A Robust Wireless Signal Classification using Deep Learning Technique in Multimedia IoT

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***Abstract*—In this paper, a robust system to classify wireless signals based on their modulation schemes is proposed. This system aims to support data communication between wireless transmitter and receiver properly. Since the utilization of cognitive radio (CR) and software-defined radio (SDR) become more massive, this requires the transmitter and receiver to reconfigure their modulation scheme based on available radio resource in real-time. A new combination of convolutional neural network (CNN) and long short-term memory (LSTM) architecture to cope up with this issue is presented which consists of few number of layers, and the addition of Gaussian noise layer. The simulation results demonstrate that the proposed system is able to achieve performance improvement in terms of accuracy rate compared to the previous algorithms.**

***Index Terms*—Convolution neural network, dropout, gaussian noise, long short-term memory, modulation classification.**

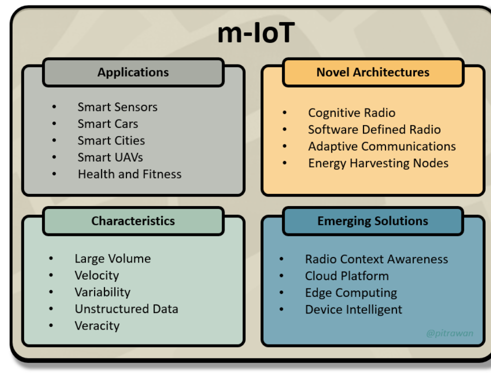

Fig. 1. Taxonomy of m-IoT.

I. Introduction

Due to the emergence of next-generation networks such as the 5G (fifth-generation) communication system, latency is becoming the most crucial issue in the telecommunication area. In the industrial area, communication between devices shall also be conducted in real-time and accurate, since the users rely on the information gathered from devices.

In the current era, to support the presence of smart industry, the internet of things (IoT) is expected to handle massive smart devices (e.g. smart sensors, smartphones, smart cars, smart UAVs) with each of them has its different characteristics. This phenomenon leads to the existence of the multimedia IoT (m-IoT) as it is presented in [1] which explained that sensor devices are no longer as scalar data gathered, but also able to be augmented with multimedia contents. The taxonomy of m-IoT is presented in Fig. 1

Since the multimedia contents generated by m-IoT are unstructured and varies, the ability of the transceivers to process the information becomes crucial. Based on the [2], cognitive radio (CR) and software defined radio (SDR) are two transceiver choices for m-IoT wireless modems. The SDR supports multi-band communications, while CR enables to use of the available bands to find highly effective spectrum communication. Based on the mentioned issues, the development of wireless signal classification becomes mandatory, since the wireless transceivers have no prior information about the received signals in m-IoT.

Instead of improving the accuracy of the classifier, the computing time of the system in solving the network issue shall also be improved. In [3], the authors proposed a real-time routing scheme for large scale networks. It shows that the computing time is one of mandatory requirement in the current trends. On the other hand, the applications of deep learning (DL) technique are proven in handling big task, such as in [4] that DL helps in classifying modulation.

Based on the mentioned studies above, the need in classifying the m-IoT signals accurately is mandatory. Furthermore, the m-IoT approach has not been exploited yet. In this paper, we propose a novel DL-based technique to classify the modulation type of the signal. The aim of this paper is to achieve an accurate classifier to cope up with the recent communication trends.

II. Deep Learning-based Signal Classification

In the recent trends, there has been discussed several studies in improving signal classification problem. Deep learning technique has been widely used and showed a good performance in classifying modulation type of the signal. A study in [5] shows a good performance of CNN algorithm (CNN A) in improving the accuracy of signal classification. The author from this paper compared several deep learning algorithms. Mainly, this algorithm occupied with convolution layers, dropout layer, flatten, and dense layer.

