Deep Learning Techniques to Improve Radio Resource Management in Vehicular Communication Network

Vartika Agarwal*, Sachin Sharma

Graphic Era Deemed to be University, Dehradun, India

*vartikaagarwal2015@gmail.com

Abstract. This paper investigates the deep learning techniques to improve Radio Resource Management (RRM) in Vehicular Communication Network (VCN). In this paper the deep learning algorithms are highlighted which are used for RRM. Deep learning technique in RRM is basically used to trained the model using various algorithms of resource management including network data. Various machine learning tools will be helpful to get best solutions for resource allocation in a large cellular network.

Keywords: Convolutional Neural Network, Weight, Bias, Radio Resource Management, Vehicular Communication Network.

1 Introduction

RRM is basically best known for its ability of controlling power consumption. RRM strategies can be implemented in different kinds of network. RRM use limited resources of radio frequency spectrum and radio network infrastructure. Function of RRM is to analyze traffic load, interference, Noise and coverage. RRM is able to perform various scheduling task such as radio resource monitoring, transmit power control etc. RRM can be of two types:

- **Static RRM:** It includes frequency allocation band plans, antenna heights, channel frequency plan, Base station antenna etc. Frequency allocation is the allocation of an electromagnetic spectrum into radio frequency bands. We can use static RRM scheme in many traditional wireless systems such as Antenna heights, channel frequency plan etc. In static RRM fixed portion of frequency channel is allotted to user who can be access points, Base station, access point or terminal equipment. We can also call it fixed channel allocation.
- **Dynamic RRM:** It is needed to transmit power output to achieve good performance within the system It includes power control algorithm, precoding algorithm, Link adaptation algorithm, Dynamic channel allocation etc. It is used to boost the capacity of GSM network without any other changes needed in the network. Dynamic RRM is used for improving the reliability of a message signal by using two or more communication channel with different features. Radio resource management is used to maximize the spectral efficiency of system.

2 Literature Review

Ultimate goal of RRM is to optimum utilization of network resources. Deep learning is basically used in radio resource management for user allocation. If there are many vehicles in traffic area, we can allocate resources to vehicle with the help of deep learning. Deep learning is helpful because there is no need to use complicated mathematical

models. Here we get information directly from data set. Wanlu sun investigate a SOLEN algorithm for solving the radio resource management problem [1]. Anver Hisham investigate the clustering based algorithm to maximize the throughput. They propose this algorithm to ensure scalability [2]. K. I. Ahmed presented a supervised deep learning model. Objective of using this model is to increase the throughput of a total network [3]. Yevhen kuznietsov introduce a depth map prediction approach for supervised learning. [4]. Yann Lecun introduce backpropagation algorithm for object detection as well as speech recognition [5]. Kandaraj Piamrat present a detailed investigation of challenges which occur for D2D based V2V communication [6]. Yik hung tam propose optimal cell size and channel assignment scheme to solve packet delay issue [7]. Shao-Yu Lien investigate about cognitive radio technology for radio resource management. This scheme is able to solve reliability as well as complexity issues which occurred in cognitive radio resource management [8]. Navid Naderializadeh proposed radio resource management scheme using deep reinforcement learning. This scheme offer better throughput, fair resource allocation as compared to other schemes [9]. In 2020, vartika et al. reviewed about Lifi, RFID and many other technologies for communication between vehicles [10].Haijun Zhang proposed a framework to deal with the power allocation, user association, sub channel in a complex scenario [11]. Yifei shen introduced the graph neural network concept for the solution of radio resource management problems. This method is highly scalable [12]. Hossain introduced a deep learning model to predict future traffic congestion [13]. In 2020, vartika et al. reviewed the internet of things in transport management and V2V communication system [14] Navid naderializaden propose a deep learning method for managing the radio resources and maximize the throughput [15]. Jia Guo propose a scheme of multi timescale radio resource management for non-real time services [16]. Qunsong zeng propose the federated edge learning framework for solving radio resource management problems. [17].In 2021, Vartika Agarwal highlighted scheduling techniques for vehicular communication networks. These techniques are basically used to preplan the whole process of resource allocation. Such techniques establish relationships among different activities [18]. Linling kung introduce various resource management schemes such as spectrum resource management, beam resource management and cross layer power management [19].

