National STEM Competition 2020

Registration Form

Team name: BUET_Rendezvous

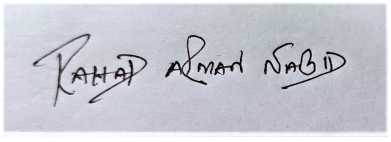
1. **Name of the Institution:** Bangladesh University of Engineering and Technology (BUET)

2. **Team members:**

	Name	Department	Student ID	Academic Year	Email
1	Rahad Arman Nabid	EEE	201506142	4th	ran.nabid@gmail.com
2	Md. Jahin Alam	EEE	201606040	3rd	jahin00003@gmail.com
3	Shams Nafisa Ali	BME	201618019	3rd	snafisaali100@gmail.com
4	Manzil-e Akbar Khan	BME	201618029	3rd	manzilkhan911@gmail.com
5	Fardeen Ahmed	BME	201618030	3rd	awrka.goku@gmail.com

3. **Team Leader:** Rahad Arman Nabid

4. **Supervised by**: Md. Farhad Hossain
Professor
PhD (Wireless Networking), MSc Engg. (EEE, BUET), BSc Engg. (EEE, BUET)



Signature of the team leader

Signature of the Supervisor
(with official seal)

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY (BUET)
TEAM NAME: BUET RENDEZVOUS

National STEM Competition 2020
Concept Paper Guideline

A Deep Learning and CNN Approach towards Signal Timing Optimization to Reduce Traffic in Road Junction

June 14, 2020

1 SCOPE OF THE PROJECT

To meet the SDG Goal 11[5]: Sustainable Cities and Communities through designing an integrated transportation system for making movement of private vehicles, mass transit, bicycling, and pedestrian walking as easy and efficient as possible, we plan to revamp the existing traffic management system of our country with the application of CNN and Deep Neural Network. Unlike the commonly seen automation strategies, like fixed time signal or traffic load sensing for estimating the number of vehicles on road, we are bringing a new perspective in this context with the help of complex computation and machine learning algorithms. Consideration of all the key parameters namely, multiple cross signal co-ordination, space, approach speed, node distances, mobility variation, standardization, cost, human factors for optimizing the traffic signal will ensure safety, efficiency and an overall enhanced mass-productivity of our countrymen.

2 TECHNICAL DETAILS OF THE PROJECT

Our algorithm has three parts:-

- Different types of car detection with the help of CNN network
- Train the predefined model with deep neural network

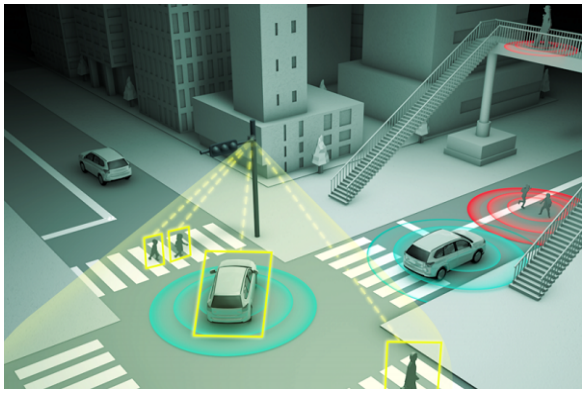


Figure 1.1: Detecting Cars

- Calculation of optimizing time with average speed and number of vehicles

2.1 Different types of car detection with the help of CNN network

Let us assume the total number of traffic nodes is five, wherein every node has 4 roads and in every road there are one incoming road and outgoing road for vehicles.

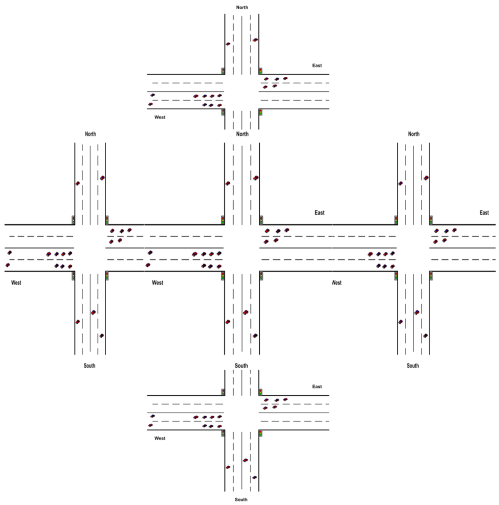


Figure 2.1: Traffic Node

Step-1:Capturing Images:
Let us consider the central node. There will be four cameras in every outer lane of all four roads. We will capture images from every camera in every cycle of traffic signal. On an important note, we will capture images instead of video capturing to save power efficiency.Then we will

transfer our data to our server.

