

A Survey on Neural Network for Vehicular Communication

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Abstract: The Vehicular Communication (VC) is currently capable to provide communication between numbers of vehicles and also becoming capable to provide communication between Vehicles and Internet of Things Devices (IoT Devices) with intelligence. In this frame of reference, this paper presents a survey that how Neural Network Algorithms can help for Vehicular Communication. So, this paper firstly provides description of categories of Neural Networks with basic architecture and examples, those are important in VC. Then VC problems are discussed regarding Neural Network. Also, applications and challenges are discussed followed by necessary examples with future scope. This article provides fundamental inspiration for new researchers regarding improvement of Neural Network VC.

Keywords: ANN, DNN, ESN, IoT, LSTM, ML, NN, RNN, SNN, VC.

I. INTRODUCTION

The vehicular networks technology is surging in current environment. As seen in today's upcoming world, the use of smart phones is growing, and people are getting attracted with Vehicular Communicating devices. There is also a growing increase in the use of Neural Networks (NN) to increase the productivity of the system, to make the interaction of humans and devices simpler and more understandable. These devices and applications are switching towards the use of Internet of Things (IoT) which tries to interconnect wireless-enabled devices sensors and other Neural Networks. As the VC technology is growing it has also increased the need for ultra-reliable data transfer, which has also increased the traffic during the transmission of data.

This, in turn, increases the necessity of such vehicular networks that provide real-time, low latency, reliable and fast data transfer. This rapid transition in communication technology has

provided an intense method to get out of the researches that are based on next-generation technologies. This technology comes up with the challenges of integrating the device with artificial intelligent functions that could exploit the VC technology and generate data and optimize them. They can be implemented by using various Machine Learning (ML) tools and integrating them all to generate NN [1]. NNs are ML based frameworks that implement various ML algorithms and approaches as Supervised Learning, Unsupervised Learning, Semi-Supervised Learning, and Reinforcement Learning. The VC technology should also support real-time HD (High Definition) streaming, cloud-based data, and other multimedia services. They increase the Quality of Service (QoS) and ultra-reliable data transfer.

II. BACKGROUND

ML was introduced from pattern matching and learning techniques that could record the data and store it in one place, which could then help in understanding the environmental features from those data. They used to predict the final outcome of the existing data [2]. It also helped to understand human behavior and interaction with the application. ML is used in entertainment, medical, financial services where they actually have predefined recorded data. Before the application gives the results the application has to be trained so that it could understand the ML tools and its working.

The training of the data is an important step as it tries to establish a relationship between input and output to achieve the target and the goal. This targeting of the data can be performed using Supervised Learning, Unsupervised Learning, Semi-supervised Learning, and Reinforcement Learning [3]. Usually to achieve supervised learning the labeled data is used which means the input and output are already known this can also be known as historic data. Unsupervised Learning means the ability to explore the data. Semi-supervised Learning includes both the services of supervised and unsupervised learning. ANN

(Artificial Neural Network) is used to understand user behavior it is an expert in dealing with humans and their interactions. They predict user behavior and extract information from those data.

III. TYPES OF ANN FOR VC

A. Recurrent Neural Network (RNN)

In RNN neurons are available in physical layers, those are linked collectively. This makes the output to be dependent on previous input as well as the current output. RNN is used to understand the mobility patterns and sequential information about the architecture of RNN. These patterns show where the user had visited or is being visited from previous times. It takes more time to train the data for RNN. An example of RNN is Echo State Networks (ESN). ESN is used to get a content prediction, resource management, and mobility and pattern matching. ESN uses RNN with a hidden layer architecture. The training of data for ENN requires the determination of error in between the presented output and the actual output. The data can be trained using ridge regressions. The Construction overview of Recurrent Neural Network for Vehicular Communication (VC) is shown in the following Fig. 1. Where starting nodes are input nodes which may be single and/or multiple. The last node is the output node which also may be single and/or multiple.

And all the nodes existing between input and output are hidden nodes. There may exist many hidden layers as per requirement. In hidden layers, each node of the Current Hidden Layer (CHL) always consists with each node of Next Hidden Layer (NHL) as shown in the following Fig. 1. Here t is representing last hidden layer and $t-1$ is representing second last hidden layer.

B. Spiking Neural Networks (SNN)

RNN uses the single value to activate the neurons when compared to other types of ANN SNN use a more accurate way to activate the neurons. In SNN engineering neurons adopts spikes to interact with one another. And when a limit point is encountered then neuron transmits an activity potential which is a slight increment in the voltage made. Neurons in SNN are created using spikes only and have quick continuous disentangling with a huge capacity. They also provide data in continuous stream. An example of SNN is Liquid State Machine (LSM) [1]. Simple training methods such as feedforward networks can be in SNN. The connecting portion for neurons in the system is the liquid which is randomly generated. The architecture of LSM includes a large number of LIF (Leaky Integrate-and Fire) models in the virtual three-dimensional column. Each of the neurons in liquid has its own state which helps it in getting a good fading. The inputs are classified using the readouts in them. All neurons in the LSM connects itself to the readouts.

