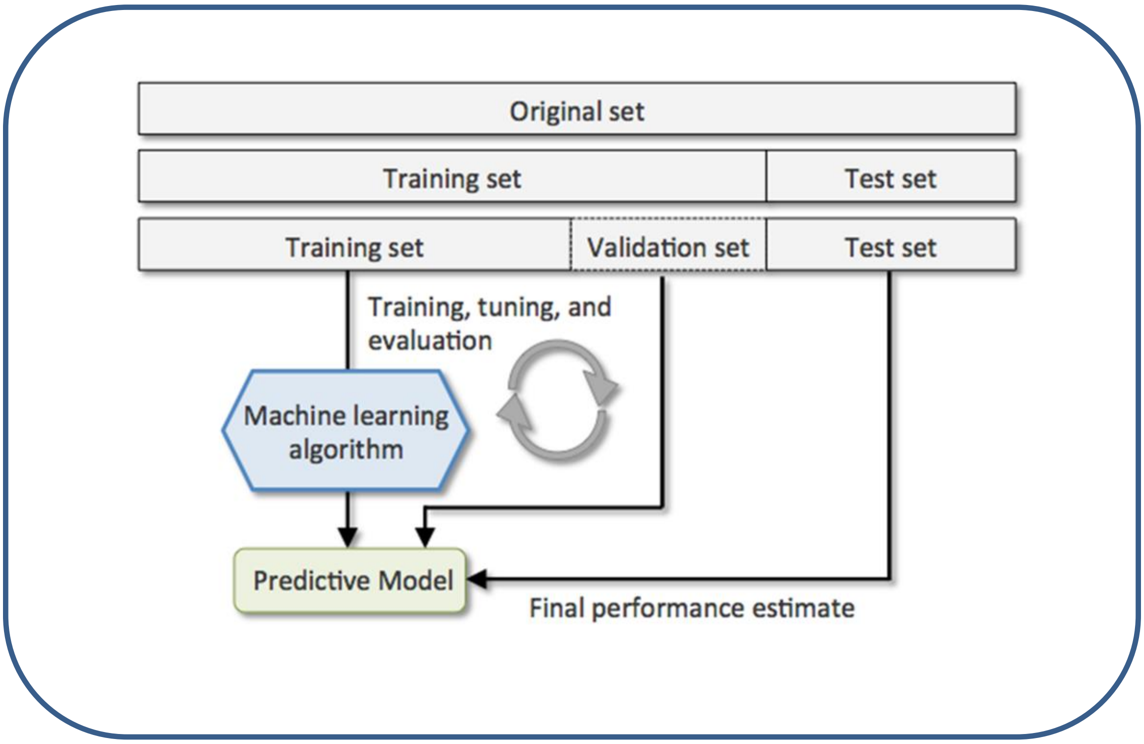
B . SNR2 with 8 numbers (integers number) generated for all signals with values (6,7,8,9,10,11,12)dB.

C . SNR3 with 8 numbers (integers number) generated for all signals with values (13,14,15,16,17,18,19,20)dB.

The classification is done to every level of SNR and results shown separately to each level and classification is improve in level 2 rather than level one and so on.

Cross Validation:

the separation of data set to train and test data need to deal with internal information related to each data and since the signals is deal with different levels of signals cross validation is used to separate the data. Algorithm 3.1 shows the main steps of the used cross validation algorithm .According to algorithm 3.1 the k value is choose k=10 which mean 10 times the data will split to train and test and the data spilt to train and test and the process is repeated until all the data is being train data and test data in the system .present the figure(3.2) Diagram showing an algorithm Cross Validation



figure(3.2) Diagram algorithm Cross Validation

Algorithm 3.1 cross validation algorithm
Input: data set Output: train data , test data
start step1: set the k to 10 step2: for i=1 to k Split the data to k folds where one fold is test and the remains fold is train. Step3: fitting the model using k-1 Step4: loop End

3.4.2 Feature Extraction Using Combination Of Moment And Cumulant:

The feature extracted from signal is critical since the data it contain suffer from the translations limitation and need to handled carefully, choosing the right feature extraction algorithm is the more challenge part in this work. Numeric features is used normally for classification of the modeled signals which will led to improve the general system efficiency, since the system is deal with different signal types as explained in data set section 3.2 (2ASK-PSK-QAM) .The extracted features in traditional way are considered not efficient due to different characteristics of each signal type which will be difficult to recognize these types .In this thesis and in order to efficient use of the feature extracted from the signals combination between the moment and the cumulant used by using groups up to 8 orders features to maximize the benefit of such features.

The type of the signals used in this thesis is categorized as follow:

A. 2ASK.
B. 2 PSK, 4PSK, 8PSK.
C. 8 QAM, 16 QAM, 32 QAM, 64 QAM, 128 QAM, 256 QAM.

3.5. Feature Optimization:

In order to get better results of the system optimization is suggested to the features to discard weak or irrelevant features in the system and keep only strong relevant features, to check the accuracy of the system six scenarios where applied to features and comparing the results obtained from applying the feature optimization algorithm and without applying it.

Two algorithm used for feature optimization (BAT and chicken) and data resulted compared and discussed in chapter four.

3.5.1 BAT Feature Selection Algorithm:

This algorithm is simply follow the behavior of bat, initially each bat will assign a frequency (Random Frequency) these frequencies is known between ranges [f min, f max].Then the data set is bring to this algorithm the weight of the input- hidden and hidden-output is calculated and the transfer function is calculated and the rand value .The following describes the execution steps of the standard bat algorithm:

- For each bat, initialize the position, velocity, and parameters and randomly generate the frequency
- Update the position and velocity of each bat with Equations (2.27) and (2.28).
- For each bat, generate a random number Update the temp position and calculate the fitness value for corresponding bat with Equation (2.29) if $rand_1 < r_i$ (t).
- For each bat, generate a random number ($rand_2$). Update A_i (t) and r_i (t) with Equations (2.30) and (2.31), respectively, if $rand_2 < A_i$ (t) and f(X_i (t))<f(p(t)).
- Sort each individual based on fitness values and save the best position .
- The algorithm is finished if the condition is met, otherwise, move on to Step 2

Algorithm (3.2): Bat Feature Optimization Algorithm
Input: vector
Output: optimized vector

Initialize the bat population $x_i(i = 1,2,3 \dots \dots n)$ andv_i ;
Define pulse frequency f_i , pulse rate r_i and the loudness A_i ;
while (t<t_{max}) do
Generate new solutions by adjusting frequency, updating velocities and positions;
if (rand r_i >) then
Select a solution among the best solutions randomly;
Generate a local solution around the selected best solution using;
end if
if (rand < A_i &&$f(x_i) < f(x_g)$) then
Accept the new solutions;
Increase $r_i$and reduce A_i;
end if
Rank the bats and find the current best ;
t=t+1;
end while

3.5.2 Chicken Feature Optimization:

This swarm algorithm used to optimize the features in the proposed system, this algorithm work by following the behavior of the chicken, the features is taking out three parts in this algorithm:

A . Rooster which is represents the best feature (fitness).

B . Hen

C . Chicks which are represent the worst features (fitness).

In the proposed system the system consists of 1 rooster (considered as the leader) and 2 hens with a set of chicks, mathematical movement of (rooster, hen and chicks).The motion of the rooster work as leader of chicken group and specified via equation (2.23)

Whereas the motion of the hens in swarm has been specified through the use of equation (2.25)

The motion of chicks in swarm is specified via the use of equation(2.26).

Algorithm (3.3): Chicken Feature
Input: vector
Output: optimized vector

Initialize a population of N chickens and define
the related parameter;
Evaluate the N chicken’s fitness values, t = 0;
While (t < Max Generation)
If (t == 0)
Rank the chicken’s fitness values and
establish a hierarchal order in the swarm;
Divide the swarm into different groups, and
determine the relationship between the chicks
and hens in a groups; End if.
For i = 1: N
If i == the rooster Update its solution using
rooster formula
If i == the hen Update its solution using hen
formula

If i == the chick Update its solution using
chick formula
Evaluate the new solution
If the new solution is better than its
previous one, update it.
End for
End While

3.6. Classification:

The design of the automatic recognition system to recognize signals need to take into consideration the following maters:

A . The classifier type and check if it is suitable for signal classification.

B . The time of the extraction of the signal is not affecting the classification process or the decision made, since some algorithm effected by the timing signal axis.

C. The type of the modulation is not affecting the classification process or the decision made since some algorithms need to have a thresholds which led to apply same SNR to many algorithms to make a decision.

In this system the classification is done via applying the classification algorithm random forest . This classification method use as a feedback to the election process which will help to provide the classification of such systems which will work on optimized features (after applying the feature optimization phase). The optimized features will select specific number of features (K) from the total number of optimized features (M), the number of the selected features shall be less than the total number of the

optimized features in the system to ensure the entire feature treated equally and no data will be discarded . The split point d is founded by select the best split point which will represent the classes in the classification algorithm this split will be applied to only the k features selected . The processes of choosing some data features from the rest number of features (M-K) and the same step repeated until number of the rest features turned to be one then n number of tree is build by using the split point obtained from the previous steps.

Algorithm 3.4 is the classification using Random Forest.

Algorithm 3.4 Classification Using Random Forest.
Input: optimized features Output: decision
Start Step1: Randomly select "k" features from total "m" features. Where k << m Step2: Among "k" features, calculating node "d" by means of best split point. Step3: Split node to daughter nodes by applying best split. Step4: Repeating 1 to 3 steps until "l" number of nodes was breached. Step5: Building forest via repeating steps 1 to 4 for "n" number times to create "n" number of trees. End

Chapter Four

The Experimental Results

Chapter Four

The Experimental Results

4.1 Introduction:

The presented chapter will show the results obtained after execution of suggested system and discussion of the results will handled with figures related to the results shows the impact of specific algorithm (classification algorithm) to the generated data set .The proposed system is implemented in two language MATLAP R2015 a to generation signals and feature extraction and JAVA Net Beans IDE 8.0.2 to classify signal using lap top computer. Experiments have been implemented on Intel (R) Core (TM) i5-2540M CPU @ 2.60 GHz , 64 bit Operating System and 4GB RAM. In the following sections, the detailed steps and implementation results will be explained for each step to accomplish the suggested system.

4.2. Signal Generation in MATLAB:

The first step in Data generation and preprocessing phase ,The input to signal generating function specified as matrix (array) and the elements of X must be binary or integers (in this thesis integer values used) starting from 0 to m-1 where the value if m is the order of modulation. Where the modulation order is power two e.g. QAM2^3 which is QAM8 and 2^4 is 16 and so on . The generated signal is simulated in MATLAB to apply process of data streaming using simulated communication system which is consist of (1 base-band modulator) (2 channel) (3 transmitter and receiver) demodulator the system is able to compute the bit error rate by send and receive signals and it can be charted in a diagram. e.g. generate the QAM-16 is done via generate the data Symbols . In column vector using the QAM mod function and the size of it is 16.