Step-2:Count Cars:
In the next part we will count the number of cars, buses, and trucks.We will analyze different algorithms to see their efficiency.We will apply our transfer learning to these model such as:

1. YOLO: Real-Time Object Detection
2. SSD: Single Shot MultiBox Detector
3. Region Proposal Networks
4. R-CNN for vehicle detection

Figure 2.2: Detecting Cars with CNN model

2.2 Train the predefined model with deep neural network

Step-3: Arrange Data Ascending Order:

We will arrange the road name in ascending order with the help of cars, bus, trucks number. But rather than taking only the number of the car, we will consider their lengths.
Suppose:
Ideal Car length: 4.48 meter
Ideal Bus length: 9.14 meter
Ideal Truck length: 7.92 meter
Ex: Suppose- A1 road-
Car-10
Bus-2
Truck-1
Suppose- A2 road-
Car-4
Bus-5
Truck-1
Suppose- A3 road-

Car-20
Bus-1
Truck-1
Suppose- A4 road-
Car-13
Bus-7
Truck-1
So Total length for A1: 70.98
The total length for A2: 71.54
The total length for A3: 106.66
The total length for A4: 130.14

This data will be preserved in our database which will be needed in the next step.
So we will assign integer value in python dictionary A1=4, A2=3, A3=2, A4=1

Step-4: Redundancy of Same Signal Handling:
Suppose one of the roads remains very busy all the time that the number of vehicles is always higher than the other roads. In those cases, only predicting from car count will give us wrong predictions. So we will consider the previous states of the roads in every 4 cycles for nodes.If the road is on in previous state we will not consider it to be open.
Ex: Suppose A1 has opened in the last signal cycle and A2 has opened two times in the last cycle. And we will make a threshold for a maximum opening of a road in 4 signals. So our next data will be:
prestateA1=1
prestateA1=2
prestateA1=0
prestateA1=0

Step-5: Connecting to other nodes:

In big cities, all the roads are connected with each other. If any node fails the other nodes will get affected. So we need consider other node's/junction's states which we can get from our server.
Ex: Suppose the back node of A1 is open and others are closed.
BacknodeA1=1
BacknodeA2=0
BacknodeA3=0
BacknodeA4=0

Training Model

A sample data-set is shown for predicting road signal which we will use for traing.
Ex: A1=1 (A1 road has most traffic)

A2=2 (A2 road has more traffic than A3)
A3=3 (A3 road has more traffic than A4)
A4=4 (A1 road has less traffic)
prestateA1=1 (A1 road has open one time in last 4 signal cycle)
prestateA1=0 (A2 road has open zero time in last 4 signal cycle)
prestateA1=0 (A3 road has open zero time in last 4 signal cycle)
prestateA1=0 (A4 road has open zero time in last 4 signal cycle)
BacknodeA1=0 (A1 back road is closed)
BacknodeA2=0 (A2 back road is closed)
BacknodeA3=0 (A3 back road is closed)
BacknodeA4=0 (A4 back road is closed)

A1	A2	A3	A4	prestateA1	prestateA2	prestateA3	prestateA4	BacknodeA1	BacknodeA2	BacknodeA3	BacknodeA4	Signal
1	2	3	4	1	0	0	0	0	0	0	0	A1

Figure 2.3: Training Data

This predetermined model is trained and tested by our deep neural network.