3 Methods of RRM

Various methods of RRM are used for scheduling of radio resource.

- Admission control: This method is used for traffic handling.
- Congestion control: It manages the system when the load exceeds threshold.
- Traffic scheduling: It handles packet data users to initiate the packet transmissions and guarantee QOS through bit rate, BER and delay adjustments.
- Power control: It maintain radio link quality.

4 Working of RRM

RRM is basically used for transmitting and receiving information between vehicles. RRM is used to control various parameters such as transmit power, user allocation, data rates as well as error coding scheme. RRM use limited resources of radio frequency spectrum.

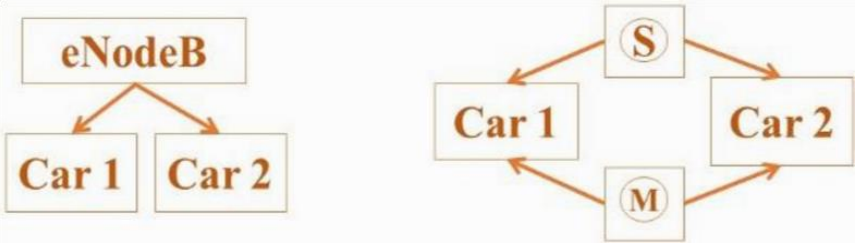

Fig. 1 Intelligent Transportation System.

In this Fig.1, concept of intelligent transportation has been proposed. Here we see that eNodeB is used as a resource (which is used for transmitting and receiving information) in vehicle to network (V2N). On the other side we see sensor and men is used as a resource in vehicle to everything and vehicle to pedestrian network.

5 Overview of deep learning

Deep learning process large number of unstructured data. Deep learning models require little guidance and are able to solve complex problem. These models are used for machine translation, robot control, time series prediction, speech recognition, Self driving cars, Voice controlled assistance, etc. These models use neural network so it provides more accurate decision in comparison of other machine learning algorithm. It is a computer software that is used for identify the neurons network. Here we use deep neural network so it is called deep learning. In deep learning, there are 3 layers as shown in Fig. 2:

a. Input layer
b. Output Layer
c. Hidden layer lies between input layer and an output layer

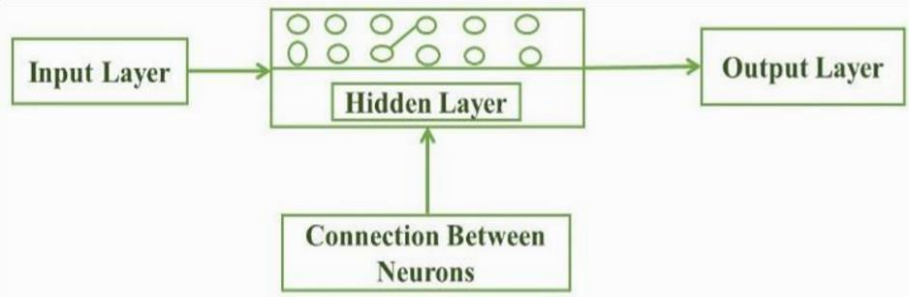

Fig. 2. Deep neural network.

Input layer takes initial data from neurons, hidden layer process it and composed from different neurons. In hidden layer data processing is done through weight, bias and an activation function. In RRM, deep learning is basically used for extract the resources. Deep learning framework minimize the power consumption by optimizing bandwidth and transmit power allocation. Deep learning is used to solve user connection, wireless access selection, frequency allocation, power control and intelligent beamforming problem.

6 Activation Functions

An activation function is most important feature of deep learning. Such function decides activation or deactivation of neurons. Activation functions introduce non- linear properties of network and define output of node for a given set of input. It calculates weighted sum of input, adds a bias and then decides it should be fired or not. Table.1 describe the components of an activation functions. These functions are basically used for deciding the activation and deactivation timing of neurons.

Table 1. Components of an activation function.