SNR is calculated when the channel has (-2,-1,…..,20) dB. The generated signals of samples signal is shown in figures (4.1, 4.2, 4.3, 4.4 and 4.5) for sample of the used signals

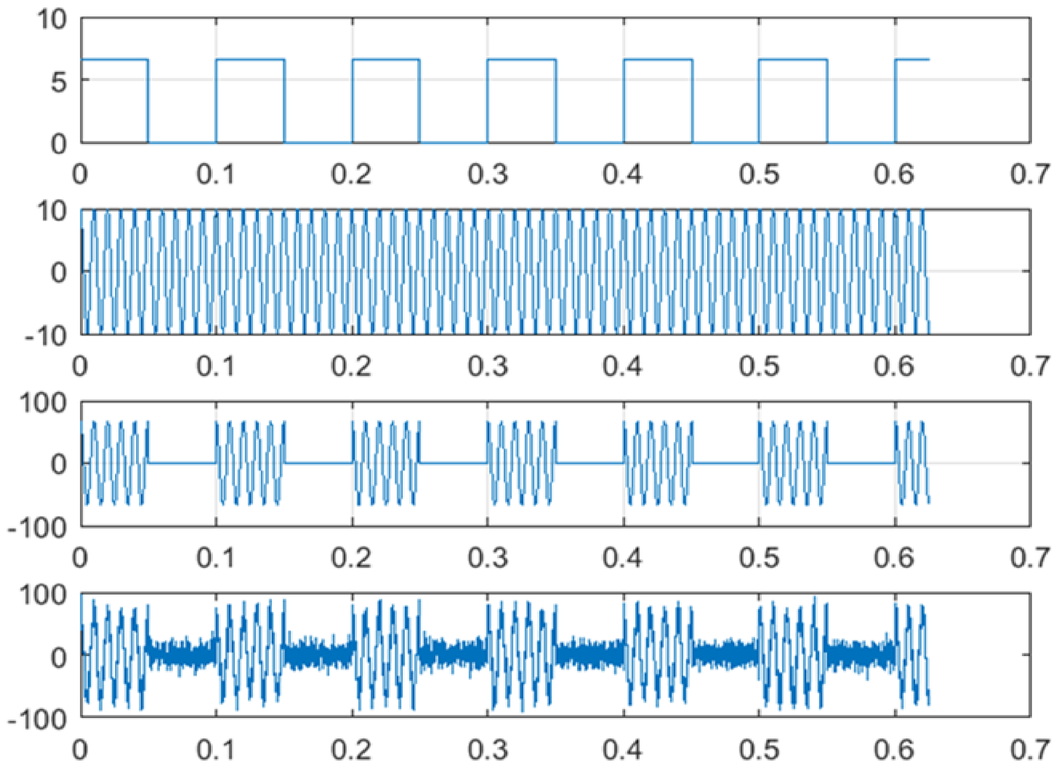


Figure (4.1)(a) input MSG (b) Carrier signal, (c) signal without AWGN noise **(d)** 2ASK signal with AWGN

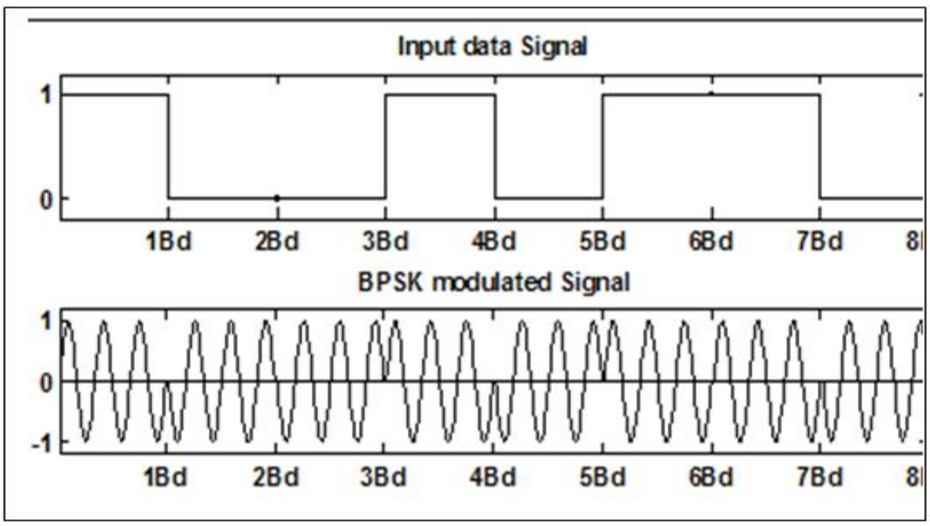


Figure (4.2)).*(a)* Carrier signal, (b) 2 PSK signal

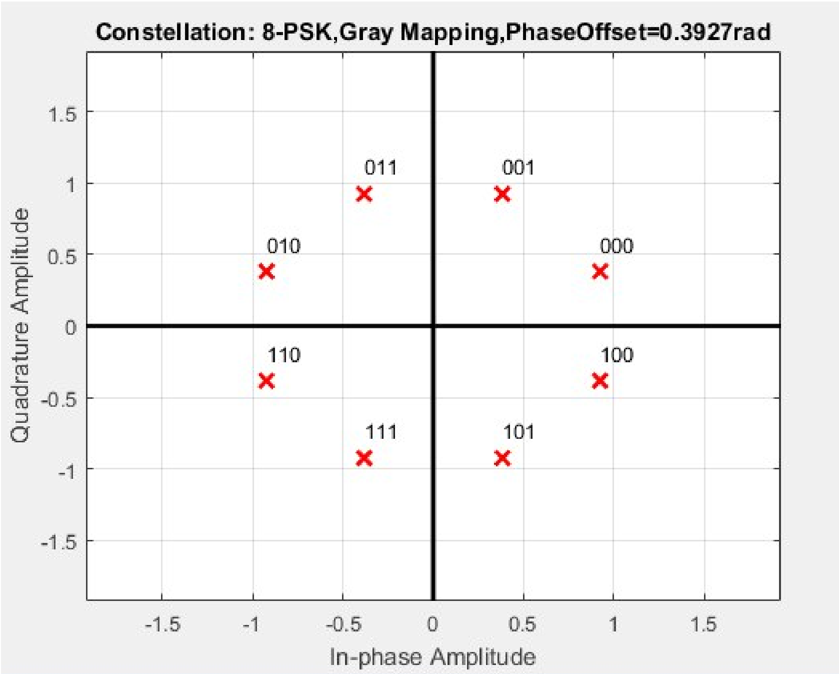


Figure (4.3) Constellation-diagram of- 8 PSK

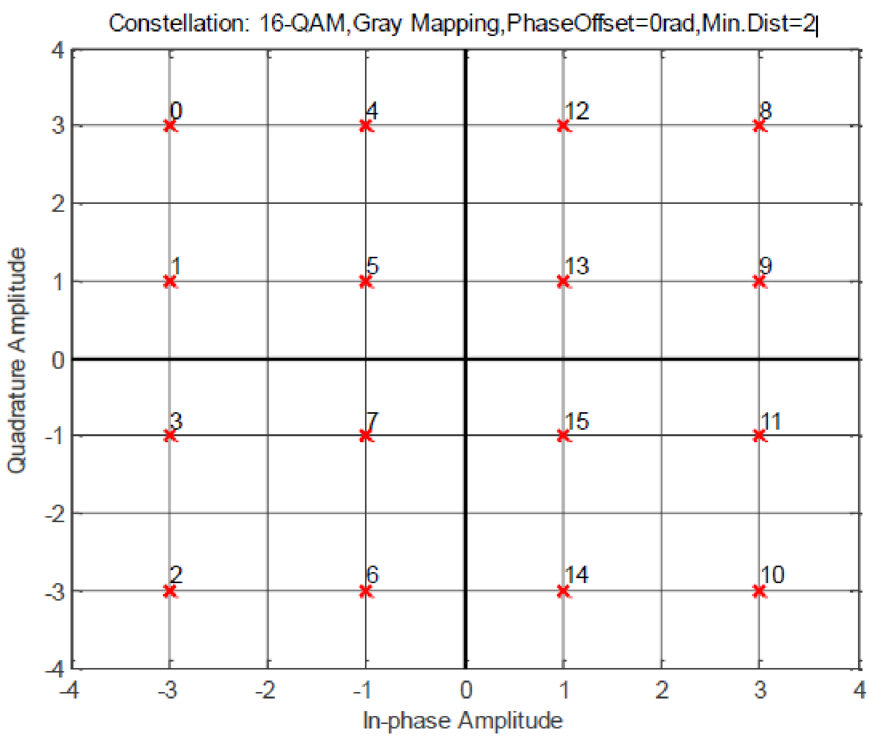


Figure (4.4) Constellation-diagramof-16-QAM

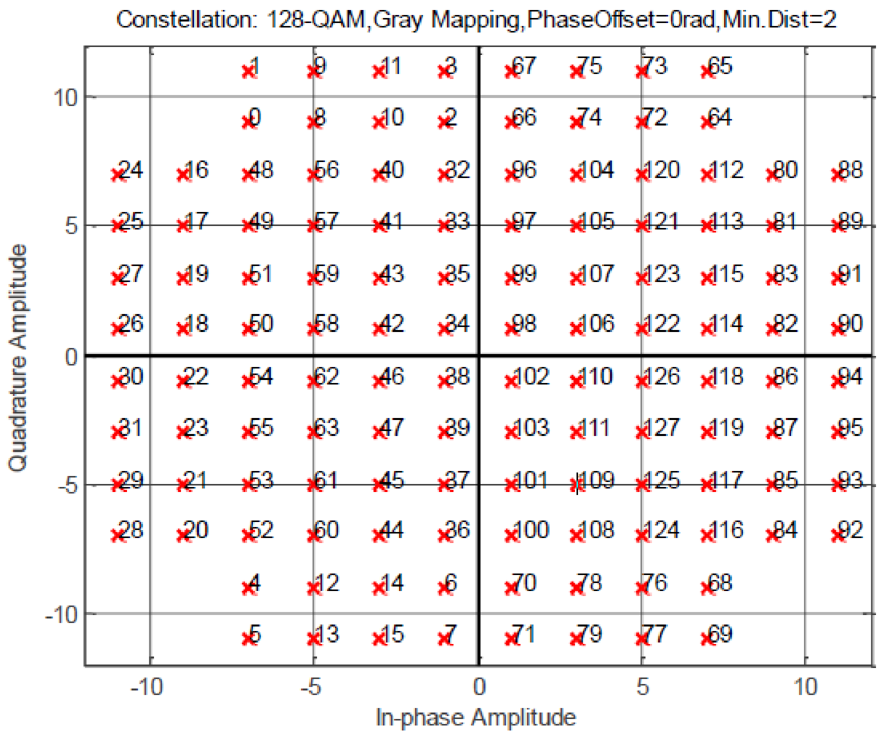


Figure (4.5) Constellation-diagramof-128-QAM

4.3 Experimental Results:

As shown in chapter three the data set split up to three main levels (SNR1, SNR2, SNR3) each one of these SNRs will get its on results of classification.

4. 3.1 .Three levels Of Classification Using Random Forest:

A .The results obtained after execution of the first SNR1 in Random Forest classification algorithm are shown in the table (4.1)

Table (4.1) The obtained results after applying the Random Forest in SNR1

TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC area	area	Class
87	0	**100**	87	93	92	99	97	2PSK
75	2	75	75	75	72	83	75	4PSK
66	4	57	66	61	58	97	65	8PSK
100	0	**100**	100	100	100	100	100	8 QAM
100	0	**100**	100	100	100	100	100	16QAM
100	0	**100**	100	100	100	100	100	32QAM
100	0	**100**	100	100	100	100	100	64 QAM
50	5	50	50	50	44	91	46	128QAM
100	0	**100**	100	100	100	100	100	256QAM
100	0	**100**	100	100	100	100	100	2 ASK
88	12	89	88	88	87	97	89	average

It is clear from the above table that the accuracy ratio of the system is within the ranges of SNR(-2,…….5) reach 89%While TP Rate: rate of true positives (instances correctly classified as a given class) 88%, FP Rate: rate of false positives (instances falsely classified as a given class) 12%, Recall: proportion of instances classified as a given class divided by the actual total in that class (equivalent to TP rate) 88% , F-Measure: A combined measure for precision and recall calculated as (2 * Precision * Recall / (Precision + Recall) 88% .

