Contents

Abstract

Traffic System is one of the biggest issues of every city.If a city having inefficient traffic control system then it can leads to very high congestion of traffic which degrade the quality and living standard of any city by increasing the average travel time and also many more dangerous issues.That's why there must be a need of efficient traffic management system.So here we are trying to show a method that makes our traffic management system more effective.basically we are going to use the concept of Artificial Intelligence,Dedicated Short Range Communications(DSRC),and Reinforcement learning(RL) which involves Q-learning,Convulation Neural Networks(CNN).By using these technologies we are going to show that how it got implemented and how our society going to get benefit from such great things.

Keywords-Dedicated Short Range Communications (DSRC),Reinforcement learning (RL), Convolutional Neural Networks(CNN),Intelligent Transport System(ITS)

List of Figures

List of Abbreviations

DSRC - Dedicated Short Range Communicationst

RL - Reinforcement learning

CNN - Convolutional Neural Networks

ITS - Intelligent Transport Systems

QL - Quality-Learning

CCTV - Closed Circuit Television

V2V - Vehicle to vehicle

V2I - Vehicle to Infrastructure

ReLU-Rectified Linear Unit for a non-linear operation

Chapter 1

Introduction

Artificial Intelligence is a very popular keyword that has been emerging in the technology field and shows the capability of innovation everywhere.it sees to have a very big thing that is going to give the solution of many problems.but what actually it is any why we are going to use for our problem statement.It is a branch of computer science that mimic the behaviour of exactly like human beings in way of thinking.it can solve many problems like speech recognition,learning,planning and many things.And in proceeding one the application can be used in solving traffic congestion problems that we are going to discuss here.so finally our aim is to design a system that can minimise the issues caused due to the heavy traffic on the roads.this can be achieved by designing the system that we are going to see in our report regarding development and deployment.And we are designing this system because of the Problems that can be faced due to traffic issues:

1. High level of traffic congestion and jams
2. Traffic rules were violated
3. Wastage of time of people
4. There can be loss of money and fuel
5. High pollution in particular areas

1.1 Application

Our designed Traffic control system using Artificial intelligent can be used at any intersection point.it just uses the ultra high quality images that were taken from the High Definition CCTV

Fig. 1.1: Huge Traffic congestion on the road [6]

cameras.Now the images taken is processed by the designed machine and then the machine operates the traffic light according to the model from which that particular machine is designed.by using this technology traffic congestion problem will reduce due to which many problems can be solved.

Fig. 1.2: Traffic Light Signal [1]

It can also be used in finding the important vehicles,like if there is ambulance with their signal on then it will be treated accordingly,it is also used to control the traffic violation.

1.2 Motivation

As we know that one of the major problem faced by a common people in day to day life is related to traffic jams.you just feel it if you have witness the same.Technological people trying to solve this issue since long but now we are very close to the solution and that's all because of some of the technology that shows their high potential and capability and why not to adopt such technology if it is able to save our time,save lives and many more.

Fig. 1.3: Health of Traffic Personnel [5]

The main source of motivation is we just need to solve this traffic jams problem anyhow.because it cost time,money,life and health.

1.3 Objectives

This seminar report aims to summarize the works that were done till today on behalf of the solution of the traffic issues,mainly focusing on how it works and how it will get implemented.

Accordingly it will get implemented with some of the advanced technologies like Convolutional Neural Network,Q-learning, DSRC etc.later we have chapters that are going to explain all these technology in very depth and after that we will see how they get combined together and make a high impact device for the betterment of human generation.and at last we will see some work done till now and it's conclusions.

Chapter 2

AI Technology

1. Q-learning(QL).
2. Convolutional Neural Network(CNN).
3. Dedicated short Range Communication(DSRC).

2.1 Q-Learning

Q-learning is a very famous reinforcement learning algorithm.here we are going to discuss q-learning and try to give the basic knowledge of background to understand to understand the algorithm.

1. **What is Q-Learning?**

   It is an off-policy reinforcement learning(RL) algorithm that tries to find the best action if any current state is given.it's called off policy because this algorithm learns from the action which is outside the current policy,just like a taking of random actions,so there is no need of policy.finally we can say that q learning tries to learn the policies that can help it to reach the maximum total reward.The Q here stands for quality.Quality here represents how useful a given action is in gaining some future reward.

2. **Create a q table:**

   Whenever q learning algorithm is performed we have to make a matrix or q-table having the shape of like state,action.and we have to make all initial values to zero.after performing some action we have to upadate and store q-values.and at last the finally designed

q-table is work as a reference table for our defined agent so that we can select the best action which will be based on the q value.

3. **Making updates in Q-learning:**

Our next step is to look after when our agent is going to interact with the environment and accordingly it has to make updates in the q table of state action pair values.