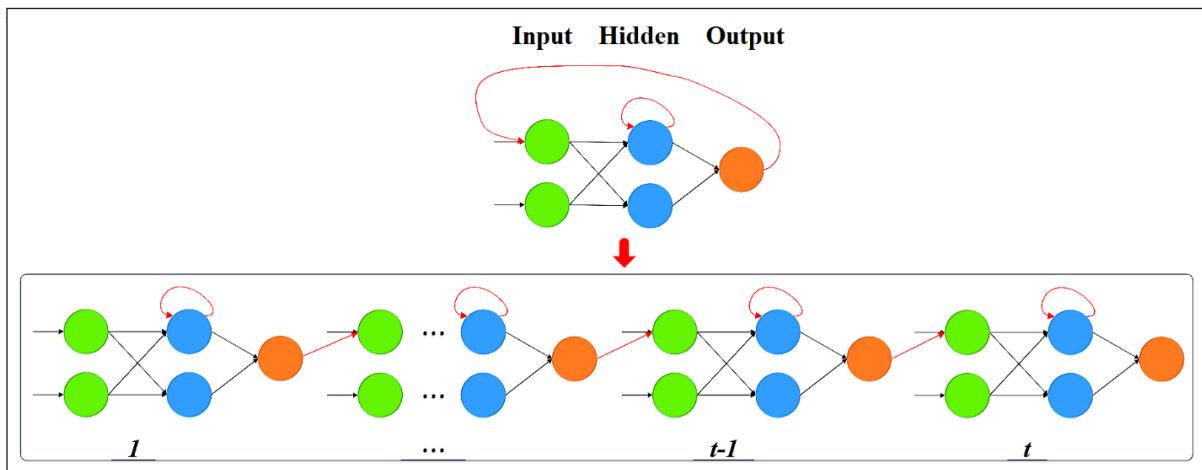


Fig. 1: Construction of Recurrent Neural Network for Vehicular Communication

C. Deep Neural Networks (DNN)

It is a NN with shrouded hidden layers among input and output. Therefore it can also be said as they have a high level of abstractions. Due to its multiple layers, they have a lot of data to train which makes them compatible with the complex problems to be solved more rapidly and effectively. DNN is more suitable for generalization and real-world tasks. DNN has a number of neurons which increases its level of performance. One main problem in DNN is overfitting which happens because of the

large number of neurons. An example of DNN is Long Short Term Memory (LSTM). LSTMs consist of three hidden layers. They consist of momentary memory in correspondence to that the loads in the system have long haul memory. Another significant sort of DNN is convolutional neural systems they were proposed to comprehend the visual symbolism. They have neurons arranged in width, height, and depth. The comparison between all three types of NNs of Vehicular Communication is discussed in the following Table I regarding input data, advantages and disadvantages.

TABLE I: SUMMARY OF THE ADVANTAGES AND DISADVANTAGES OF NNS REGARDING VC

	Typical type of input data	Advantages	Drawbacks
RNNs	Time-dependent data	<ul style="list-style-type: none"> • Effectiveness in processing time-related data such as wireless traffic • Ability to capture dynamic temporal behaviors such as content requests or device mobility • Ability to make use of sequential information such as sequential symbols received by a user 	<ul style="list-style-type: none"> • Training complexity due to the loop connections between neurons • Limited memory to record historical data
SNNs	Continuous data	<ul style="list-style-type: none"> • Effectiveness in processing continuous data such as amplitudes of wireless signals • Large memory available for data collection • Ability to cope with rapidly changing, dynamic network behavior (e.g., dynamic traffic) • Ability to perform multiple learning tasks 	<ul style="list-style-type: none"> • Training complexity due to dynamic neurons • Specific training method is needed for each type of SNN • Need to sample the states of neurons
DNNs	High-dimensional data	<ul style="list-style-type: none"> • Inherent ability to find low-dimensional representations (features) of high-dimensional data such as images and wireless traffic pattern • Better learning capability compared to shallow ANNs • Effective in learning very complex functions 	<ul style="list-style-type: none"> • Hard to tune for practical applications • Large training dataset is required • Computationally intensive to train

IV. APPLICATIONS OF NEURAL NETWORKS REGARDING VEHICULAR COMMUNICATION

As we see, the use of VC technologies gradually increasing as movable devices. The use of ML algorithms is also increasing in Vehicular Communication technologies. So the need to give the users an efficient communication system. They can be used for prediction, intelligence, data analytics purposes. They predict the data set according to the inputs received by the users. They also can process a larger data set and parse information from data. VC also uses NNs to study faults, failure and further disturbing cases present in the system. ANNs can predict information from various IoT sensing elements and then integrate data accordingly. The second application can be seen as being self-organizing by using different kinds of ML algorithms. Here the ANNs can serve as RL (Reinforcement Learning) tools. These can help to get through complex networks and learn about the client information and foresee their behavior.