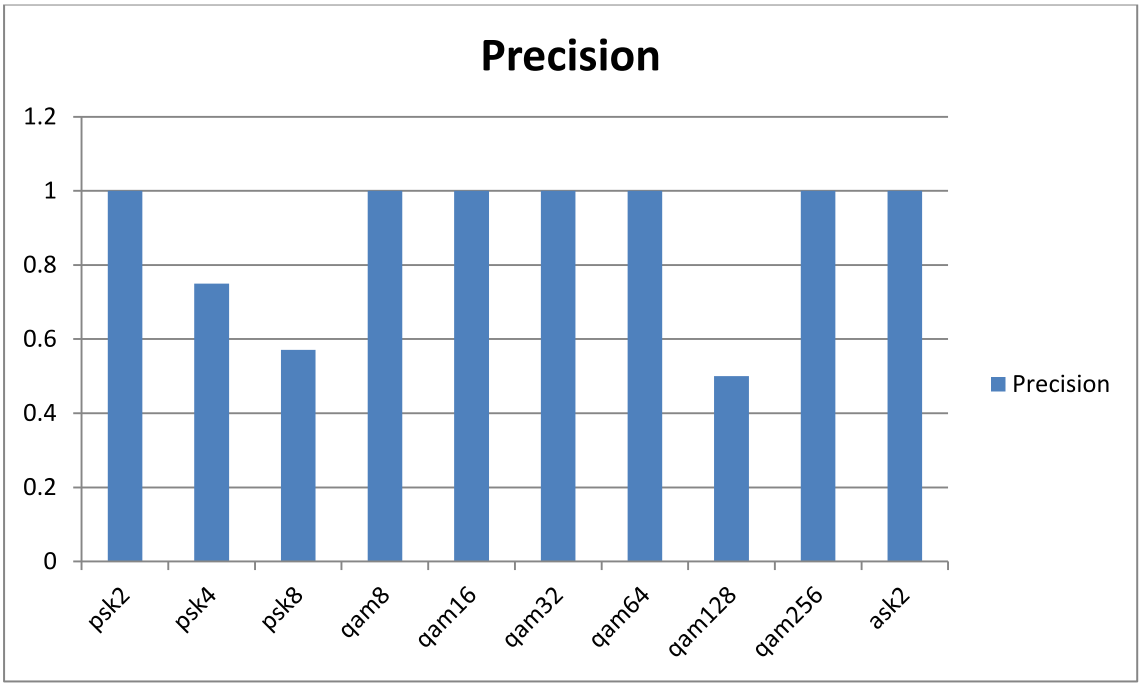


Figure (4.6) show the application of precision for the random forest algorithm in SNR1

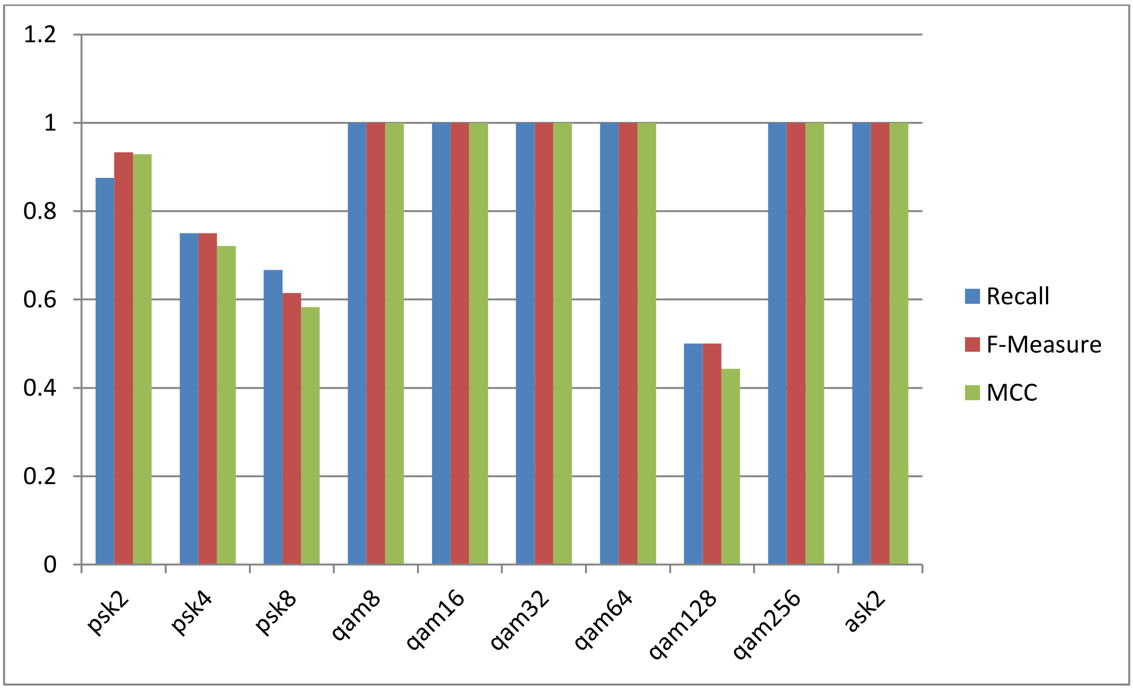


Figure (4.7) show the application of (recall, f-measure and MCC) for the Random Forest algorithm in SNR1

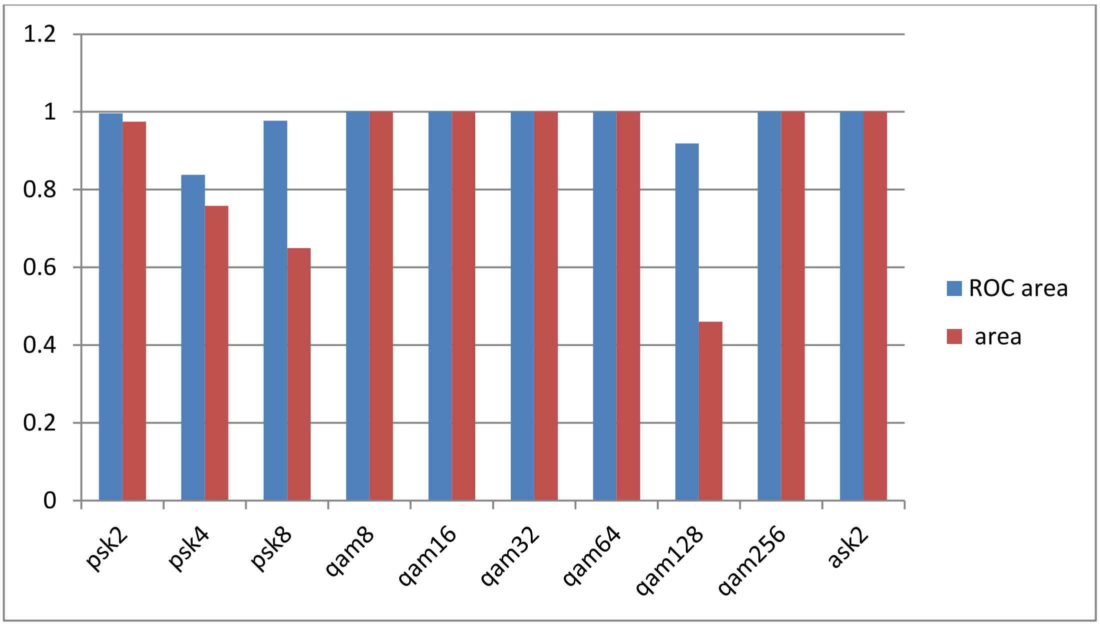


Figure (4.8) show the application of ROC area and area for the Random Forest algorithm in SNR1

B . The results were obtained after execution of the SNR2 in Random Forest classification algorithm are displayed in table (4.2)

Table (4.2) the obtained results after applying the Random Forest in SNR2

area	ROC area	MCC	F-Measure	Recall	Precision	FP Rate	TP Rate	Class
86	98	74	76	83	71	3	83	2PSK
7	73	23	0	0	0	1	0	4PSK
98	99	100	100	**100**	100	0	100	8PSK
100	100	100	100	**100**	100	0	100	8 QAM
100	100	100	100	**100**	100	0	100	16QAM
100	100	100	100	**100**	100	0	100	32QAM
98	99	86	87	**100**	77	3.5	100	64 QAM
82	96	83	83	**100**	100	0	71	128QAM
100	100	100	100	**100**	100	0	100	256QAM
100	100	100	100	**100**	100	0	100	2 ASK
93	98	91	91	92	91	8	92	average

Comparing the results were obtained after execution RF Algorithm between Tables (4.1) and (4.2) And for three of the performance evaluation criteria(Precision , Recall, F-Measure) Within two levels of the SNR The results are at the second level (Precision=91% Recall=92%, F-Measure=91%) Higher compared to the first level (Precision=89% Recall=88%, F-Measure=88%) . the results of the characteristics (TP Rate, FP Rate, Precision, Recall, F-Measure, MCC, ROC area and area) is raised by moving from one SNR to other (from low level SNR to higher level SNR).

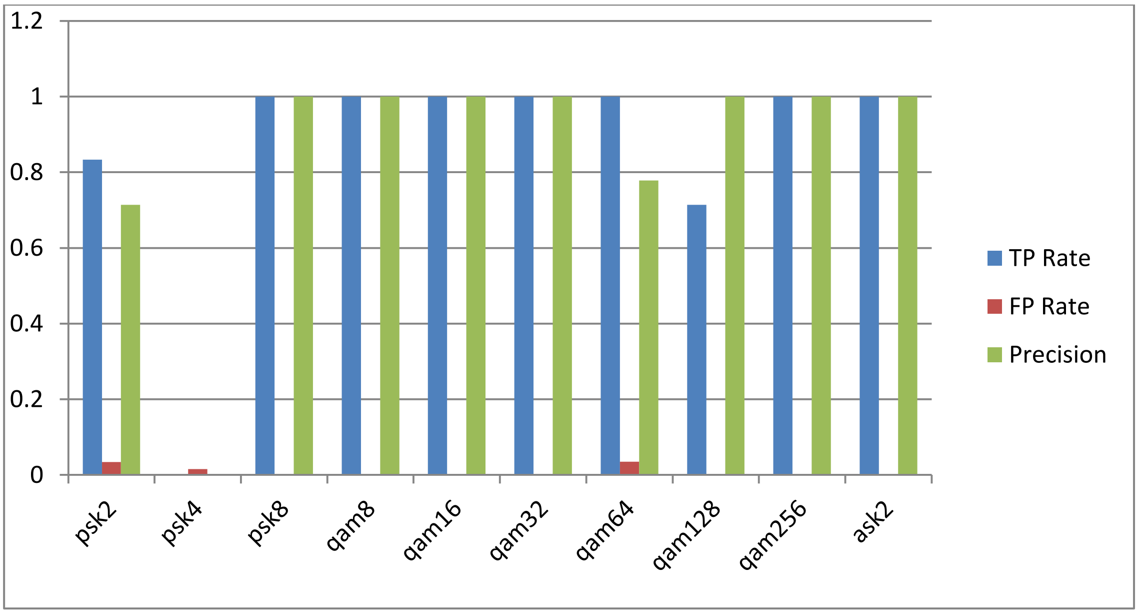


Figure (4.9) shows application of TP area, FP area and precision for the random forest algorithm in SNR2

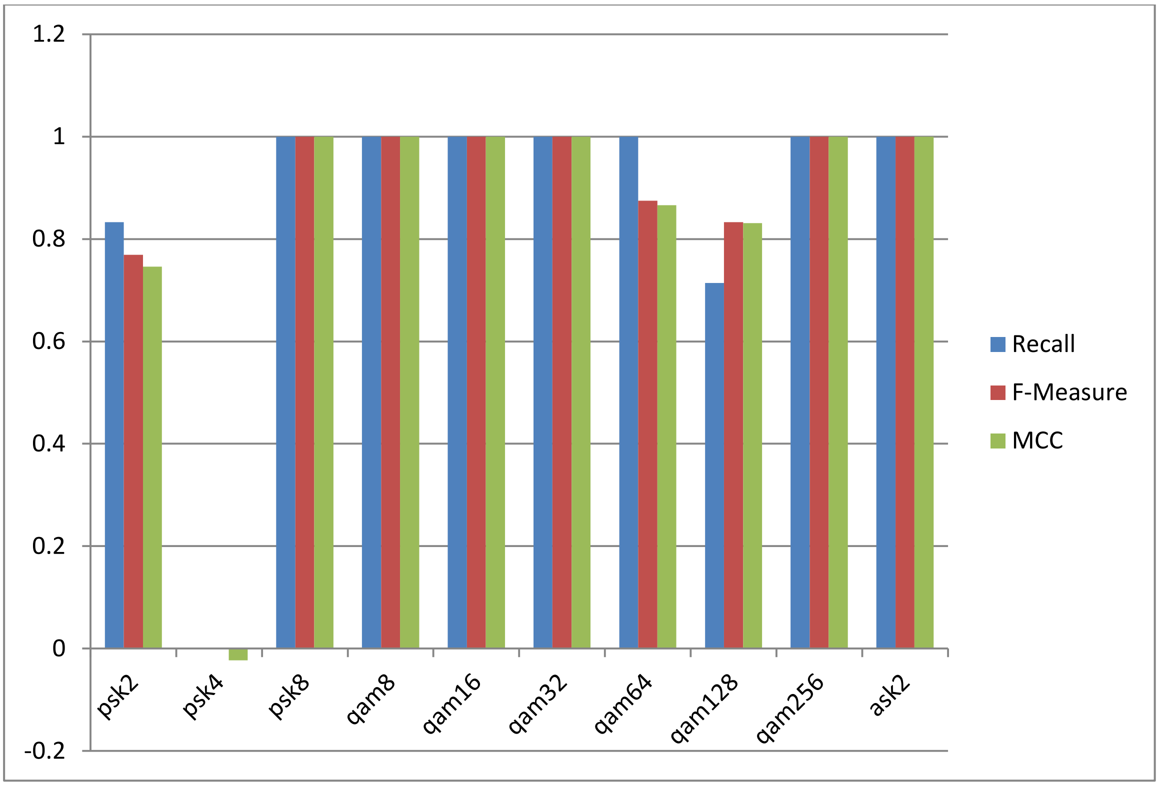


Figure (4.10) displays application of recall, f-measure and MCC for the Random Forest algorithm in SNR2