Activation Function	Details
Weight	Weight is basically used to control signal between two neurons. It increase the steepness of an activation function.
Bias	Bias is just the opposite of weight function. It decide how slow the activation function will trigger.

In Fig. 3, inputs are I_1 and I2, and weights are denoted as W_1 and W_2.
Result is - $\boldsymbol{z = f(x) = \Sigma v_i u_i}$
Where i = no of input
The weight is used for the effectiveness of an input. Processing done by a neuron is denoted as: Result = sum (weights*inputs) + bias
Result = $weight_1 * input_1 + weight_2 * input_2$ + Bias

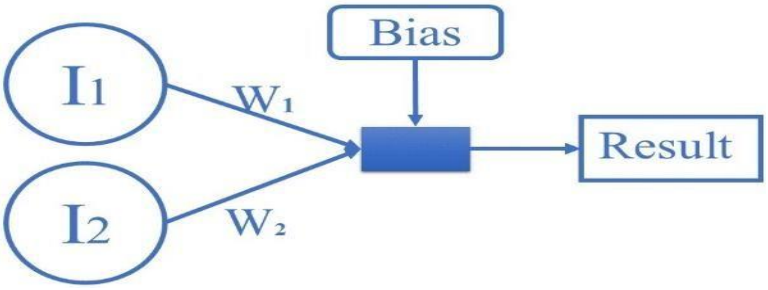

Fig. 3. Activation function.

7 Need of Bias

In Fig. 4,

Y= mx + c.

Where, weight is denoted through m, bias is denoted through c and without bias, graph will be formed like this.

Fig. 4. Concept of BIAS.

If bias is absent, model will be passing through from origin only. Bias makes model more flexible. Otherwise model will pass through from anywhere, not only from origin. For example, let us take an activation function act () which get triggered on any input which is greater than 0. (Table 2)

Table 2. Weight and Input.

Input (I)		Weight (W)	
I_1	2	W_1	2
I_2	1	W_2	2

$$\text{Result (R)} = I_1 * W_1 + I_2 * W_2$$

$$= 2*2 + 2*1 = 6$$

If we can add bias = - 6 in result, then output will be 0. It means activation function will not trigger

8 Convolutional Neural Network

Convolutional neural network is basically used for recognition of an image, image classification, object detection as well as face recognition. CNN takes image as an input and process it. CNN is used to perform tasks such as classification of image, image recognition, object detection etc. It has multiple hidden layer which is used for extracting information from an image [Fig. 5].

CNN is composed of 4 different layers:

a. Convolutional layer

b. Rectified Linear Unit (RELU) layer

c. Pooling layer

d. Fully connected layer

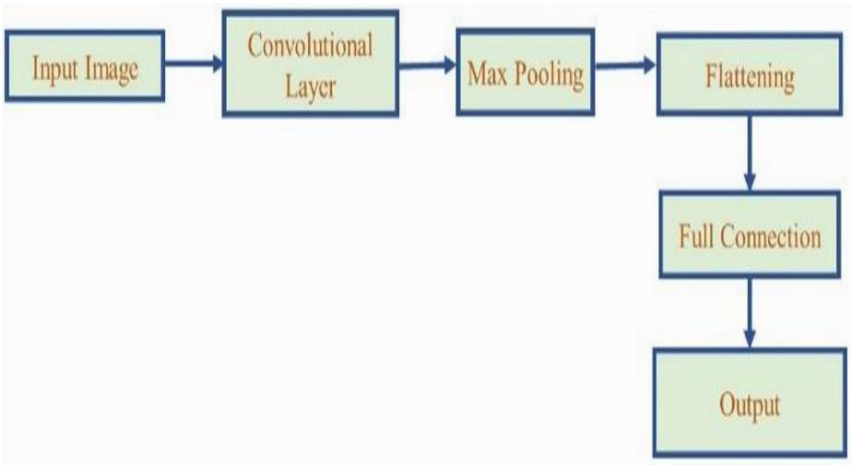

Fig. 5. Convolutional neural network.

a. Convolutional Layer:— In deep learning, convolutional layer is used for extracting image features. It has several filters which are used for convolution operation.