2.3 Calculation of optimizing time with avg speed and number of vehicles

In our next step, we will get an output from deep neural network model.
Suppose , the answer is A1 road.This road has:
Car-13
Bus-7
Truck-1
The total length for A1: 130.14 meter and lets assume A1 has 3 lanes.
So in every lane length (130.14/3)=43.38.
Max limit in Dhaka city is 25 km/h or 6.94 m/s.[3]
Min acceleration : 0.28 m/s[4]
So on time for every signal is :
t=sqrt(2*s/0.28)
=sqrt(2*43.38/0.28)
=309.85 s
= 5.16 min

3 What output from the project can be considered for the assessment of its success

We will preform three evolution tests:
CNN Model Evaluation : Two noted evaluation metrics for the YOLO algorithm are Mean Average Precision (mAP) and Mean Average Recall (mAR) which are to be maximized. A test set of different vehicles clustered together will be presented to the model with definite ground truths. The model's output will provide us with its predictions which will be compared to the ground truth values. Three terms will be found:
1.Truth-Positive (TP) : Correct predictions with respect to the ground truths.
2.False-Positive (FP) : Wrong Predictions
3.False-Negative (FN) : Missed Predictions

$$Precision = \frac{TP}{TP + FP} \tag{3.1}$$

and

$$Recall = \frac{TP}{TP + FN} \tag{3.2}$$

values are then calculated varying IoU threshold to get Precision-Recall curve from which 11-point interpolation is done to get the 'Average Precision' at 11 different Recall values for each class. If there are N number of classes (cars, trucks, rickshaws, buses... etc) :

$$mAP = \sum_{n=0}^{N} Average\,Precision\,Of\,'i'\,th\,Class \tag{3.3}$$

To calculate mAR is more straight-forward, as shown below:

$$mAR = \frac{2}{N} \int_{.5}^{1} Recall \times (IoU) \times d(IoU) \tag{3.4}$$

Deep Neural Model Evaluation : In Deep Neural Network Segment we will measure not only (1)Precision, (2)Recall but also (3)Accuracy, (4)Confusion matrix, (5)F1-Measure.
We already know that our prediction will be good cause we already know the cases of all events. But we also try to split the data into test and train set for any unknown situations.

1) Accuracy: Accuracy shows the percentage of the accurate results of department selection.

2)Confusion matrix: shows the number when the results true and false when they were predicted either positive and negative.

3) F1-Measure: Combines precision and recall in calculation.

$$F1 = \frac{2}{\frac{1}{Precision} + \frac{1}{Recall}} \tag{3.5}$$

$$= 2 \times \frac{Precision * Recall}{Precision + Recall} \tag{3.6}$$

Simulation of Our Optimize Time with Existing Algorithms : We will simulate it in matlab "Vehicle Traffic Patterns at an Intersection (SimEvents)". (This is an IEEE authorized simulation paper)

4 How does the project contribute in the development of sustainable technology

The bulk of the focus of the project will be on the pre-processing stage to train the algorithm in order to i.) detect and count the number of cars in any street and ii.) display the appropriate traffic signal based on specific parameters. The technology involved in the physical implementation of the system requires very simple technology. The system consists of a set of video cameras that can capture at a respectable frame rate, all feeding their readings to the central micro-controller unit, which also contains the algorithm to be implemented. The micro-controller, will then output the appropriate traffic signals which it will be displayed by the connected traffic lights. As the description suggests, the project is not making a serious sacrifice in terms of financial and technological aspects in order to gain a higher efficiency. The simplicity of the practical aspects of this project can ensure the sustainability of this project. The complexity of the hardware is relatively low, so the chance of a systemic failure, past the development stage is very low and this reduces the maintenance costs involved. In the case of a failure, the simplicity of the technology involved ensures that the repairing process will be smooth and relatively inexpensive. The whole system is therefore is easy to implement, easy to maintain and in the necessary situation, easy to repair, while also, promising a huge improvement in traffic flow which can promise a high sustainability.

5 Describe what makes the project innovative

Moderating traffic flow on a road or at any intersection, whether it is a 2–road or a 4-road intersection, is executed by the traffic police at the site of intersection. In the more technologically developed areas, it is automated by a time connected to the traffic lights. Both these methods, even though they get the job done, have major areas of improvement. The areas of improvement regarding the traffic police are the ones that one be mentioned in the case of any task powered by manual labor; chances of human error, a toll on the human body and mind which in turn affects the performance of the traffic flow. The automated timer method manages to give consistent results for a long period of time and therefore, it does not give the most efficient results. Our project involves the use of machine learning and neural networks, to achieve the best of both worlds. The project's informativeness comes from its ability to make instinctive, intuitive and adaptive judgments done by the humans, while maintaining a

high accuracy, efficiency and consistency in performance by capitalizing on the benefits of automation. It also quantifies and then inputs the different sizes of cars present in each street, to take into account the total weight of the traffic. This is done with very little sacrifice made in terms of finance and complexity of technology.