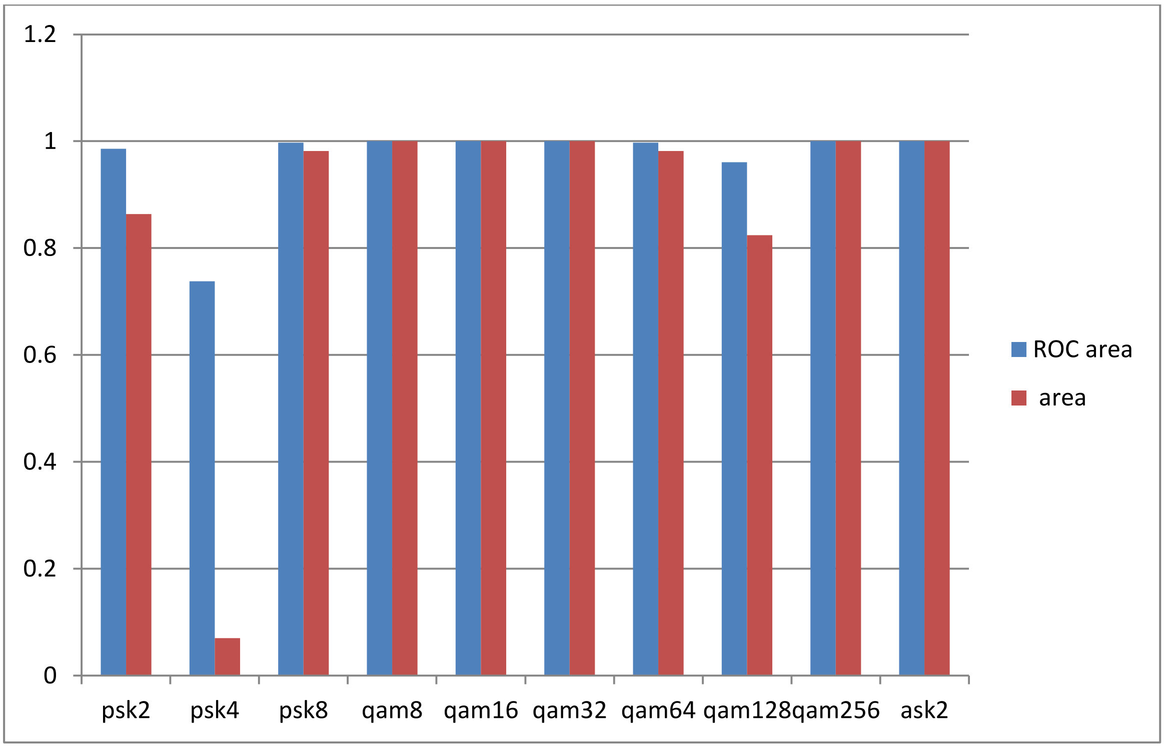


Figure (4.11) shows the application of ROC area and area for the random forest algorithm in SNR2

C . The results obtained after execution of the SNR3 in Random Forest classification algorithm are displayed in table (4.3)

Table (4.3) the obtained results after applying the(RF) in SNR3

TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC Area	PRC Area	Class
100	0	**100**	100	100	100	100	100	2PSK
62	4	62	62	62	58	96	71	4PSK
50	4	50	50	50	45	95	681	8PSK
100	0	**100**	100	100	100	100	100	8 QAM
100	0	**100**	100	100	100	100	100	16QAM
100	0	**100**	100	100	100	100	100	32QAM
100	0	**100**	100	100	100	100	100	64 QAM
100	0	**100**	100	100	100	100	100	128QAM
100	0	**100**	100	100	100	100	100	256QAM
100	0	**100**	100	100	100	100	100	2 ASK
92	8	92	92	92	91	99	94	average

Comparing the results obtained after implementing the RF algorithm between Tables (4.1) and (4.2)(4.3) The results of the properties (TP Rate, FP Rate, Precision, Recall, F-Measure, MCC, ROC area and area) are raised by moving from SNR One to the other (from low-level SNR to high-level SNR) focusing on three of the performance evaluation criteria ((Precision=92% Recall=92%, F-Measure=92%))as they reached their highest values in the third level.

4.3.2 Three levels of classification using Random Forest (with features optimization (Chicken)):

A. The results obtained after execution of the first SNR1 in Random forest classification algorithm after the feature optimization using chicken algorithm are displayed in table (4.4)

Table (4.4) the obtained results after applying the(RF) with (CSO) in SNR1

TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC Area	Area	Class
100	0	**100**	100	100	100	100	100	2PSK
75	7	54	75	63	59	93	445	4PSK
16	2	33	16	22	19	90	33	8PSK
100	0	**100**	100	100	100	100	100	8 QAM
100	0	**100**	100	100	100	100	100	16QAM
100	0	**100**	100	100	100	100	100	32QAM
100	0	**100**	100	100	100	100	100	64 QAM
100	0	**100**	100	100	100	100	100	128QAM
100	0	**100**	100	100	100	100	100	256QAM
100	0	**100**	100	100	100	100	100	2 ASK
91	9	90	91	90	89	98	89	average

Comparing the results were obtained after execution RF Algorithm without optimization of the first SNR1 1n Tables (4.1) less than The results obtained in Random forest classification algorithm after the feature optimization using chicken algorithm are displayed in table (4.4) Within the same range of SNR the properties (TP Rate, FP Rate, Precision, Recall, F-Measure, MCC, ROC area and area) are raised after optimization .

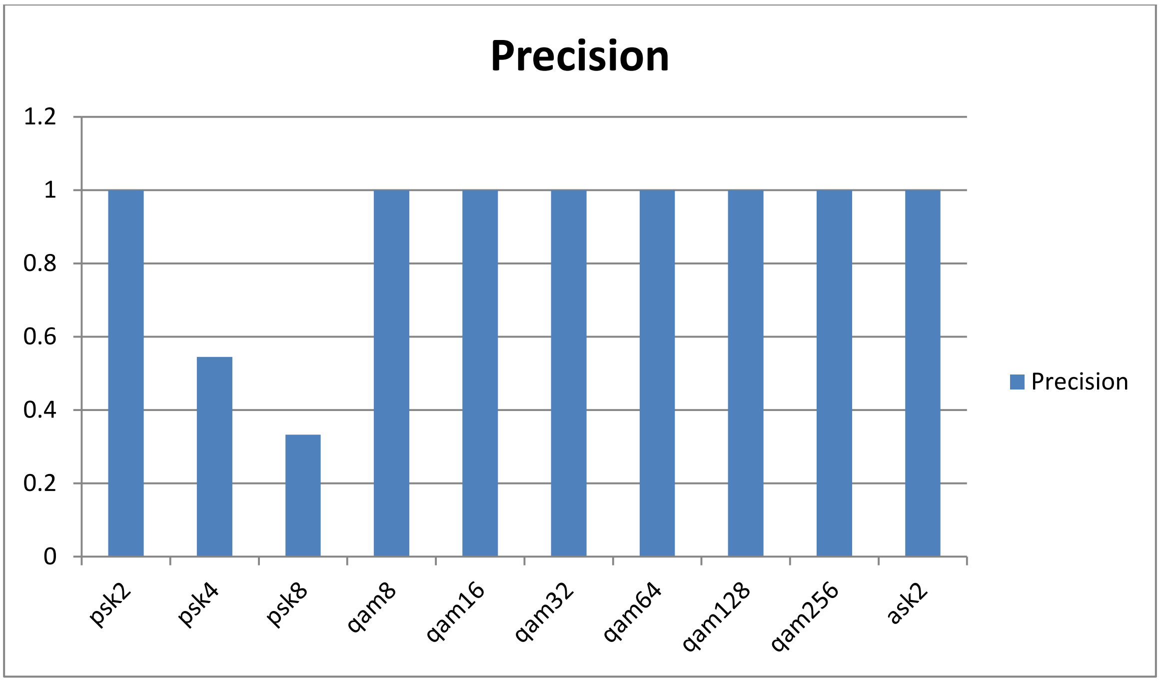


Figure (4.12) shows The application of precision for the (RF) with (CSO) in SNR1

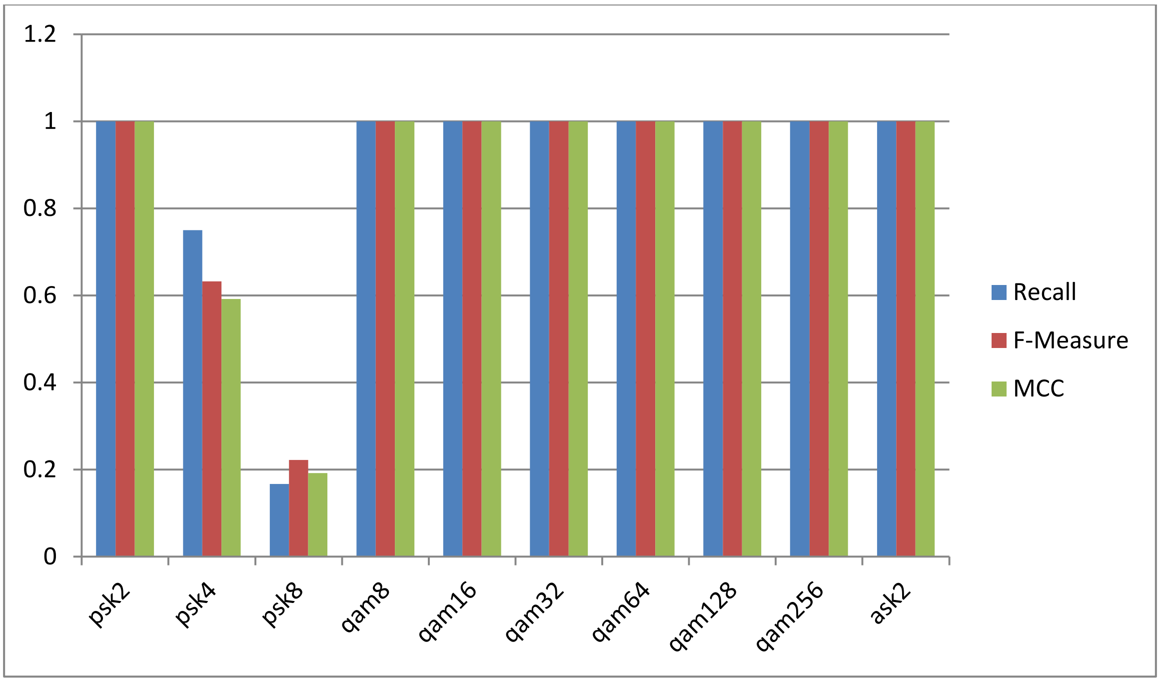


Figure (4.13) show the application of (recall, f-measure and MCC) for (RF) with (CSO) in SNR1

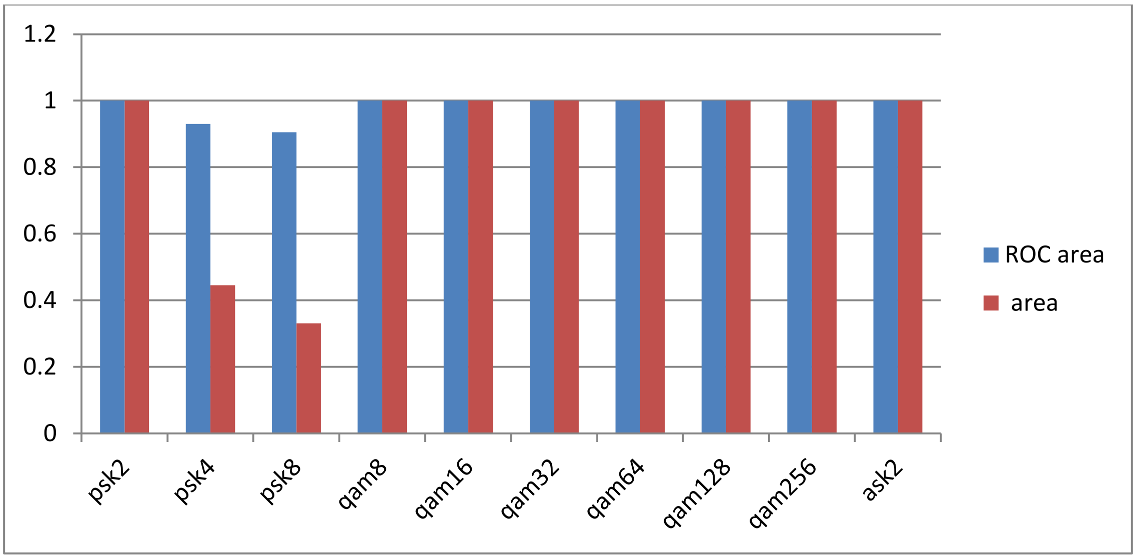


Figure (4.14) shows the application of ROC area and area for the (RF) with (CSO) in SNR1