Taking action:Explore or Exploit

There are two ways for an agent to interact with any environment.in first case we are taking q table as reference and look for all possible action if any state is given.and the way of selecting the action is based on the value which is maximum of all of them.This process is called as exploiting as here we are using the knowledge or information that is already present with us and our decision is based on that only.

In the second case we have to act randomly to take any action.This process is called exploring.here we are not looking for getting maximum reward instead we are selecting our action randomly.Taking action randomly have their own importance because by doing this the agent is open to discover and explore new states that might not be taken into consideration during the exploitation process.

4. **How to make updates:**

Update is happening after each action and step and it ends when the process is done.Done here means when agent reaches any terminal point.terminal state means winning of a game,completion of any task or reaching the end point of any path or death in a game etc.agent here is not learning many things after ending of a single process rather it will learn by doing the same process number of times.

Three basic steps here are:

(a) Agent start with a state(s1) it will take an action(a1) and in response of that it will gain a reward(r1).

(b) Agent refer the q-table and action is selected by taking maximum value or by random.

(c) updating of Q-values.

5. **Conclusion:**

   Well this is very short and precise.we discussed here why it is an off-policy reinforcement learning algorithm.we discuss all the method how the q table is being updated,why it is being used.we learned how the q learning select any action based on given state by maximizing the total reward.

   There are many more things related to Q learning but hopefully we covered here all the basic aspects of it.

2.2 Convolutional Neural Network(CNN)

Convolutional Neural Network is one of the very popular category of neural network which is widely used in image recognition,classification,face recognition,object detection etc.these are some of the fields where CNN is very popular.

Convolutional Neural Network classifies an image by taking an input image,then does it's processing and then based on output classifies it into certain categories.Machines looks an input image as an array of pixels and it depends mainly on it's resolution.it will take height*width*depth.an image of 6*6*3 array of matrix of RGB,3 here is used for RGB values.

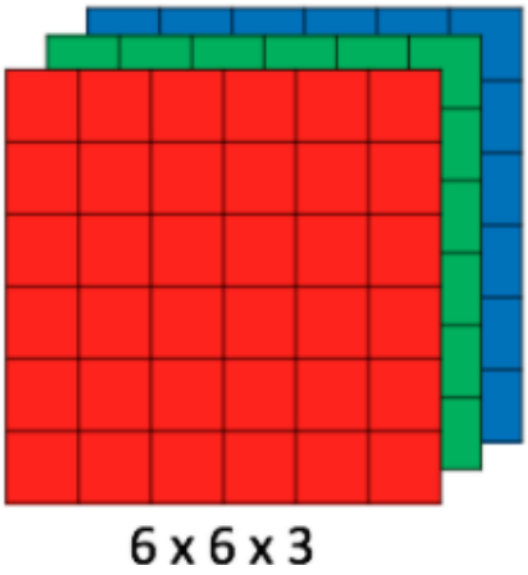

Fig. 2.1: Array of RGB Matrix [8]

basically CNN is used to first train and then test,firstly every input image have to pass through a convolution layers having filters(kernals),pooling,fully connected layers,pooling and then apply some function to classify the object having probabilistic values between 0 and 1.The

below given figure shows that how an input image is processed then classifies the object according to the final output value.

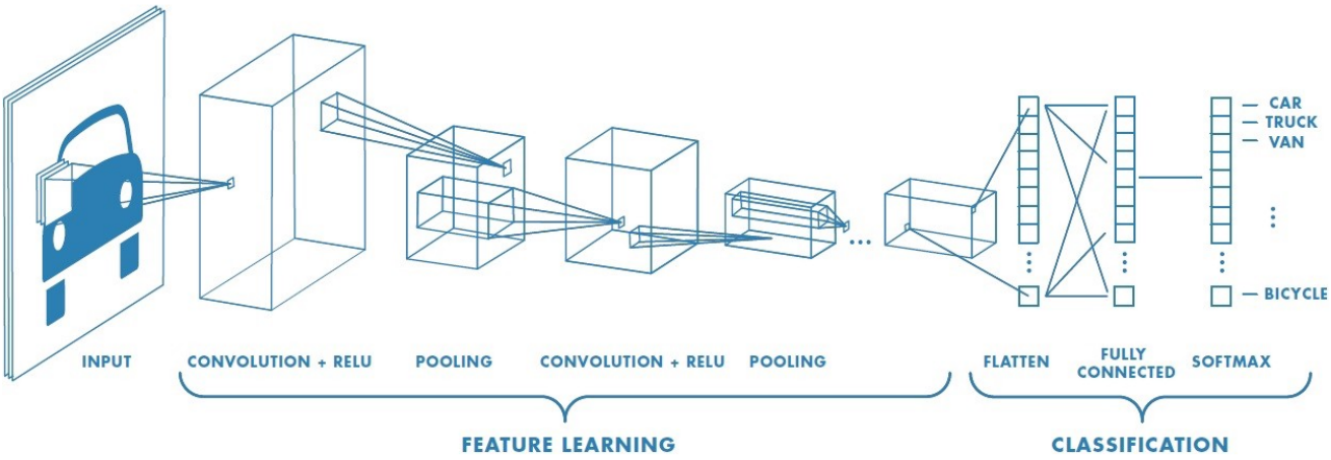

Fig. 2.2: **Neural network with many convolutional layers [6]**

2.2.1 Convolution Layer

It is the first layer that is used to extract features from the given input image.This layer helps to preserves the relationship between pixels with the help of learning image features by making small squares of input data.It operates mathematically by taking two inputs one is image matrix and the other is filter or kernel.