b. ReLU Layer:— ReLU means rectified linear unit. After Extracting features next step is ReLU layer. It is basically used to perform an element-wise operation and sets all the negative pixels to 0. Whereas convolutional layer set all pixels in the form of 0 or 1.

c. Pooling Layer:— Pooling layer is used to perform operation on fixed part of an image such as edges, corners, body, eyes, car, feathers etc. [Fig. 6]

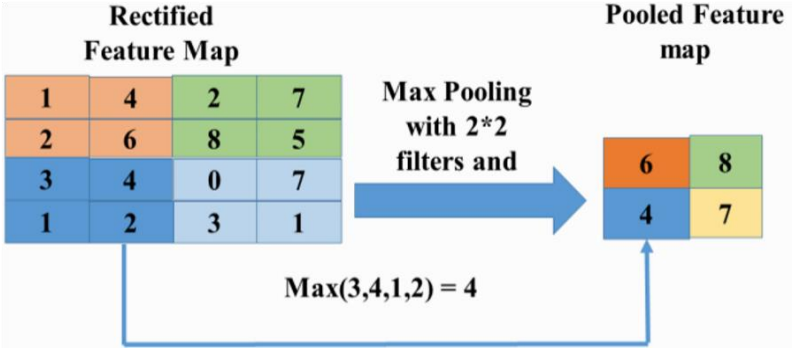

Fig. 6. Pooling layer.

d. Fully connected Layer - After this, convolutional neural network structure looks like as per Fig. 7.

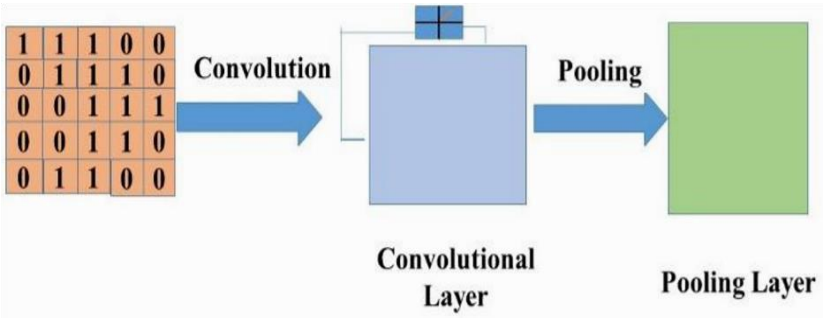

Fig. 7. Structure of convolutional neural network.

- Flattening – It is used to convert result into vector form [Fig. 8].

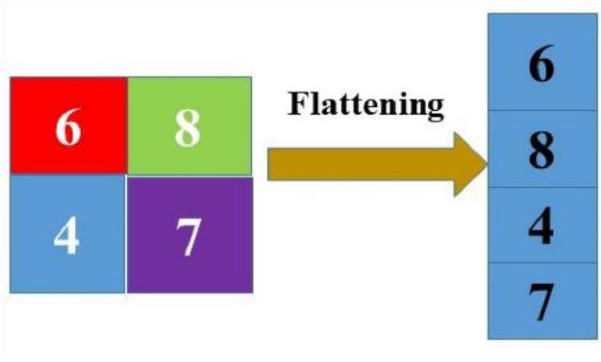

Fig. 8. Flattening.

After this, convolutional neural network looks like as mentioned in Fig. 9.

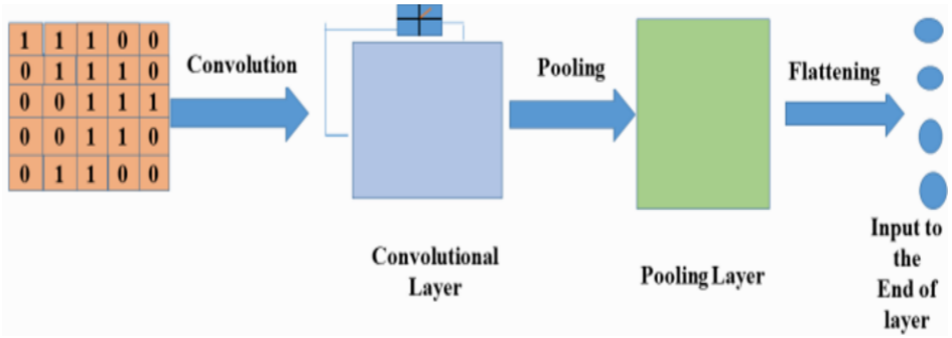

Fig. 9. Convolutional neural network.