B. The results obtained after execution of the SNR2 in random forest classification algorithm after the feature optimization using chicken algorithm are displayed in table (4.5)

Table (4.5) the obtained results after applying the Random Forest in SNR2 with Chicken feature optimization

TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC Area	PRC Area	Class
83	3	71	83	76	74	97	65	psk2
0	1	0	0	0	23	87	16	psk4
100	0	**100**	100	100	100	100	100	psk8
100	0	**100**	100	100	100	100	100	qam8
100	0	**100**	100	100	100	100	100	qam16
100	0	**100**	100	100	100	100	100	qam32
100	0	**100**	100	100	100	100	100	qam64
100	0	**100**	100	100	100	100	100	qam128
100	0	**100**	100	100	100	100	100	qam256
100	0	**100**	100	100	100	100	100	ask2
96	4	94	95	94	94	99	94	average

Comparing the results were obtained after execution RF Algorithm without optimization of the SNR2 1n Tables (4.2) less than The results obtained in Random forest classification algorithm after the feature optimization using chicken algorithm are displayed in table (4.5) Within the same range of SNR the properties (TP Rate, FP Rate, Precision, Recall, F-Measure, MCC, ROC area and area) are raised after optimization .

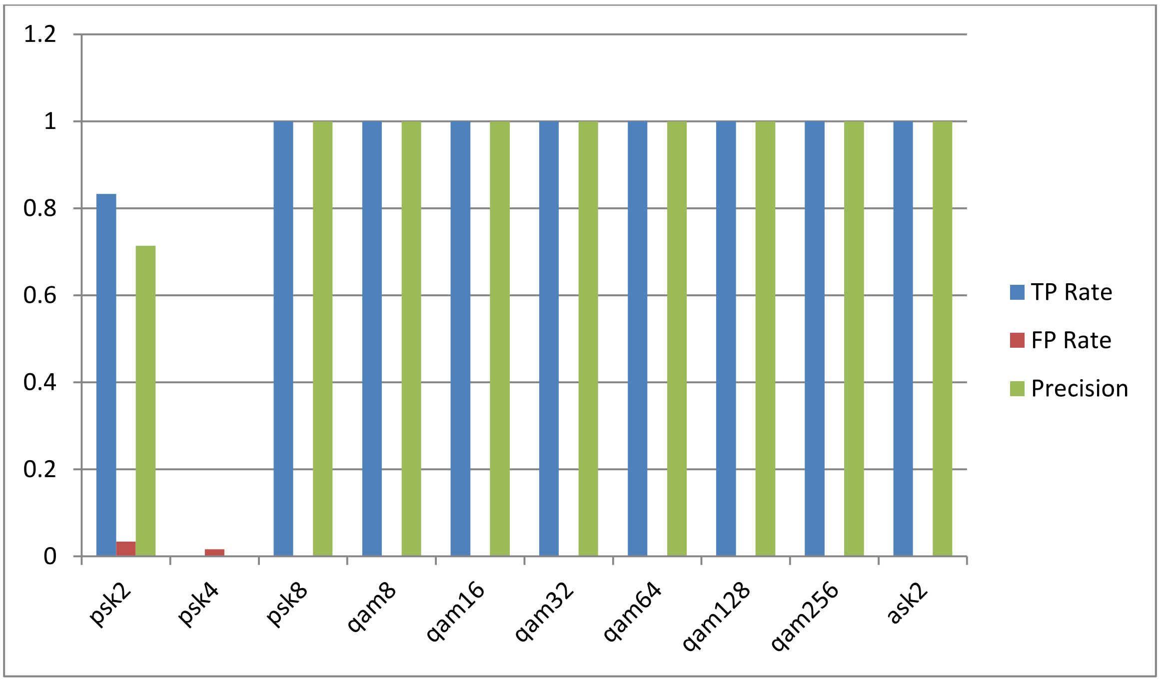


Figure (4.15) shows the application of TP area, FP area and precision (RF) with (CSO) in SNR2

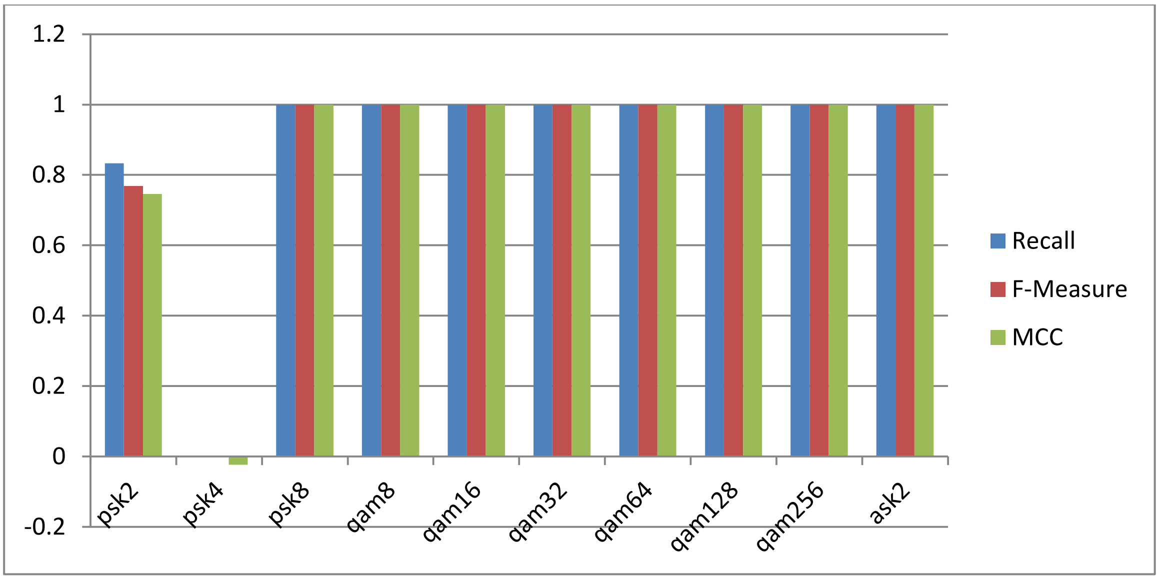


Figure (4.16) shows the application of recall, f-measure and MCC for (RF) with (CSO) in SNR 2

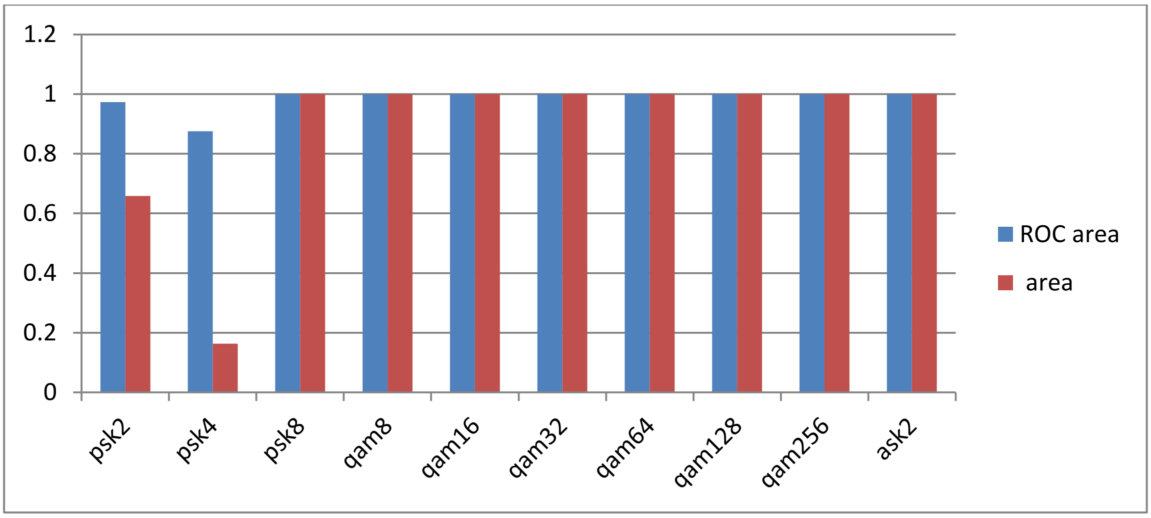


Figure (4.17) shows the application of ROC area and area (RF) with (CSO) in SNR2

C . The results obtained after execution of the first SNR3 in random forest classification algorithm for optimized features using chicken are shown in table (4.6)

Table (4.6) results obtain following applying the Random Forest for optimized features using Chicken in SNR3

TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC Area	PRC Area	Class
100	0	**100**	100	100	100	100	100	psk2
87	4	70	87	77	755	96	65	psk4
50	1.5	75	50	60	58	95	57	psk8
100	0	**100**	100	100	100	100	100	qam8
100	0	**100**	100	100	100	100	100	qam16
100	0	**100**	100	100	100	100	100	qam32
100	0	**100**	100	100	100	100	100	qam64
100	0	**100**	100	100	100	100	100	qam128
100	0	**100**	100	100	100	100	100	qam256
100	0	**100**	100	100	100	100	100	ask2
94	6	94	94	94	94	99	93	average

Comparing the results were obtained after execution RF Algorithm without optimization of the SNR3 1n Tables (4.3) less than The results obtained in Random forest classification algorithm after the feature optimization using chicken algorithm are displayed in table (4.6) Within the same range of SNR the properties (TP Rate, FP Rate, Precision, Recall, F-Measure, MCC, ROC area and area) are raised after optimization . In addition, The result are raised by moving from SNR One to the other (from low-level SNR to high-level SNR)he results increase unevenly after improving the features with an algorithm (CSO) .

4.3.3 Three levels of classification using random forest (with features optimization (BA)):

A . The results obtained after execution of the first SNR1 in random forest classification algorithm after the feature optimization using Bat algorithm are displayed in table (4.7)

Table (4.7) the obtained results after applying the Random Forest in SNR1with Bat feature optimization

TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROCArea	Area	Class
87	0	**100**	87	93	92	99	97	psk2
75	4	66	75	70	67	83	75	psk4
83	3	71	83	76	75	97	60	psk8
100	0	**100**	100	100	100	100	100	qam8
100	0	**100**	100	100	100	100	100	qam16
100	0	**100**	100	100	100	100	100	qam32
100	0	**100**	100	100	100	100	100	qam64
50	4	57	50	53	48	91	.49	qam128
100	0	**100**	100	100	100	100	100	qam256
100	0	**100**	100	100	100	100	100	ask2
89	11	90	89	89	88	97	89	average

Comparing the results were obtained after execution RF Algorithm without optimization of the first SNR1 1n Tables (4.1) less than The results obtained in Random forest classification algorithm after the feature optimization using BA algorithm are displayed in table (4.7) Within the same range of SNR the properties (TP Rate, FP Rate, Precision, Recall, F-Measure, MCC, ROC area and area) are raised after optimization While the results remain after Optimization the algorithm CSO In table (4.4) is higher than the results after Optimization the algorithm BA(4.7) and within the same level of SNR .