Take a 5*5 matrix whose image pixel values are 0 and 1 and a filter matrix 3*3 which is shown in the below figure.

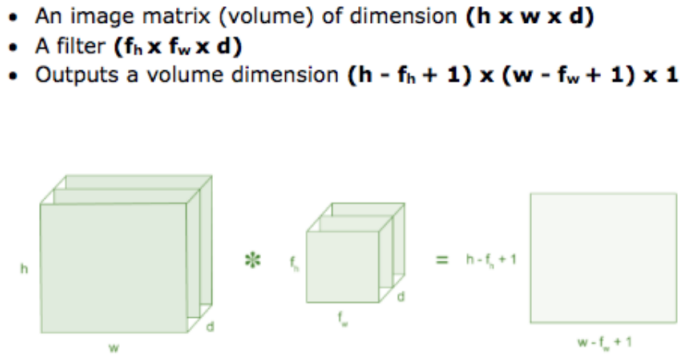

Fig. 2.3: **Image matrix multiplies kernel or filter matrix [1]**

Now the given 5*5 matrix is got multiplied with 3*3 filter matrix which is termed as feature map.the output shown is in the below figure.

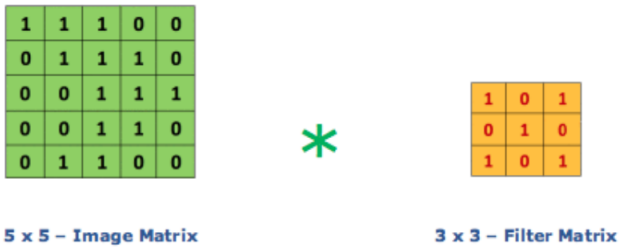

Fig. 2.4: **Image matrix multiplies kernel or filter matrix [4]**

Convolution of an image with varities of filters is able to perform some operations such as detection of edges,sharpen and blur by applying filters.The given below figures shows many examples of the same.

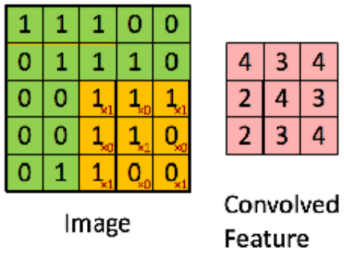

Fig. 2.5: **3 x 3 Output matrix[9]**

2.2.2 Strides

Strides is defined as the number of pixels that will shifts over the given input matrix.If the stride is given as 1 then we have to move the filters to 1 pixel at a time.The given figure shows how convolution will work with the strides of 2.

2.2.3 Padding

There are chances of some cases when the given input image is does not get perfectly fit by the filter that's why we have to options for it:

- **We have to make the padding of pictures with zeros so that it would fit.**

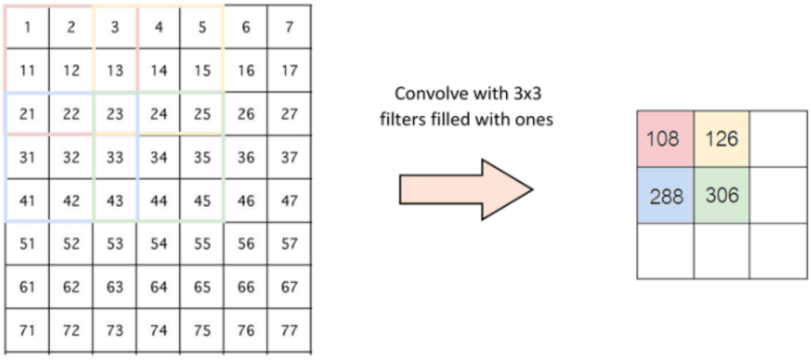

Fig. 2.6: **Stride of 2 pixels [1]**

- **if the filter do not fit then we have to drop that particular part of the image.This is defined as valid padding as it consider only the valid part of the image.**

2.2.4 Non Linearity (ReLU)

Rectified Linear Unit for a non-linear operation(ReLU).The output is $f(x) = \max(0,x)$.

ReLU is important because it is used to introduce Non-Lineraity in our CNN.it is because of the reason that ConvNet can learn non-negative values.

we can also use other non-linear functions like sigmoid and tanh.ReLu is very popular so that it is used by Most of the data scientist and the main reason behind this is ReLU is better than other two in terms of performance.