9 Machine Learning Algorithms Used for RRM

- **Separate resource block and power allocation algorithm (SOLEN):** It is basically used for solving the radio resource management problem. In SOLEN algorithm we can divide the problem into multiple stage and solve it.
- **Requirement of VUE (Vehicular User Equipment**)

  Resources assigned to vehicle for a limited time span. Let us assume that there are a finite number of resources, outage probability will be calculated as follows.

$$Qk'out\ Pr\{fo \sum i = 1\ plog2(1+ri)<Nk\} \quad (1)$$

Where Q is the number of complex symbols per resource. Requirement of CUE (Cellular user Equipment): With regards to fairness, assume proportional bandwidth among C-UEs

that means resources allocated to the CUE during the scheduling time for all m'∑M'. and ∑m'=F. Firstly, drive RB allocation scheme then present power allocation algorithm and summarize the SOLEN method

- RB allocation: It is a method of determining where resources should be allocated. for resource allocation constraints for VUE and CUE are replaced with another constraint. Each VUE and CUE will have maximum power constraints.
- Power allocation: In power allocation, we define sub VUE which is sharing the same resources with m^{th} sub C-UE.
- SOLEN algorithm: We can use following algorithm for maximize the cellular sum rate.

Separate Resource Block and Power allocation algorithm

- Initially use max power constraint for each VUE and CUE.
- Use Hungarian method to solve problem and obtain efficient solution.
- Take input and calculate decision variables.
- Apply power allocation algorithm.
- Calculate optimal solution.

- **Clustering method**: In clustering method we can partition the problem into small unit so that we can reduce its complexity. It is used for multi-hop communication and optimize the effect of co-channel interference as well as adjacent channel interference.

Fig. 10. Vehicular user equipment devices.

In above Fig.10, we denote transmitting VUE with R, receiving VUE with S and interfering VUE with T respectively (I,j) is denoted as a link between VUE R to VUE S. Ri ⊂ N= receivers to VUE R. VUE R want to send the messages to the VUE in Ri. Clearly, |Ri| = 1 and Ri = N \ {i} implies that VUE R use unicast as well as broadcast communication, respectively. Ri ⊂ N = Set of intended receivers to VUE_i .
There is a link from VUE R to VUE S. During the scheduling interval, M message are generated in the network. We can divide available resource block into timeslots and it is denoted as ($f_{,t()}$).

10 Comparison Between Different Models

Comparison between different models are as follows in Table 3.

Table 3. Comparison between models.

Convolutional Neural Network	SOLEN Algorithm	Recurrent Neural Network	Clustering Method	Long Short Term Memory Network
Class of Deep neural network	Machine learning algorithm for radio resource management	Artificial Neural Network algorithm	Power allocation algorithm	Artificial Recurrent neural network architecture
Used for image detection	Used for D2D based V2V communication	Used to deal with time series data	Used for maximizing the sum rate	Used for dealing with Vanishing Gradient Problem.
Feature extraction	Resource allocation	Single output prediction	Multihop communication	Single output prediction
It takes image as input and perform various task such as image recognition, object detection as well as image classification.	Takes input and calculate decision variable	Connect two classes of network through directed graph	Divide the problem into small units and optimize the effect of co-channel Interference.	Capable of learning long term dependencies by remembering information for long periods.

11 Conclusion

In this paper, SOLEN algorithm, clustering method, Recurrent neural network, Long short term memory network and supervised deep learning approaches are discussed. All these methods are basically used for maximizing the sum rate. SOLEN algorithm is used to enable D2D based V2Vcommunication. This algorithm is able to fulfill latency and reliability requirement. Clustering method is able to optimize problem and divide it into a set of smaller problem. This method reduces complexity. We describe convolutional layer approach too which is basically used for feature extraction.