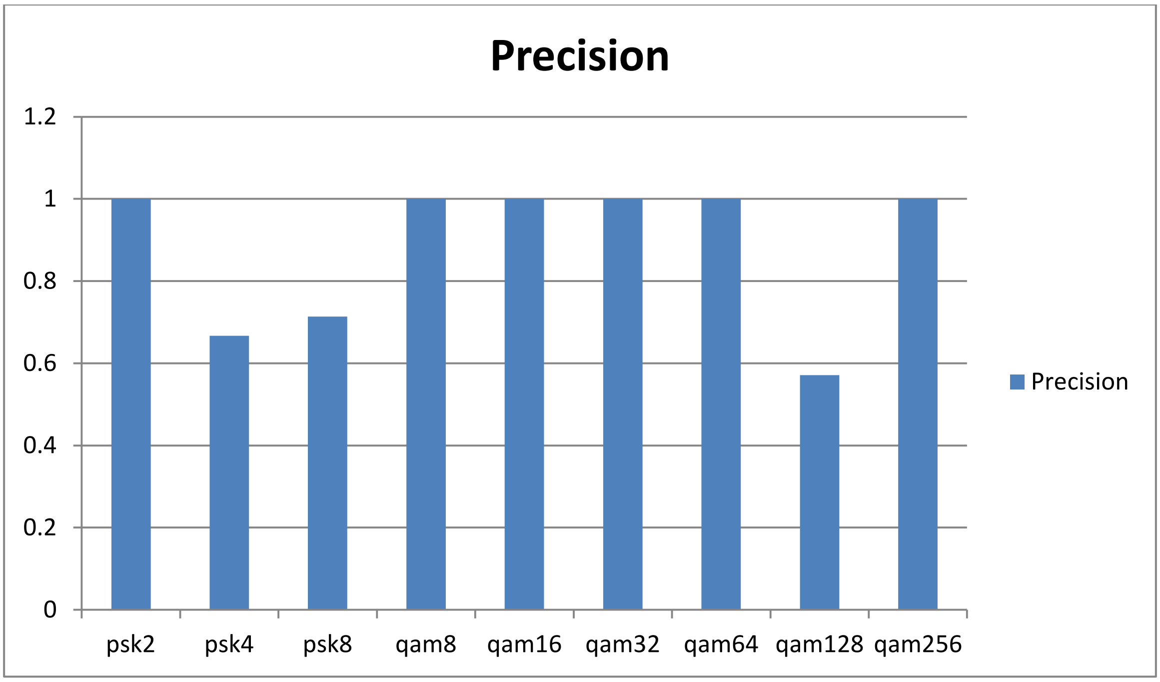


Figure (4.18) shows the application of precision for the(RF) with (BA) in SNR1

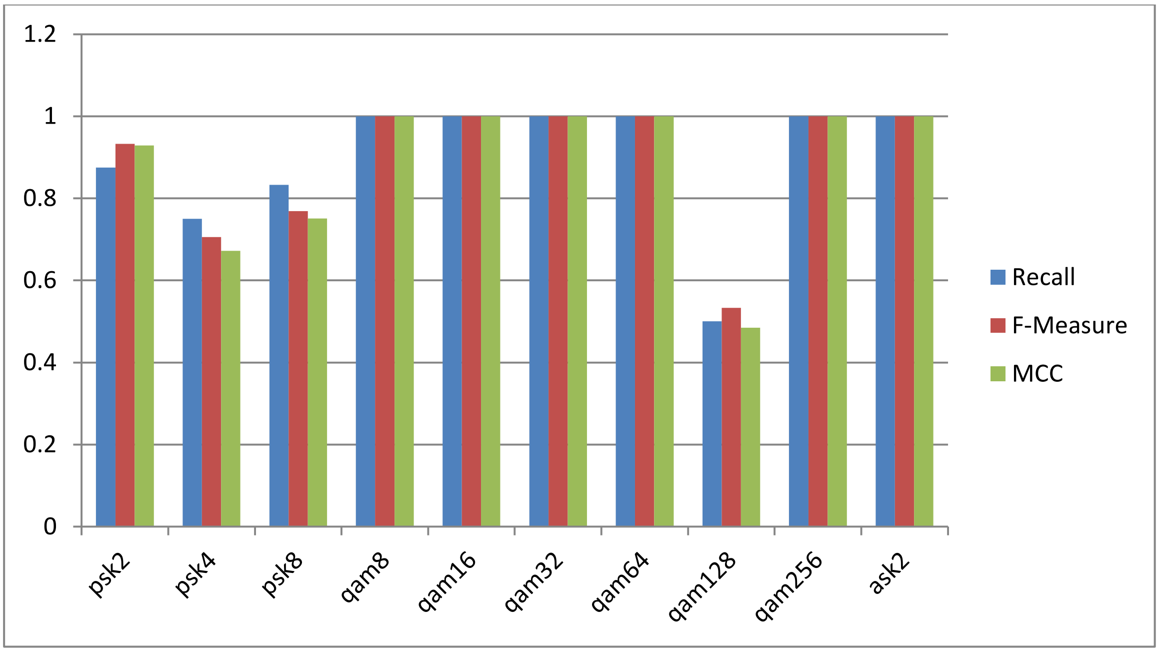


Figure (4.19) shows the application of (recall, f-measure and MCC) the(RF) with (BA) in SNR1

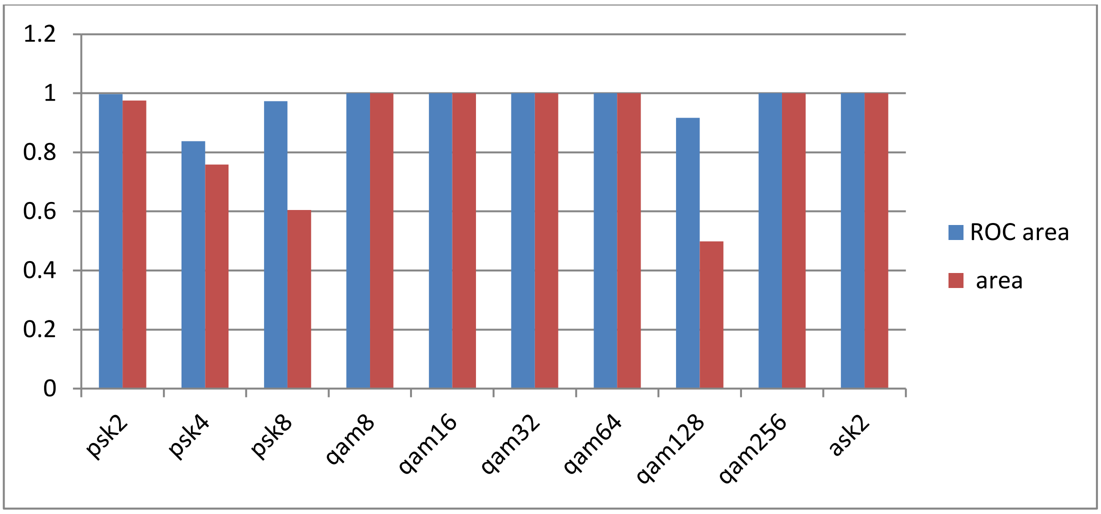


Figure (4.20) shows the application of ROC area and area for the(RF) with (BA) in SNR1

The results obtained after execution of the SNR2 in Random Forest classification algorithm after the feature optimization using Bat algorithm are displayed in table (4.8) .

Table (4.8) the obtained results after applying the random forest in SNR2 with Bat feature optimization

TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC Area	PRC Area	Class
100	3	75	100	85	85	98	87	psk2
0	0	0	0	0	0	52	39	psk4
100	0	**100**	100	100	100	99	95	psk8
100	0	**100**	100	100	100	100	100	qam8
100	0	**100**	100	100	100	100	100	qam16
100	0	**100**	100	100	100	100	100	qam32
100	4	77	100	87	86	100	100	qam64
71	0	**100**	71	83	83	94	82	128 qam
100	0	**100**	100	100	100	100	100	qam256
100	0	**100**	100	100	100	100	100	ask2
86	7	92	93	92	92	97	93	average

Comparing the results were obtained after execution RF Algorithm without optimization of the SNR2 1n Tables (4.2) less than The results obtained in Random forest classification algorithm after the feature optimization using BA algorithm are displayed in table (4.8) Within the same range of SNR the properties (TP Rate, FP Rate, Precision, Recall, F-Measure, MCC, ROC area and area) are raised after optimization While the results remain after Optimization the algorithm CSO In table (4.5) is higher than the results after Optimization the algorithm BA(4.8) and within the same level of SNR .

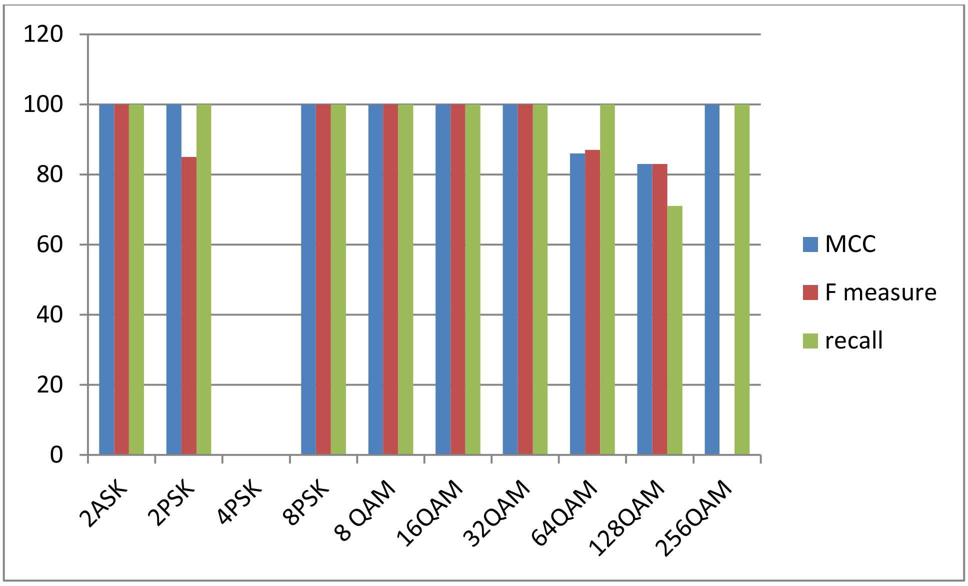


Figure (4.21) shows the application of TP area, FP area and precision the(RF) with (BA) in SNR2

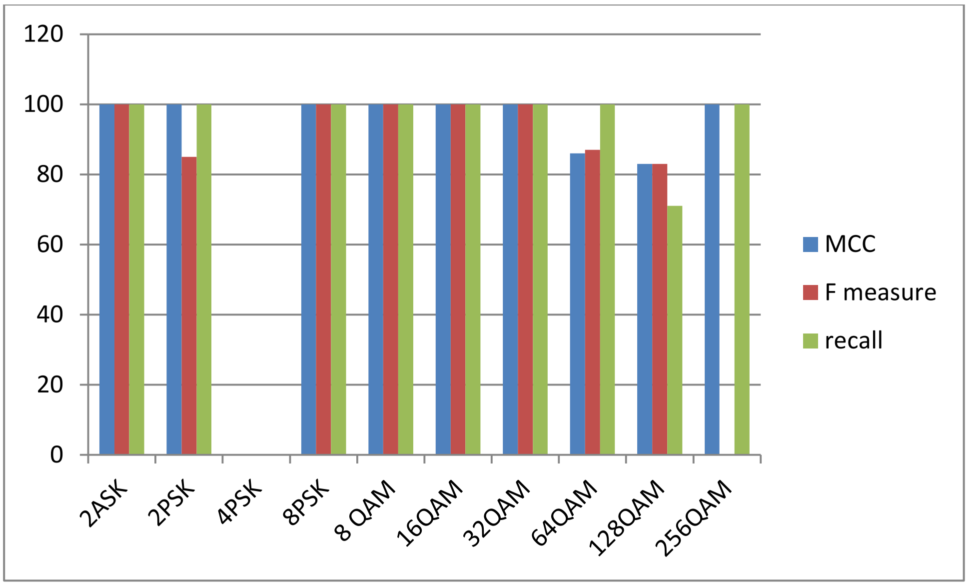


Figure (4.22) shows the application of recall, f-measure and MCC for the(RF) with (BA) in SNR2

