Identification of Analogue Modulated Signal via Artificial Intelligence

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Abstract. Referring to a huge usage of the analogue modulated signal in both civilian and military applications, and impotency of identification it, the importance is came from many reasons also to how to get an algorithm to recognize an analogue modulated signal via AI for high performance of identification and simple to use. The identification is a middle-step between recognizing and signal demodulation. Selecting the most suitable variables are for input modulated signal and with (AI) assistant to identify some of analogue modulated signals such as (AM, DSB, SSB, and FM). Using simulation with Gaussian noise (0 dB to 10 dB) and AI. Classification system consisting from 3 parts: 1- Pre-processing stage which is talking about Feature keys extraction did. The element keys extraction did so as to get input include keys for the AAMR classifier, 2- Training stage which talked about the preparation, and Analog programmed adjustment acknowledgment (AAMR) classifier advancement,. and 3- Testing stage which talked on the classifier performance evaluated using 25% of all generated data as a test data. Using two algorithms (SCG and CONJGRAD), In the SCG, the possibility of each single key feature for each single modulation scheme with variance SNR results got. A couple of methods compared and the results show that the performance of the AI based recognition system is superior to the decision classifiers based on way with less SNR values. Both of the suggested identification systems are capable to discriminate (AM, DSB, SSB, and FM) at SNR>5 dB with a success rate 100%.

Keywords: classification, pattern identification, AI, variables.

1. Introduction
Acknowledgment of Signal is a serious significant piece of both nonmilitary personnel and military applications. Likewise, because of the high use of simple signals in ongoing innovation like remote interchanges, at whatever point as of late investigates are focus on order sorts of signs.
AMR is a system for acknowledgment of the clamor and set back signs which had an obscure tweak plot. Strategies of AMR are Artificial Intelligence (AI), Decision-theoretic, and Statistical example acknowledgment [1]. AMR of analog signals is the big important process of signal problem in telecommunication fields. It is the mid-level between signal interception with information recovery, which classify the type of modulation for the received signal automatically for additional process of demodulation and another tasks [2]. The modulation scheme is the quite big important properties used in signal classification and monitoring. Modulation recognition systems (MRS) should be correctly classifying the incoming signal's modulation scheme in the presence of noise [3].

2. Problem statement

There are numerous issues confronting media transmission builds in their works, they need an appropriate answer for get dependable, and exact outcomes dependent on simple apparatuses and procedures. The order of the tweaked signal is one of these issues, and how to perceive the sign dependent on neural systems to utilize these signs.

3. Literature survey

A. Ghani and Lamontagne in 1993, presented to use a (MLP) with back-propagation for AMR. They looked for a communication signals with 4 different modulations: AM, FM, SSB-USB, SSB-LSB, and NON-COHERENT FM [2]. Where the signs reenacted with SNR created arbitrarily somewhere in the range of 5 and 25 dB, and just ghostly highlights utilized as information sources highlights to gauge the phantom force thickness of the sign. They got the best outcomes when they utilized the Welch Periodogram to deliver an info vector of size 70. They tended to another issue was that no fixed guidelines exist on the most proficient method to pick the size and topology for ideal execution of MLP. They utilize the pruning systems called (OBD) strategy, this procedure prepares a completely associated system and afterward erases a fundamental number of loads without intensifying and improve the presentation potentially. The outcome is appeared by diminishing the weight over a half utilizing (OBD) method and the exhibition was superior to a completely associated arrange. In addition, when contrasted with the outcomes from the MLP approach with a traditional measurable classifier called K-NN classifier, the MLP was longer to prepare and quicker when running.