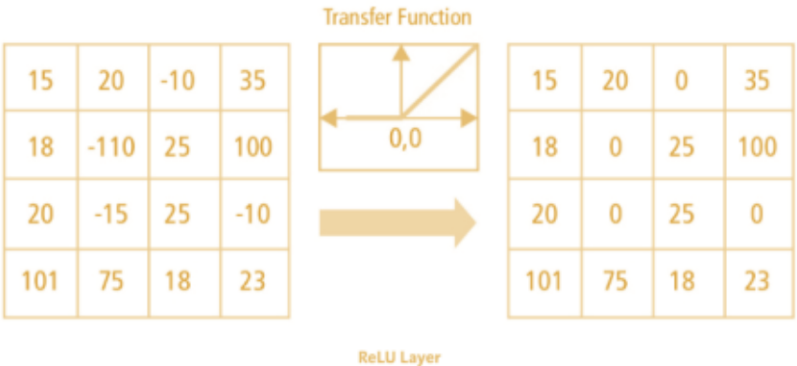

Fig. 2.7: **ReLU operation [6]**

2.2.5 Pooling Layer

Pooling is used to reduce the number of parameters when the input image is too large.spatial pooling is used to reduce the dimensionality of the map but the important information is retained.spatial pooling can be of variuos types:

- **Max Pooling**
- **Average Pooling**
- **Sum pooling**

Max Pooling is defined as taking of largest element from the rectified feature map.if we take the average value then it is called average pooling and if we take the sum of all elements of the feature map then it is called sum pooling.

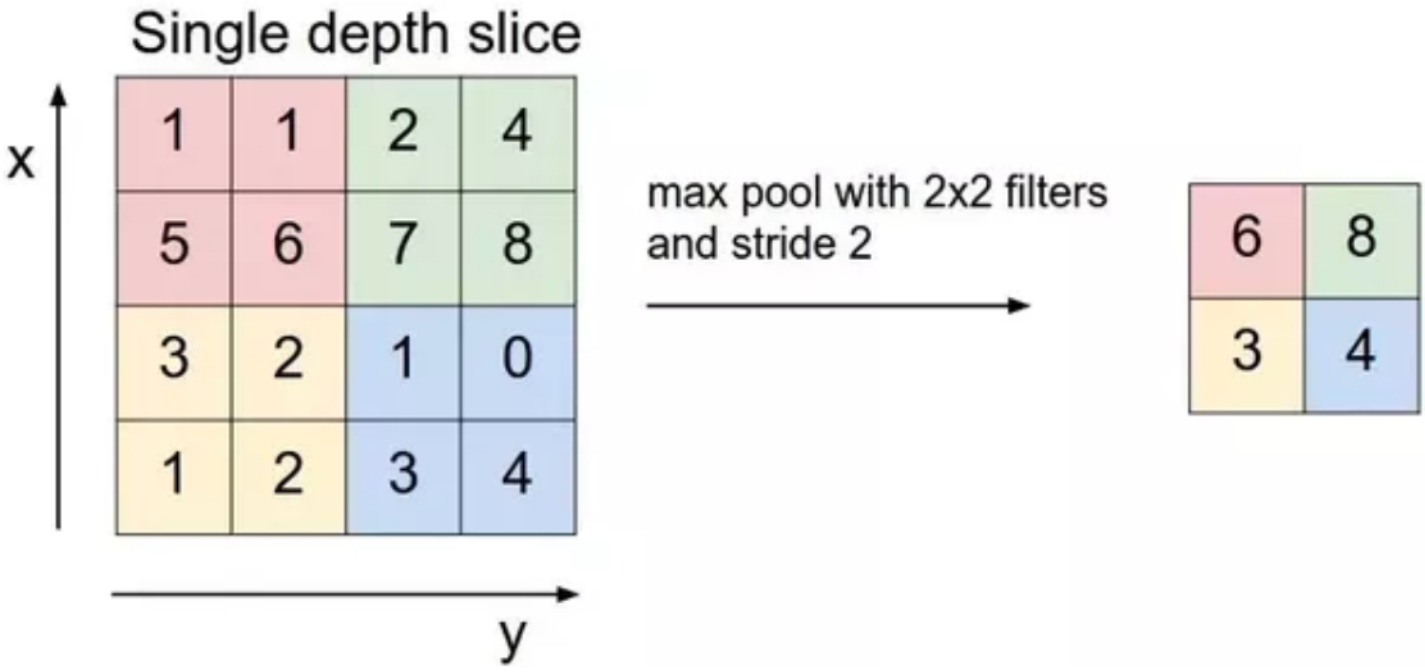

Fig. 2.8: **Max Pooling [9]**

2.2.6 Fully Connected Layer(FCL)

In fully connected layer we have to flattened our resultant matrix into vector and after that feed it into a FCL like neural network.