Another deep learning algorithm that widely used in signal classification is MLP algorithm. In [6], a class-modular MLP algorithm was proposed in classifying passive sonar signal. The signal was generated by an omnidirectional hydrophone in a shallow water environment. Those above studies showed

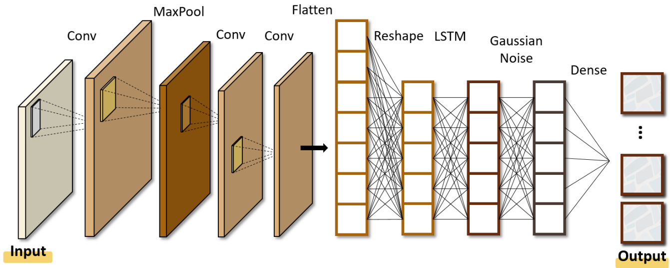

Fig. 2. The architecture of the proposed algorithm.

a good performance of CNN and MLP algorithms in solving classification problems, however, those studies above only consider the accuracy rate in the system, the computing time required in classifying the signal has not been elaborated yet, and the accuracy rate has not been compared further.

III. Proposed System Design

In this section, we exploit the proposed system in detail. We simulated our system using Google Colaboratory with GPU specification: 1x Tesla K80, 2496 CUDA cores, and 12 GB GDDR5 VRAM. We also simulated the other algorithms in the same environment and the same dataset to achieve an objective comparison.

A. Proposed Algorithm

In this paper, we propose a combination of CNN and LSTM algorithms to classify the modulation type of the signal. The detailed architecture of our proposed algorithm illustrates in Fig. 1. The architecture of our proposed algorithm consists of a few number of layers to process the input in short time and a big number of filters that will learn the detail of signal features optimally. All the convolutional layers used rectified linear unit (ReLU) activation function, which transforms the output into 0 if the input value is less than 0, and transforms to X if the input value more than 0. On the last dense layer, we used a softmax activation function to interpret the output optimally as defined in the below equation:

$$S\left(y_i\right) = \frac{e^{y_i}}{\sum_j^{j=i} e^{y_i}}. \tag{1}$$

In addition, the adam optimizer is used as an optimization function and cross-entropy loss as the loss function.

IV. Simulation Result

The simulation results of this paper are discussed in this section. Several simulations were conducted and the comparison with the previous works is also presented. Fig. 4 illustrates the accuracy rate of all algorithms in different signal to noise ratio (SNR). It can be seen from the graph that by utilizing CNN-LSTM, the system achieved the highest accuracy rate, which is 86.38% compared to the other algorithms. While CNN A achieved 75.98%, and MLP achieved 70.96% accuracy rate in classifying modulation of the signal. Compared to the other algorithms, our proposed algorithm still outperforms the others.

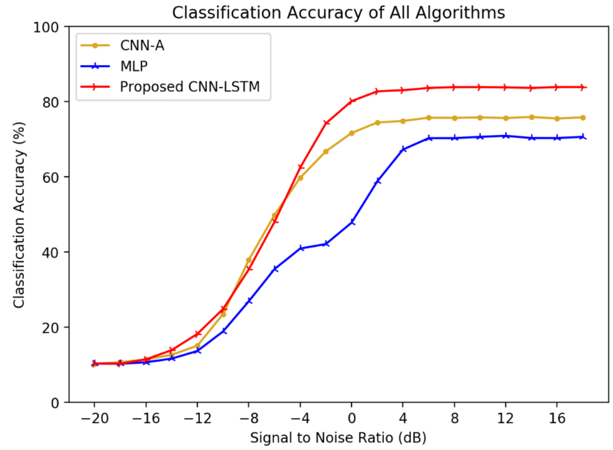

Fig. 3. Classification accuracy of all algorithms.

V. Conclusion

Modulation is a mandatory requirement in the wireless communication system in order to transmit the information to another receiver. In the recent trends such as in m-IoT, the modulation type of the system can change due to several reasons, so that high accurate and low computing time of classifier is needed to cope up with this demands. In this paper, we have proposed a novel deep learning algorithm to classify modulation type of the signal. The combination of CNN-LSTM algorithm successfully classify the signal accurately. Simulation results show that the proposed algorithm is effective, as proven by the achieved accuracy rate and computing time during simulations. As in future works, the application in the m-IoT environment will be elaborated more, as well as the architecture of the algorithm can be enhanced in order to improve the accuracy rate and the computing time.

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