B. Aluisio, Lucas, and Luiz in SBrT 2012, introduced a strategy to the programmed acknowledgment through a proportion of closeness that got from Information Theoretic Learning (ITL), which called Correntropy coefficient [3]. Correntropy is a nonlinear similitude estimated between two factors despise a significant number of unimaginative techniques; the proposed way doesn't require pre-handling of a sign. Also, the proposed AMR system utilizes a simple type of assessing the correntropy coefficients, determined over formats containing the basic highlights of simple adjusted signs, in the arrangement task. Numerical measures introduced show that the recommended AMR structure, in view of estimations of similitude by means of correntropy coefficient, that the utilization of an extra period of pre-preparing for separating highlight of the got signal isn't fundamental. Investigates on AMR can amass in couple strategies, either by insights from the receipt sign to characterize a (ML) work or by removing highlights of the sign, concerning playing out the order utilizing distinctive Pattern Recognition procedures. The AMR process concerned 2 stages namely: A) Pre-processing level of signal to extracting feature, and B) Suitable choice of the modulation form based on the selected signal features by the classifier system.
C. Ketterer, Jondral, and Costa proposed in 1999, a time-frequency approach, this scheme is a two-step process. First, autoregressive modeling used to estimate the carrier frequency. Next, the time-frequency information. It applied to estimate (phase, frequency, and amplitude), allowing the separation of FM and PM signals respectively. Simulations show modulation classification performance over 97% for SNR levels larger than 10 dB [4].

4. Subject of work
The subject of research is attempting to remove all the potential highlights, for example, ideas, factors, for example, plentifulness, stage, recurrence, image rate, SNR and all attributes and parameters of the simple sign transmitted before it arrives at the beneficiary end. What's more, investigated the qualities intelligently utilizing AI as indicated by past data and parameters esteem figured out how to the Neural Network (NN) at that point coordinate the data and parameters esteem with recently learned highlights, think about the similitudes and contrasts among it and study the present case to get an official choice of the transmitted wave and ordering it. A) AI using Scaled conjugate gradients (SCG) technique, and B) AI using Conjugate gradients (CONJGRAD) technique.

5. AI classifier for analogously modulated signals (multi-layer perceptron MLP)
The general capacity of AI is to deliver the example of the yield while given specific info design; the ideas taken from the mind's capacity to recall of the premise of certain information designs, learning this mapping finish with comparable technique thoughtfully as the cerebrum that is summing up from various models. Simulated intelligence is comprising of various basic computational gadgets that enjoyed the neurons in the human cerebrum, associated with the weighted association, for example, dendrites and axons, the most well-known sorts of AI utilized in AMR is multi-layered Perceptron MLP or Auto-affiliation Neural Network (AAI) [5].

![Fig 1: The Structure of the Neural Network in AI toolbox – MATLAB](Rada A.El-Khoribi, 2014)

Perceptron models a neuron by getting weighted information sources and restoring a win or bust yield contingent upon whether the weighted whole of data sources is less or bigger than a flexible edge, Perceptron comprise of the loads, the summation processor, and the balanced edge [6].

6. Classification approach of patterns
The PC that dependent on arrangement of examples is significantly found with enormous applications use and regions like's clinical applications, distinguishing proof biometrically, methods of grouping of discourse, deficiency discovery, and optical character acknowledgment, as I'll spin around the acknowledgment of sign. Despite the fact that that immense number of kinds of information, as appeared in figure 3. It's present initial a smidgen of plans of pre-preparing performed. That might be activities of picture or sign handling, for example, sifting, division, and change, to get a portrayal of the uniform of the information. From that onward, dimensionality-deducting procedure of the information by extricating as conceivable as most modest number of removed highlights which stress a traits of classes, and differentiations among classes. At that point, the highlights fill in as contributions to the classifier, which execute the last recognizable proof assignment.
The classifier to execute the recognizable proof, it ought to get the data on what class speak to by what information. Additionally figures out how to sum up, with the end goal that new and unclassified models characterized as needs be. A) Signal Pre-processing, and 2) Feature Extraction.

7. Classification methods.
   A classifier should use having got a feature vector to output a class label or, instead of that, a group of prospects or levels of confidence that sign to the results of prediction. The classification approaches of analogue modulated signals divided into 2 major groups [7]: A) Maximum Likelihood method, and B) Pattern recognition method.