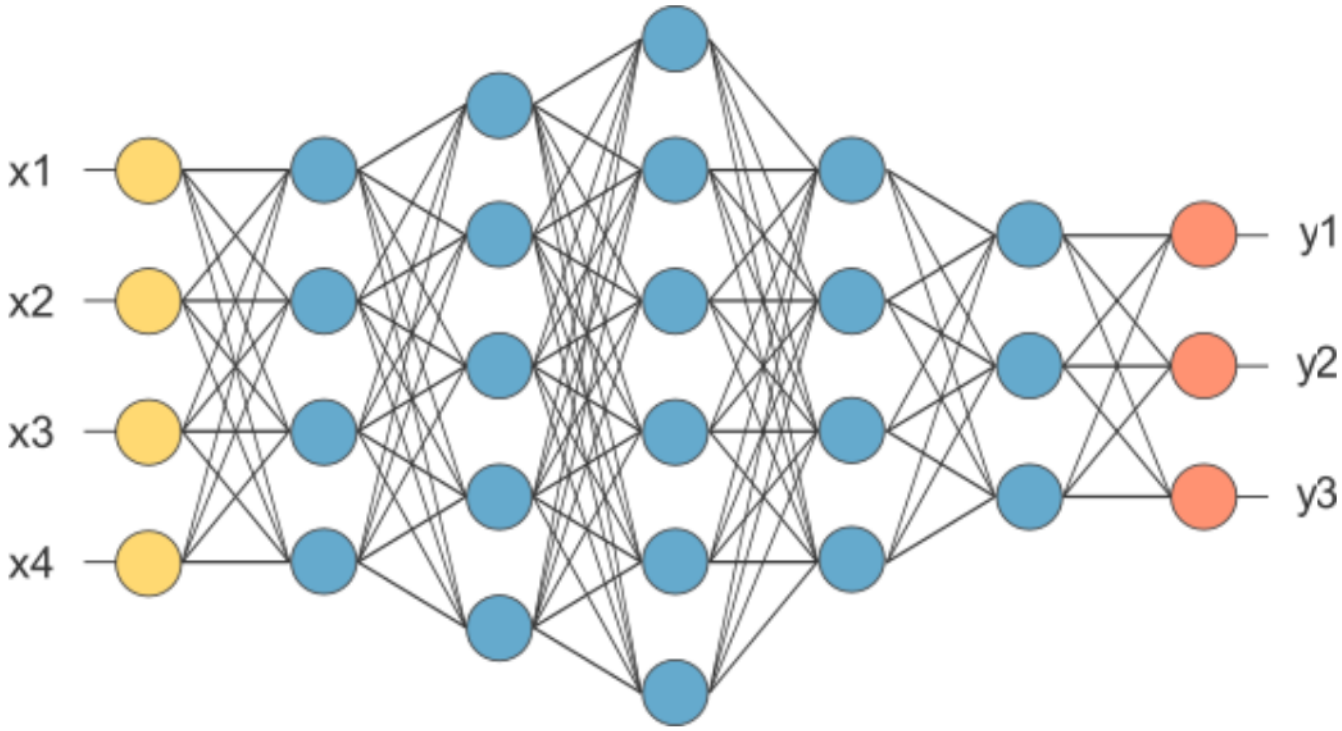

Fig. 2.9: **After pooling layer, flattened as FC layer [7]**

In the given above diagram,it is shown that how it is getting converted as a vector.At last we have an activation function which classify the output as object.

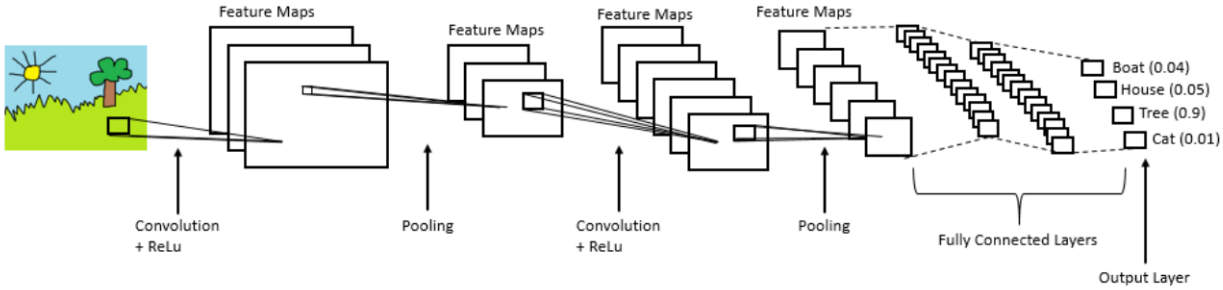

Fig. 2.10: **Complete CNN architecture[6]**

2.3 Dedicated short-range communication (DSRC)

DSRC is basically a wireless communication technology.It is used to manage intelligent transportation system (ITS).In this communication can be done by either to vehicle or to infrastruc-

Fig. 2.11: **V2V and V2I Connections [1]**

ture.It get operated on the 5.9GHz band of some radio frequency.because of the specturm it can work for short distances and in some cases upto medium distances.