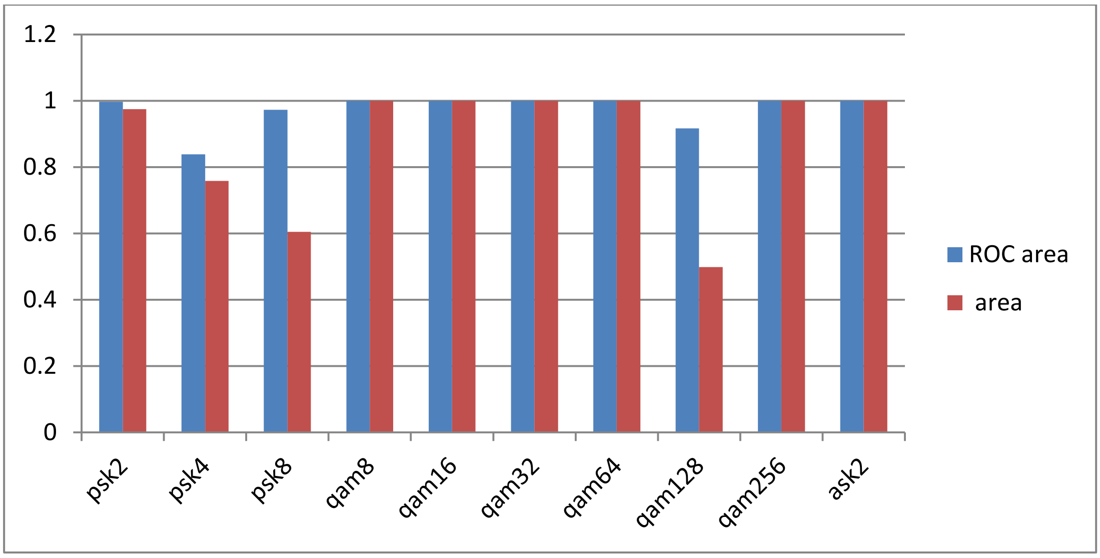


Figure (4.23) shows the application of ROC area and area for the(RF) with (BA) in SNR2

The results obtained after execution of the SNR3 in RF classification algorithm for optimized features using BA are displayed in table (4.9)

Table (4.9) the obtained results after applying the Random Forest for optimized features using Bat in SNR3

TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC Area	PRCArea	Class
100	0	**100**	100	100	100	100	100	psk2
50	4	57	50	53	48	97	78	psk4
50	5	42	50	46	41	97	71	psk8
100	0	**100**	100	100	100	100	100	qam8
100	0	**100**	100	100	100	100	100	qam16
100	0	**100**	100	100	100	100	100	qam32
100	1	88	100	94	93	100	100	qam64
87	0	**100**	87	93	92	100	100	qam128
100	0	**100**	100	100	100	100	100	qam256
100	0	**100**	100	100	100	100	100	ask2
89	10	89	89	89	88	99	95	average

Comparing the results were obtained after execution RF Algorithm without optimization of the SNR3 1n Tables (4.3) less than The results obtained in Random forest classification algorithm after the feature optimization using BA algorithm are displayed in table (4.9) Within the same range of SNR the properties (TP Rate, FP Rate, Precision, Recall, F-Measure, MCC, ROC area and area) are raised after optimization While the results remain after Optimization the algorithm CSO In table (4.6) is higher than the results after Optimization the algorithm BA(4.9) and within the same level of SNR .

4.4 Comparison Between Performance (Chicken, Bat):

The results drawn from Two different techniques (chicken, Bat) optimization algorithm) and classification by Random Forest .

Table(4.10) results obtain after applying CSO in SNR (-2,-1,0,……20)

Precision				Recall			F measure		
SIGNAL	**SNR1**	**SNR2**	**SNR3**	**SNR1**	**SNR2**	**SNR3**	**SNR1**	**SNR2**	**SNR3**
2ASK	**100**	**100**	**100**	100	100	100	100	100	100
2PSK	54	71	**100**	100	100	100	100	76	100
4PSK	33	0	70	75	0	87	63	0	77
8PSK	**100**	**100**	75	16	83	5	22	100	6
8 QAM	**100**	**100**	**100**	100	100	100	100	100	100
16QAM	**100**	**100**	**100**	100	100	100	100	100	100
32QAM	**100**	**100**	**100**	100	100	100	100	100	100
64QAM	**100**	**100**	**100**	100	100	100	100	100	100
128QAM	**100**	**100**	**100**	100	100	100	100	100	100
256QAM	**100**	**100**	**100**	100	100	100	100	100	100

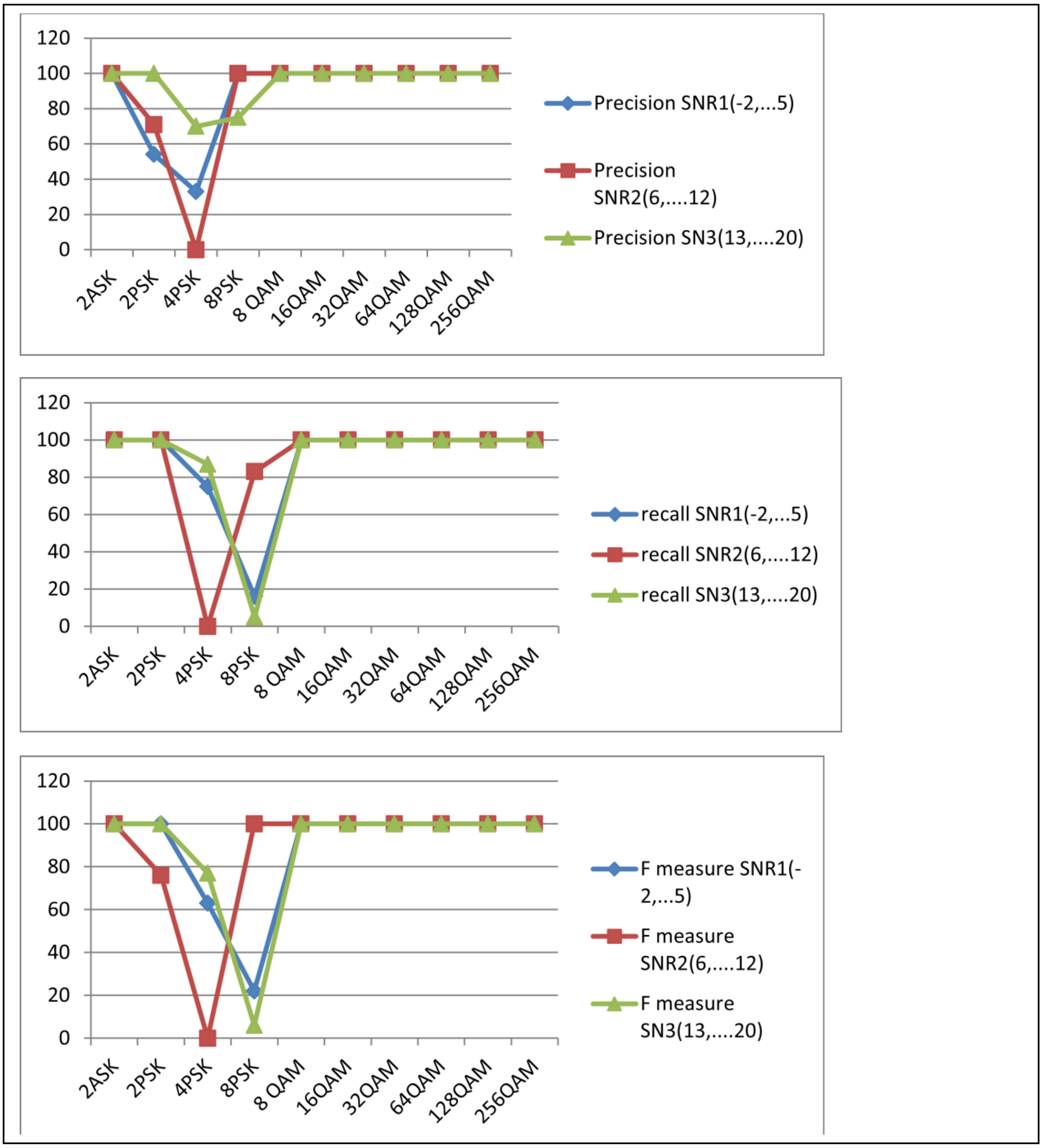


Figure (4.25) shows the(Precision ,recall, F measure)for the random forest algorithm in SNR(-2,-1,0,……20) with Chicken optimization

Table(4.11) results obtain after applying BAT in SNR (-2,-1,0,……20)

Precision				Recall			F measure		
SIGNAL	SNR1	SNR2	SNR3	SNR1	SNR2	SNR3	SNR1	SNR2	SNR3
2ASK	100	100	100	100	100	100	100	100	100
2PSK	100	75	100	87	100	100	93	85	100
4PSK	66	0	57	75	0	50	70	100	53
8PSK	71	100	42	83	100	50	76	100	46
8 QAM	100	100	100	100	100	100	100	100	100
16QAM	100	100	100	100	100	100	100	100	100
32QAM	100	100	100	100	100	100	100	100	100
64QAM	100	77	88	100	100	100	100	87	100
128QAM	57	57	100	50	71	87	53	83	93
256QAM	100	100	100	100	100	100	100	100	100

Illustrated when comparing results between Show chicken algorithm more efficiently than Bat algorithm has higher performance and higher classification accuracy And for all levels SNR (-2……..20). And We focus on three basic criteria(precision, Recall, F-Measure). Table (4.10),(4.11) represent the results obtained and Comparison between Proposed Techniques

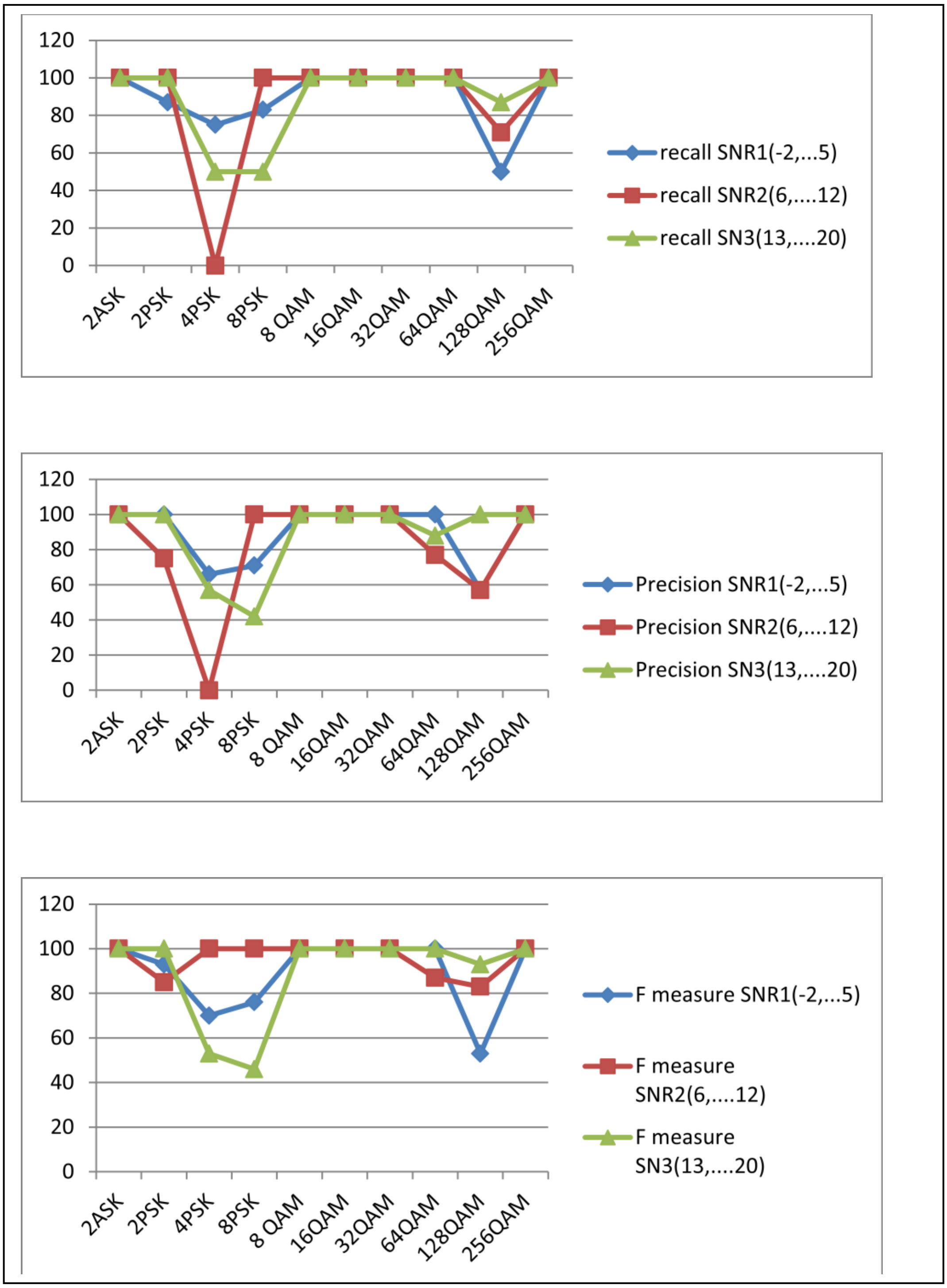


Figure (4.26) shows the(Precision ,recall, F measure)for the random forest algorithm in SNR(-2,-1,0……20) with Bat optimization

Chapter Five

Conclusions and Suggestions for Future Works

Chapter Five

Conclusions and Suggestions for Future Works

5.1Conclusions

Throughout design as well as implementation related to the presented study and control the results of the test. Several conclusions were reached, some of which are listed below:

- When used (CSO with RF) have 95 % success rate for SNR between (20-13)dB and the a Classification accuracy of (94%) for the SNR ranging from (6-12) dB but regarding for the low SNR values (5≥ SNR) .The classification accuracy (90%) dB .While algorithm (BA Swarm Optimization) for the modulated signals obtained a classification accuracy of around 90% for the SNR between (20-13) dB and the a classification accuracy of (92%) for the SNR classification from (6-12) dB but regarding for the low SNR values(5≥SNR) The classification accuracy (89%) using the optimization .
- When used (RF) classifier with (CSO) algorithm obtained a with higher classification accuracy compared with other optimization Algorithms.
- By experiments shows (RF) algorithm high performance in the proposed system.