A. UAV Vehicular Networks

This gives network from firmament to land remote clients. A system with low latitude UAVs (Unmanned Aerial Vehicles) is usually preferred because it provides more flexibility and establishes faster communication [4]. Short term, three dimensional, flexible UAVs are used for collection, delivery, and transmission. They provide better communication because of links that are present in them called the Line of Sights (LoS) links. As we know UAVs have flying nature this helps them to recognize or track the user's location and its environmental features. To provide any distance at any time they can easily implement ANNs techniques. UAVs collect data that they can exploit dynamically using ANN tools and algorithms. It defines the nobility patterns of data understanding its locations and predicting its behaviors. Along with this, they have some limitations also as they get only limited time to collect data, with limited power supply and computational time. An

achievable prototype for UAVs can be seen as to which clients normally visit daily. A forecast calculation utilizing ESN with ideas is utilized in the system to get content from clients and to comprehend their portability designs. For resource management, we use LSMs with RL based algorithms [5]. LSM is capable to take down random data and also process user demands just as content caching. The advantage of using ESN concepts is that it provides a proper resource allocation that gets good content caching and even the ability to make decisions. The data in this can be trained in an offline manner and training can be implemented in the cloud.

B. Virtual Reality (VR) of Vehicular Communication

At the point when a VR instrument is worked, it sends the data which incorporates the client's areas, directions, and other information over the VC links [6]. Then BSs (Base Stations) use this information to create 360-degree images and send those images to the users. Even the images in VR are changed by the development of the client's eye overhead. The use of ANNs promises to solve all the problems in VR. ANNs have two main applications to be used with VR [7]. First ANN can be used to predict user behavior and future interactions with the product. Next ANN builds up a self-arranging ability to randomly modify its content and management. It also adjusts the quality of images in their format according to network environments. They do face challenges also as data collected from users contain errors and hence if we train the exact data then the performance of ANN can be decreased.

C. Mobile Edge Caching and Computing for Vehicular Communication

Caching in VC devices includes the popular content of users their information time delays and stores them. Coded caching let the network devices to have multicast operations [8]. The goal for mobile edge computation is that it gives low computation times, exploiting local resources. We can use

ANN for prediction purposes. ANNs can be used to find social information and interactions. By abusing the data between the gathered information of clients and their social data ANN can anticipate the client's conduct and investigate the information designs. The content request distribution can help to determine what content is to be displayed to end-users. An effective clustering algorithm is also used in NNs to categories the users depends on their activities and their interest [9]. Therefore the system operator must review every content used in the future so that it improves the caching and provide users improved content caching. Data cleaning is an important part of data analysis and is considered in mobile edge computing. This process requires more time when compared to data learning.

D. Co-Existence of Multiple Radio Access Technology in VC

The use of VC devices is increasing and thus it is also important to get enhanced 5G technologies and services. This could be accomplished through PHY/MAC/organize advancements and other proficient methods for utilizing the range. One feature is that it resides in the integration of several other radio technologies. To use this we use Multi-RAT technologies. By using this data can be easily transmitted over LTE and WiFi networks [10]. It ensures a consistent transmission of data and provides a good experience to users. To get the full advantages of multi-RAT technologies we use ANN. They can be applied to large data sets and can easily be exploited to get full sorted information. To train the data we use the Reinforcement algorithm which is used to calculate gradient concerning expected potential. We have tried to connect the LSTM network with a game-theoretic framework and solve various optimization problems.

E. Internet of Things Based Vehicular Communication

We see that many of the VC devices as sensors, vehicles, or other objects from the internet ecosystem. They try to connect using wireless links. They exchange real-time information and deliver solutions related to those problems. Still, IoT faces some challenges where its feature is not being fully used. IoT still has problems in computation, data analytics, transmission, and other issues [11]. ANN has four main applications used in IoT. First, it tries to extract important information from data patterns. Second, using ANN-RL algorithms they can be dynamically self-organized and modify them according to their system requirements. Third, they use algorithms to classify the data collected from sensors. A final and foremost goal is to decrease connection among person with IoT instruments [12]. Using ANN they still face some challenges while exchanging the information over channels and transmitting information also. For more precise and accurate data they should classify data more properly. Various ML algorithms are used in IoT to solve certain problems those algorithms are DNN, FNN and are

tested for robot navigation with body postures and other gestures and movements. FNN is used in this case and information is fed in one direction only. To guarantee the trustworthiness of the framework one neuron can be mapped with only one IoT instruments. ANN can be utilized for information pressure, decrease the size of forwarded information and concentrate significant data. DNN is used for human identification feature whereas an IoT system can differentiate between individuals and pre-allocate them various spectrum or computational resources to the device. FNN is a basic neural system utilized in frameworks with small preparing gave. But they can only be used where the number of transmitters and receivers is less.

V. CONCLUSION

This survey paper provides a review of NNs which is currently applicable in Vehicular Communication. In this firstly types of NNs for VC are discussed. Then we review utilization of the neural systems with respect to Vehicular Communication. These applications include details of UAV Vehicular Network, VR of VC, Mobile Edge Caching and Computing for Vehicular Communication, Co-Existence of Multiple Radio Access Technology in VC and IoT based VC. The future of Vehicular Communication is based on Neural Network and IoTs.

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