DSRC have some special features like it has low latency and having high reliability. inter-operability is supproted here and it is also secure.as it has very short range that's why it get very low interference even in the bad weather conditions.That's why it is a very ideal technology for communication between the fast moving vehicles.

There are two mode of working of DSRC technology

- **vehicle-to-vehicle (V2V)**
- **vehicle-to-infrastructure (V2I)**

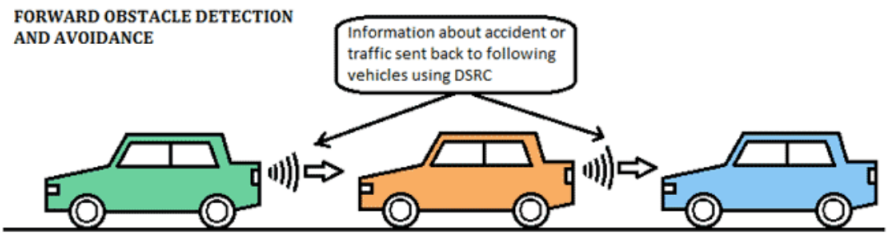

Fig. 2.12: **Wireless Meassage Passing [9]**

In vehicle to vehicle DSRC technology the communication is done between the pair of vehicle through OBUs(on-board units).This communication is done mainly for maintaining security.it gives the alert to the car if the car in front going to slows down.

Vehicle to infrastructure is done between vehicle and the infrastructure nearby.The infrastructure is equipped with the RSU(road side units).It has many applications like this can guide the driver regarding the safety risks.it is also used to collect tolls and parking payments.

Chapter 3

Traffic Control System Designing

Now we have reached to the implementation part here we are going to see that how we can use the above discussed technology to design a system that can change lives of people.At first we will discuss the state represantation of it and then it's system design after that how it is trained and deployed.

3.1 State Representation

If we want a good working model then there must be need of relevant information related to traffic as much as possible.and most information is conveyed through possiblities of DSRC technology.

reinforcement learning make choices by doing many experiments by chosing as many as possible choices of inputs.we selected a state representation including the distance to the nearest vehicle at each approach, number of vehicles at each approach, current traffic light phase elapsed time and current time, as shown in the given below figure

current traffic light phase (green or red) is represented by a sign change in the per-lane detected car count and distance rather than by a separate indicator. In initial experiments, we observed slightly faster convergence using this distributed representation (sign representation) than a separate indicator.The output is positive if the ReLU layer is active else the output is negative, so our representation may encourage different units to be utilized during different phases, accelerating learning. There are many possible representations and our experimentation with different representations is not exhaustive, several different representations is handled with reasonable performance with the help of reinforcement learning.

Information	Representation
Detected car count	Number of detected vehicles in each approach
Distance to nearest detected vehicle	Distance to nearest detected vehicle on each approach; if no detected vehicle, set to lane length (in meters)
Current phase time	Duration from start of current phase to now (in seconds)
Amber phase	Indicator of amber phase; 1 if currently in amber phase, otherwise 0
Current time	Current time of day (hours since midnight), normalized from 0 to 1 (divided by 24)
Current phase	Detected car count and distance to nearest detected vehicle is negated if red, positive if green

Fig. 3.1: DETAILS OF STATE REPRESENTATION[1]

3.2 System Design

Here we are going to provide one of the system realization for our proposed scheme,which is based on DSRC.

The system consist of an 'On Vehicle' unit and an 'On Roadside' unit,which is shown in the figure below.Basic Safety Message(BSM) is sensed by the DSRC RoadSide unit(RSU) which is broadcasted by the OnBoard Unit(OBU),the important useful information is parsed out and then send it to the Q learning based decision making unit.Decision is then make by this unit based on the information which is provided by the RSU.

The figure shows the flowchart explaining how the decision is make by RL based control unit.As the figure shows,every second DSRC RSU provide the state representation to the control unit,for all the possible action Q value is calculated and if the current phase has higher value then it retains the phase if not then phase swtich is done.apart from the main logic that has been discussed, a sanity check is performed on the agent: a mandatory maxi-mum and mini-mum phase time.