5.2 Suggestions For Future Works

The thesis clearly highlights problems that may need attention in the future

- Work needs to separate more sets of digital and analog signals Check additional number of levels, M > 4 for ASK and method extension to other digital modulations MFSK .
- By experiments suggest obtain strong learning algorithms and use of other optimization technics to increase the accuracy of classification for modulated signals such as fish swarm algorithm (FSA) and cuckoo search (CS) algorithm.
- Apply the procedure to real world signals
- Investigations and create the key features for more solid against changing SNR can enhance the efficiency of signal's classification with extremely low SNR.
- To classify FSK signals, band limitations will hinder the performance of classification. Thus, more studies in detecting features which have not been majorly impacted via bandwidth might allow improving the performance.

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Appendix A: Feature Extraction Result:-

The simulation results for the extracted features (FE) which were performed in this thesis are divided into three :

1- FE of MPSK signal identification

2- FE M QAM signal identification

3- FE MPSK signal identification which is specified in section 2.5

The results were extracted from the generated signals using MATLAB programs, version 2015 A, for different values of SNRS. All the results are calculated to attain the clear separation between all the features of each modulated scheme with other schemes, and minimize the numbers of feature extraction. Tables (B.1) to (B.12)

Table (A.1) HOS OF 2ASK

HOM& HOC	FE at SNR =-2	FE at SNR=0	FE at SNR =5	FE at SNR=10
$E_{s,4,4}$	-0.031988958	2.183106369	0.116382939	0.365889772
$C_{s,8,8}$	-0.031988958	2.598562836	-0.307436166	4.325354351
$C_{s,4,4}$	0.005861769	2.1873561	0.092342243	3.432480405
$C_{s,2,1}$	0.032693902	2.636403793	1.128962765	-0.037207062
$C_{s,2,2}$	0.046403141	2.073732378	-0.048574974	3.041587369

Table (A .2) HOS OF 2PSK

HOM& HOC	FE at SNR =-2	FE at SNR=0	FE at SNR =5	FE at SNR=10
$E_{s,4,4}$	38.38466771	21.29597067	-3.131664001	28.65220695
$C_{s,8,8}$	-2.61483054	0.934113251	-4.798561748	12.35375157
$C_{s,4,4}$	15.57012426	2.378628201	7.112283076	19.00469631
$C_{s,2,1}$	-2.662495562	2.467831181	-2.780329138	9.382139726
$C_{s,2,2}$	-93.34720193	-19.65990955	67.13574404	44.28048485

Table (A.3) HOS OF 4PSK

HOM& HOC	FE at SNR =-2	FE at SNR=0	FE at SNR =5	FE at SNR=10
$E_{s,4,4}$	0.647074377	4.692960753	-53.15401485	8.768656206
$C_{s,8,8}$	-0.234050181	-0.427724449	-29.43205303	12.33857839
$C_{s,4,4}$	1.944322347	2.1060484	-35.01674221	8.863886429
$C_{s,2,1}$	0.409323576	-0.432435718	-21.48160727	12.80339251
$C_{s,2,2}$	2.774482515	-4.034150543	-101.6180026	7.628767873

Table (A.4) HOS OF 8PSK

HOM& HOC	FE at SNR =-2	FE at SNR=0	FE at SNR =5	FE at SNR=10
$E_{s,4,4}$	-1127.716328	18593.45801	1681.710823	-10.0176605
$C_{s,8,8}$	64.57816113	18051.27024	2031.085402	22.96566764
$C_{s,4,4}$	654.3192062	19494.5483	1894.131853	-36.99319442
$C_{s,2,1}$	-206474754.1	1117292933	9717076.771	560128.955
$C_{s,2,2}$	-42904542.42	1279748029	7809187.179	429060.3892

Table (A.5) HOS OF 8 QAM

HOM& HOC	FE at SNR =-2	FE at SNR=0	FE at SNR =5	FE at SNR=10
$E_{s,4,4}$	-2.217025275	-48.14391675	21.53955219	-0.198264948
$C_{s,8,8}$	63.45862011	-638.2680076	39.02495741	13.40271182
$C_{s,4,4}$	-1.238434573	-948.8673362	41.78213047	4.414147753
$C_{s,2,1}$	27.16764688	-1015.624505	42.96452111	5.45130926
$C_{s,2,2}$	-160.2091838	-1053.412703	43.00665157	-6.649022886

Table (A.6) HOS OF 16 QAM

HOM& HOC	FE at SNR =-2	FE at SNR=0	FE at SNR =5	FE at SNR=10
$E_{s,4,4}$	-48362.21036	-170640.577	17808.87959	-150.5357526
$C_{s,8,8}$	-5539.462852	-90572.09094	16922.03685	1817.749978
$C_{s,4,4}$	94062.70437	-171109.6278	17970.7801	-812.4222425
$C_{s,2,1}$	52730.54167	-117485.6921	17028.09297	114.2220132
$C_{s,2,2}$	16976.04677	-102772.8516	12323.06298	257.0318043

Table (A.7) HOS OF 32 QAM

HOM& HOC	FE at SNR =-2	FE at SNR=0	FE at SNR =5	FE at SNR=10
$E_{s,4,4}$	44.48448812	12.0376015	6.354719491	0.013068693
$C_{s,8,8}$	53.21983967	4.166116118	7.222949342	0.091985688
$C_{s,4,4}$	-2.871556848	-68.38476567	10.60587178	0.704644321
$C_{s,2,1}$	1.152834798	-65.17894653	10.2801809	5.378760844
$C_{s,2,2}$	11.29461018	-79.48206498	11.68526334	-4.452641346

Table (A.8) HOS OF 64 QAM

HOM& HOC	FE at SNR =-2	FE at SNR=0	FE at SNR =5	FE at SNR=10
$E_{s,4,4}$	-0.297594008	-0.158333099	1.62455251	0.695285768
$C_{s,8,8}$	2.42369597	0.039458997	1.813455566	0.69628382
$C_{s,4,4}$	-0.235281072	0.055171299	1.914566429	0.715841727
$C_{s,2,1}$	-0.071546597	-0.076452429	1.623290228	0.721407774
$C_{s,2,2}$	0.107361125	-0.068542887	1.525608391	0.780406041

Table (A.9) HOS OF 128 QAM

HOM& HOC	FE at SNR =-2	FE at SNR=0	FE at SNR =5	FE at SNR=10
$E_{s,4,4}$	10.66736465	-0.073785924	-32.54257646	4.098024742
$C_{s,8,8}$	4.137372449	-0.233927041	-11.02550911	5.487568774
$C_{s,4,4}$	3.522762171	0.366679531	-6.934186655	6.507248159
$C_{s,2,1}$	17.08373942	-0.683170482	-59.22355682	4.308090494
$C_{s,2,2}$	31.22806896	-2.610613699	-129.9004774	3.645308706

Table (A.10) HOS OF 256 QAM

HOM& HOC	FE at SNR =-2	FE at SNR=0	FE at SNR =5	FE at SNR=10
$E_{s,4,4}$	38.38466771	21.29597067	-3.131664001	28.65220695
$C_{s,8,8}$	-2.61483054	0.934113251	-4.798561748	12.35375157
$C_{s,4,4}$	15.57012426	2.378628201	7.112283076	19.00469631
$C_{s,2,1}$	-2.662495562	2.467831181	-2.780329138	9.382139726
$C_{s,2,2}$	-93.34720193	-19.65990955	67.13574404	44.28048485

الخلاصـــــة

لا تزال الاتصالات الرقمية في دور التطور والتوسع. يشكل تمييز الاشارة المضمنة الرقمية اليا (AMI) اهمية كبيرة في مجال تصنيف هذا النوع من الاشارات. تمتاز AMI باستخداماتها الواسعة والمتعددة في التطبيقات العسكرية والمدنية. تستخدم في التطبيقات العسكرية للمراقبة الاليكترونية وتمييز اشارات التشويش، اما في التطبيقات المدنية فتستخدم في الراديو المعرف برمجيا Software defined radio ، اجهزة الاستلام والارسال الذكية، الراديو الادراكي Cognitive radio، مراقبة الاشارات وغيرها في هذا العمل ، قدم نظامًا ذكيًا هجينًا للتعرف على أنواع الإشارات الرقمية ، بما في ذلك ثلاث وحدات رئيسية: وحدة استخراج المعالم ، وحدة المصنف ، وحدة التحسين لتصنيف التعديل ، تم بناء معرفات التشكيل الرقمي التلقائي (ADMI) لتصنيف العشرة انواع الأكثر شعبية من مخططات التشكيل الرقمي ، وهي (2ASK، 2PSK، 4PSK, 8PSK، 16QAM 8QAM، 32QAM، 64QAM، 128QAM، 256 QAM)، مع نسبة الإشارة إلى الضوضاء تتراوح من (-٢ إلى ٢٠) . باستخدام المميزات الاحصائية ذات المرتبة العالية High order statistics والتي تتمثل بالعزوم و Cumulants ذات المرتبة العالية. تم اختيار الاعداد القليلة الحاوية على صفات التمييز لتجنب التعقيدات في الاجهزة وتقليل وقت التدريب واستخدم خوارزميات التحسين(خوارزمية سرب الدجاج ،خوارزمية سرب الخفافيش)(Chicken Swarm Optimization ، Bat Swarm Optimization) واستخدمت خوارزمية); Random Forest (RF))لأول مرة في هذا العمل تظهر نتائج المحاكاة للنظام المقترح ، (AWGN) تتراوح بين (١٣-٢٠) يكون معدل النجاح٩٥% عند استخدام خوارزمية (RF,CSO) اما عند استخدام SNR منخفض(SNR ≥ ٥) تصل دقة التصنيف الى ٩٠% بينما تبلغ ٩٤% لنطاق الاشارات المعدلة لقيم SNR تتراوح بين (٦-١٢) اما عند استخدام خوارزمية (BAT,RF) يكون معدل النجاح٩٠% في مستوى من SNR منخفض (SNR ≥٥). بينما تصل دقة التصنيف الى ٩٢% لقيم SNR تتراوح بين (٦-١٢) لنطاق الاشارات المعدلة في حين تنخفض دقة التصنيف الى ما يقارب ٨٩% عند مستوى من SNR يتراوح بين ((١٣-٢٠)) تم اجراء مقارنة عادلة بين النظاميين المقترحين لتحسن الميزات المستخرجة(Chicken Swarm ,BAT Swarm) مع (Random Forest) افضل مصنف في نفس الظروف اظهرت المقارنة بوضوح ان (Random Forest, Chicken Swarm

Bat Swarm Optimization ,) لديها معدل نجاح اعلى من (Optimization
. (Random Forest

جمهورية العراق
وزارة التعليم العالي والبحث العلمي
جامعة ديالى
كليــة العلوم

استخلاص معالم الاشارات المضمنة باستخدام محسنات السرب ومصنف الغابات العشوائيه

رســالة

مقدمة الى قسم علوم الحاسوب / كلية العلوم / جامعة ديالى وهي جزء من متطلبات نيل درجة الماجستير في علوم الحاسوب

من قبل

بتول عبد الهادي سلطان

باشراف

أ.م.د طه محمد حسن

أ.م .د هادي عذاب حمد

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