8. Strategy of classification.
   Right now the work, I will make a neural system contain from some concealed layers to learn it with certain parameters to remove appropriate highlights helping me to group our objective regulation sign. To make that subject of study have to recognize and allude to the primary techniques of sign adjustment arrangement. As the subject of research alluded to that beforehand, signal recognizable proof dependent on (AI) regular with three stages [8].
   1- Features extraction of the modulated signal,
   2- Learn the (NN) with the features extraction, and
   3- Testing the (NN) and getting results.

   Thus, splitting the randomized data for data training, a validation data, and data testing which sets via 50%, 25%, and 25% respectively.

9. Key feature.
   The highlights extraction intends to remove the estimations of parameters of the balanced sign in a particular time, so there are numerous valuable parameters helping us to characterize the gathering of tweaked flags and perceive our objective plan. And the features are: (γmax): Maximum of spectral power density of the normalized-center instantaneous amplitude, (σdp): Standard deviation of direct value of center non-linear component of instantaneous phase, (P): Spectrum symmetry value, (v20): Combined order moments, based on the Joint Power Estimation and Modulation classification algorithm, (X): Mean of amplitude, (β): Power of signal, (σaa): Standard deviation of absolute value of normalized-center instantaneous amplitude, and (σap): Standard deviation of absolute value of non-linear component of instantaneous phase.
10. Analogue classification.

Simple programmed adjustment acknowledgment (AAMR). Utilizing MATLAB code, the message from the outset adjusted on the baseband. The five regulated plans utilized are (AM, DSB, SSB, and FM) and the four phases include in building up the AAMR talked about in the accompanying:

A. **Pre-processing stage.** Feature keys extraction did. The element keys extraction did so as to get input include keys for the AAMR classifier. Highlight keys register the most modest number of highlights from the crude tweaked signals extricated. The keys of highlight picking is an exchange off among diminishing the quantity of highlights to limit the AI input size, as long as the multifaceted nature of computational and containing all the fundamental highlights for the solid acknowledgment for the simple sign adjustment plans. With respect to the simple classifier. The seven element keys are extricated from a(t), and φ(t) of the reenacted signal [9].

![Graphical Illustration of γmax in analog signal](image1.png)

**Fig 4:** Graphical Illustration of γmax in analog signal

That figure show the values of γmax according to analog modulation schemes and its effectiveness of classifying analog signals and especially discriminating between AM and FM with DSB and SSB regarding to its amplitude.

![Graphical Illustration of σdp in analog signal](image2.png)

**Fig 5:** Graphical Illustration of σdp in analog signal

The above figure show the values of σdp according to analog modulation schemes and its effectiveness of classifying analog signals and especially discriminating between AM with FM, DSB and SSB regarding to its phase.
This figure shows the values of $P$ according to analog modulation schemes and its effectiveness of classifying analog signals and especially discriminating between SSB with FM, AM and DSB regarding to highest power of signal.

**Network Training stage.** It is the second phase of AMR improvement, which talked about the preparation, and Analog programmed adjustment acknowledgment (AAMR) classifier advancement. The design of the created AAMR having the measurable keys for extract highlight utilizing MLP organize and talked about as the info informational indexes. The MLP made out of one information layer, fifteen concealed layers of computational neurons and one yield layer of computational hubs [10]. Three neurons in input layer are completely associated relating to the quantity of info highlights, and seven neurons in concealed layer and furthermore four neurons in yield layer comparing to the quantity of focuses as appeared in as in Fig 7.
Fig 8: AAMR architecture of analog signal

C. Network Testing stage. After development and training stages of classifier or network, the classifier performance evaluated by use 25% of all generated data as a test data [11]. It carried out of different SNR values (0, 5, and 10) dB.