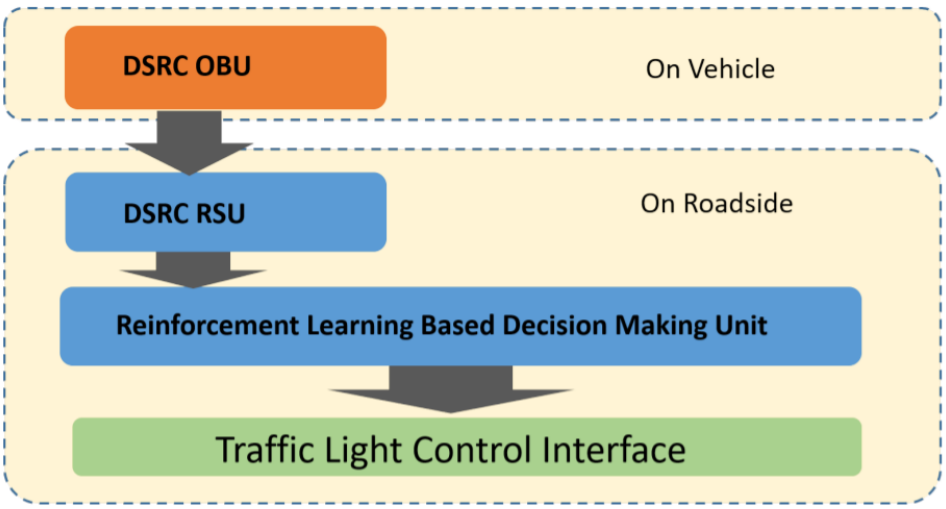

Fig. 3.2: One possible system design for the proposed scheme [9]

3.3 Implementation

In this part we are going to see the proposed model at the system level.the system is implemented in the two steps,first is the training phase and the second one is deplyoment phase.as given in the below figure,we can first trained the agent with the help of simulator,after that it is applied at the intersection,which is connected to the real life traffic signal,and then the control of traffic gets started.

1. **Training Phase:**

   By iteracting with a traffic simulator our agent got trained.the arrival of vehicle and the determine process of vehicle is randomly generated by simulator.in case of DSRC based detection of vehicle system,the detection is judged by the penetration rate of the DSRC.The traffic state st is obtained by the simulator and after that the current reward is calculated,which is feeded to the agent.with the help of q learning algorithm automatic updation started happening on the basis of information that is provided by the simulator.in between,action at is chosen by agent and it is forwarded to the simulator.so simulator have to make update,and it has to change the phase of traffic light according to the indication given by agents.These process has to repeat again and again till convergence,the point at which the training of agent is completed.The agent performance is highly dependent on the simulator quality.To apply this in real world the car flow is generated by the simulator according to the vehicle arrival in history record on the real intersection point.we have

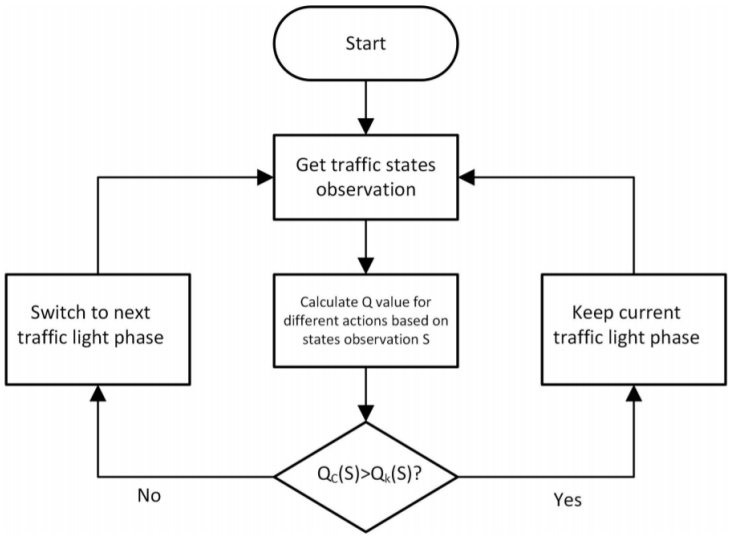

Fig. 3.3: Control logic of RL based decision making unit [7]

to check the car flow in different part of the day,current time is also specifies in the state representation,this is done because the agent should be able to adapt the different car flow during during different time and different day.our goal for training here is to minimise the average travel time for all travelers.during training,the machine goes through various schemes but finally it adapt an optimal scheme which gives the minimum average travelling time.

2. **Deployment Phase:**

   In this phase,The designed software agent is fixed at the intersection point so that traffic light can be controlled.Here,the already learned Qfunction is not updated by the agent,but it only control and manage the traffic signal.The agent current traffic state st is detected by the detector and based on that st,the agent have to choose the action from the already trained Q-netwrok and control the traffic signal to change it accordingly. all these is performed in real-time, so that continuous traffic control can be enabled.