References

[1] Sun, W., Ström, E. G., Brännström, F., Sou, K. C., & Sui, Y. (2015). Radio resource management for D2D-based V2V communication. *IEEE Transactions on Vehicular Technology*, *65*(8), 6636-6650.

[2] Hisham, A., Ström, E. G., & Brännström, F. (2019). Radio Resource Management for V2V Multihop Communication Considering Adjacent Channel Interference. *arXiv preprint arXiv:1908.06866*

[3] Ahmed, K. I., Tabassum, H., & Hossain, E. (2019). Deep learning for radio resource allocation in multi-cell networks. *IEEE Network*, *33*(6), 188-195.

[4] Kuznietsov, Y., Stuckler, J., & Leibe, B. (2017). Semi-supervised deep learning for monocular depth map prediction. In *Proceedings of the IEEE conference on* CVPR (pp. 6647-6655)

[5] Yan, L., Yoshua, B., & Geoffrey, H. (2015). Deep learning. *nature*, *521*(7553), 436-444.

[6] Piamrat, K., Ksentini, A., Bonnin, J. M., & Viho, C. (2011). Radio resource management in emerging heterogeneous wireless networks. *Computer Communications*, *34*(9), 1066-1076.

[7] Tam, Y. H., Hassanein, H., & Akl, S. (2009). Resource Management in Multi-hop Cellular Networks.

[8] Lien, S. Y., Chen, K. C., Liang, Y. C., & Lin, Y. (2014). Cognitive radio resource management for future cellular networks. *IEEE Wireless Communications*, *21*(1), 70-79.

[9] Naderializadeh, N., Sydir, J., Simsek, M., Nikopour, H., & Talwar, S. (2019) When multiple agents learn to schedule: A distributed radio resource management framework. *arXiv preprint arXiv:1906.08792*.

[10] Agarwal, V., Sharma, S., & Agarwal, P. (2021). IoT Based Smart Transport Management and Vehicle-to-Vehicle Communication System. In *Computer Networks, Big Data and IoT* (pp. 709-716). Springer, Singapore.

[11] Zhang, H., Long, K., & Karagiannidis, G. K. (2020). Deep Learning Based Radio Resource Management in NOMA Networks: User Association, Subchannel and Power Allocation. *IEEE*

Transactions on NSAE 7(4), 2406-2415.

[12] Shen, Y., Shi, Y., Zhang, J., & Letaief, K. B. (2020). Graph neural networks for scalable radio resource management: Architecture design and theoretical analysis. *IEEE Journal on Selected Areas in Communications*, *39*(1), 101-115.

[13] Hossain, M. S., & Muhammad, G. (2020). A deep-tree-model-based radio resource distribution for 5G networks. *IEEE Wireless Communications*, *27*(1), 62-67.

[14] Agarwal, V., & Sharma, S. (2020, December). IoT based smart transport management system. In *International Conference on Advanced Informatics for Computing Research* (pp. 207-216). Springer, Singapore.

[15] Naderializadeh, N., Sydir, J., Simsek, M., Nikopour, H., & Talwar, S. (2019). When multiple agents learn to schedule: A distributed radio resource management framework. arXiv preprint arXiv:1906.08792.

[16] Guo, J., Yang, C., & Chih-Lin, I. (2018). Exploiting future radio resources with end-to-end prediction by deep learning. IEEE Access, 6, 75729-75747.

[17] Zeng, Q., Du, Y., Huang, K., & Leung, K. K. (2020, June). Energy efficient radio resource allocation for federated edge learning. In 2020 IEEE International Conference on Communications Workshops (ICC Workshops) (pp. 1-6). IEEE

[18] Agarwal, V., Sharma, S., & Bansal, G. (2021, May). Secured Scheduling Techniques of Network Resource Management in Vehicular Communication Networks. In *2021 5th International Conference on Intelligent Computing and Control Systems (ICICCS)* (pp. 198-202). IEEE.

[19] Kuang, L., Chen, X., Jiang, C., Zhang, H., & Wu, S. (2017). Radio resource management in future terrestrial-satellite communication networks. IEEE Wireless Communications, 24(5), 81 87