Table 1: Specifications for the Developed AAMR

| Item | Parameters | Value       |
|------|------------|-------------|
| 1-   | Type of neural network architecture | Feed-forward |
| 2-   | Number of neuron in input layer    | 3           |
| 3-   | Number of neuron in hidden layer   | 7           |
| 4-   | Number of neuron in output layer   | 4           |
| 5-   | Coefficient of weight-decay         | 0.01        |
| 6-   | Activation function in hidden layer | tanh        |
| 7-   | Activation function in output layer | Logistic    |
| 8-   | Maximum number of epochs            | 150         |
| 9-   | Learning algorithm                  | SCG, and CONJGRAD |

Table 2: Developed AAMR Success Recognition Rate

| Modulation scheme | Percentage of success recognition rate at different SNR |
|-------------------|--------------------------------------------------------|
|                   | 0 dB | 5 dB | 10 dB |
| AM                | 99.9 | 99.95| 99.99 |
| DSB               | 99.94| 99.97| 99.99 |
| SSB               | 99.98| 99.99| 100   |
| FM                | 99.97| 99.99| 99.99 |
| Overall success rate (%) | 99.95 | 99.98 | 99.99 |
| Operational time taken (millisecond) | 1.11 | 1.12 | 1.11 |

Average operational time = 1.115 millisecond

Table 3: Input data value for AAMR

|       | AM  | DSB | SSB | FM  | $\gamma_{\max}$ | $\sigma_{dp}$ | $P$ | $v_{20}$ | $\beta$ | $\sigma_{ip}$ | $\sigma_{oo}$ |
|-------|-----|-----|-----|-----|------------------|---------------|----|----------|--------|--------------|--------------|
| AM    | 99.97| 0.00| 0.00| 0.00| 59.75           | 0.16          | 0.00| 0.00     | 0.42   | 0.16         | 0.00         |
| DSB   | 0.00 | 99.95| 0.00| 0.00| 46.20           | 1.45          | 0.00| 0.00     | 0.44   | 0.00         | 0.00         |
| SSB   | 0.00 | 0.00 | 99.97| 0.00| 5.00            | 0.00          | 1.00| 0.00     | 0.17   | 0.00         | 0.00         |
| FM    | 0.00 | 0.00 | 0.00 | 99.98| 6.53            | -0.08         | 0.00| 0.32     | 4.01   | 0.00         | 0.00         |
11. Summery.

The importance of this work is focusing on AMR for analogue modulation schemes by AAMR. This classifier are capable to classify any modulated scheme without pre-knowledge about the modulated schemes. The results obtained using training algorithms SCG and CONJGRAD display SCG s quicker than CONJGRAD training algorithms.

12. Conclusion.

Our commitment of this work is on the improvement of AAMR dependent on AIs, which can naturally perceive all types of balance plans. The section is principally center in meeting one of the destinations of this exploration work. The calculation of grouping is a significant part of regulation acknowledgment framework. There are two techniques develop for the order dependent on AIs: the first dependent on SCG and the second dependent on the CONJGRAD preparing calculations. In the SCG, the chance of each single key element for each single tweak conspire with fluctuation SNR results got. A few strategies analyzed and the outcomes show that the presentation of the AIs based acknowledgment framework is better than the choice classifiers dependent on route with less SNR values. Additionally, subject of study have likewise contrasted the exhibition of this calculation and various classifiers in the writing.

| Table 4: Results among different classification approaches with AI |
|---------------------------------------------------------------|
| Classification Approach | 15 dB | 10 dB | 5 dB |
|-------------------------|-------|-------|------|
| DT                      | 98.12 % | 98.5 % | 52.25 % |
| Fully connected         | 78%   | 70%  | 63% |
| Hierarchical            | 90%   | 78%  | 63% |
| Maximum likelihood      | 99%   | 97%  | 96% |
| Time frequency          | 97%   | 90%  | 87% |
| AI                      | 100 % | 100 % | 100 % |

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