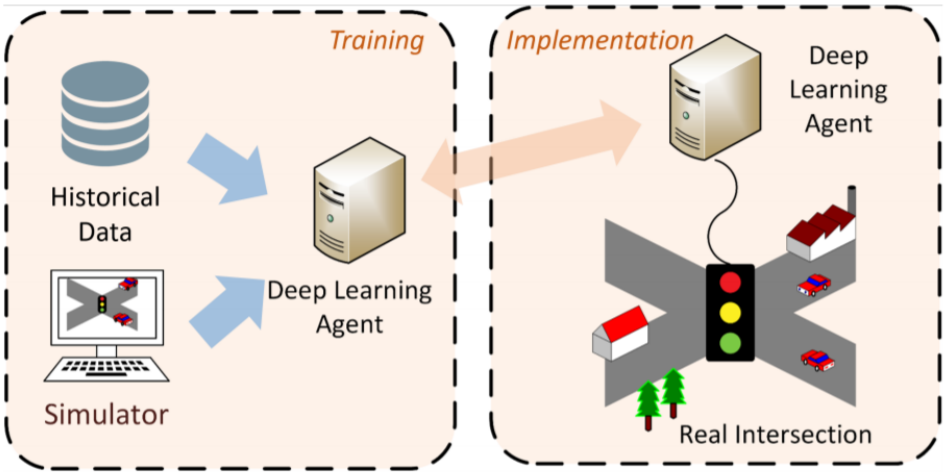

Fig. 3.4: The deployment scheme [6]

Chapter 4

Conclusion

In this Report we have gone through the detailed study of reinforcement learning,Q-learning, Convolutional Neural Network And DSRC technology which in combination used to control traffic by detection of vehicles at the intersection point with the help of high definition CCTV cameras.The result of our study shows that with the help of these technologies we can optimize the traffic control system. we can make our system more efficient.we have gone through the numerical results on a single intersection point with high,medium and low traffic on the road and our q-learning is able to show that it can handle all types of traffic successfully.Hope in the future we are going to see such technology in our real life also.we have show all the process how it works by accepting the information from the output of CNN and then this information is processed by the q-learning which is feeded to the system.the information on the road we can also get through the V2I technology and later processed to make decision.So we can say that it is very clear that how this system can can implemented and why it is needed by our society.

References

[1] "Traffic congestion and reliability: Trends and advanced strategies for congestion mitigation," https://ops.fhwa.dot.gov/congestion report/ executive summary.htm, 2017, [Online; accessed 19-Aug-2017].

[2] P. Mirchandani and L. Head, "A real-time traffic signal control system: architecture, algorithms, and analysis," Transportation Research Part C: Emerging Technologies, vol. 9, no. 6, pp. 415–432, 2001.

[3]] "Traffic light control and coordination," https://en.wikipedia.org/wiki/ Traffic light control and coordination, 2016, [Online; accessed 23- Mar-2016].

[4]] E. van der Pol, "Deep reinforcement learning for coordination in traffic light control," Ph.D. dissertation, Masters thesis, University of Amsterdam, 2016

[5] B. Abdulhai, R. Pringle, and G. J. Karakoulas, "Reinforcement learning for true adaptive traffic signal control," Journal of Transportation Engineering, vol. 129, no. 3, pp. 278–285, 2003.

[6] B. Kerner, C. Demir, R. Herrtwich, S. Klenov, H. Rehborn, M. Aleksic, and A. Haug, "Traffic state detection with floating car data in road networks," in Intelligent Transportation Systems, 2005. Proceedings. 2005 IEEE. IEEE, 2005, pp. 44–49.

[7] L. Li, Y. Lv, and F.-Y. Wang, "Traffic signal timing via deep reinforcement learning," IEEE/CAA Journal of Automatica Sinica, vol. 3, no. 3, pp. 247–254, 2016.

[8] A. Chattaraj, S. Bansal, and A. Chandra, "An intelligent traffic control system using rfid," IEEE potentials, vol. 28, no. 3, 2009.

[9] H. Van Hasselt, A. Guez, and D. Silver, "Deep reinforcement learning with double q-learning." in AAAI, vol. 2. Phoenix, AZ, 2016, p. 5.

[10] T. Haarnoja, H. Tang, P. Abbeel, and S. Levine, "Reinforcement learning with deep energy-based policies," arXiv preprint arXiv:1702.08165, 2017.

[11] F. Belletti, D. Haziza, G. Gomes, and A. M. Bayen, "Expert level control of ramp metering based on multi-task deep reinforcement learning," IEEE Transactions on Intelligent Transportation Systems, vol. 19, no. 4, pp. 1198–1207, 2018.

[12]] L. Codeca, R. Frank, S. Faye, and T. Engel, "Luxembourg SUMO ´ Traffic (LuST) Scenario: Traffic Demand Evaluation," IEEE Intelligent Transportation Systems Magazine, vol. 9, no. 2, pp. 52–63, 2017.

Acknowledgement

I would like to thank sincerely to my guide Mrs. Umangi Patel, Computer Engineering, SVNIT for her invaluable guidance, constant assistance, support, endurance and constructive suggestions for the betterment of the technical seminar. I would also like to express a deep sense of gratitude to the faculty of Computer Engineering Department for helping me directly or indirectly in completion of this seminar.