6 How many people will be benefited from the project

Our solution will reduce traffic congestion and its effects on businessmen and employers in several ways. Primarily, it ensures rapid corporate activities such as shipping/receiving, logistics and distribution, client meetings and other business activities. Secondarily, it does not hinder worker availability and productivity by affecting employees' commutes as people will not have to experience 35 to 37 hours of delay per commute, per year (or about four-and-a-half minutes per one-way trip, relative to free-flowing traffic).
Drivers in free roads have been reported to experience less stress and aggression than ones driving in congested roads. The people of Dhaka generate 36 million trips per day[2]. 35% of those are work trips. Reducing trip time can brighten the mood of citizens.
One of the most destructive effects of traffic congestion is its impact on the environment. Despite the growing number of hybrid (mix type) vehicles on the road, cars stopped in traffic still produce a large volume of harmful carbon emissions while signal is red. Reduced congestion on road will improve air quality and implicitly benefit all of the citizens.
There are 21,006,000 people in Dhaka with 964,500 registered vehicles (and 400,000 unregistered vehicles). The city's traffic congestion eats up 5 million man hours every day causing a loss of the average loss stands at Tk 370 billion a year[1].

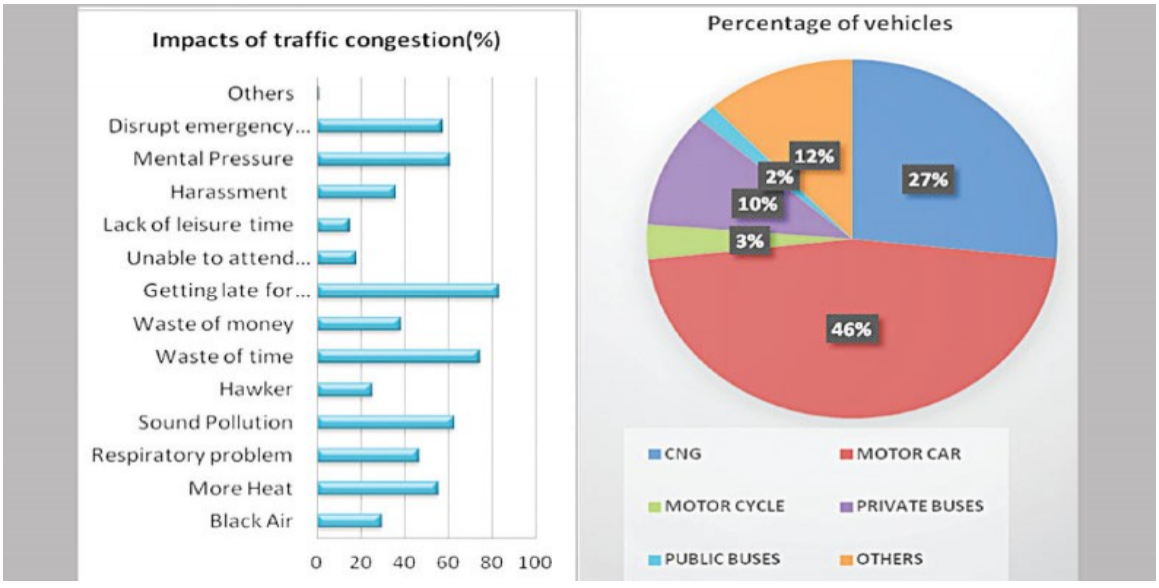


Figure 6.1: Impacts of traffic Jam[6]

7 MOTIVATION TO PARTICIPATE IN THE COMPETITION

STEM (Science, Technology, Engineering, and Mathematics) offer a wide array of sustainable development opportunities with diversified skills to meet the future challenges. By employing our obtained knowledge, skills and critical thinking capability, we want to contribute in solving the major problems for our local community and dream to materialize the SDG 2030 vision. Presently, the entire world is shifting towards a technological revolution by incorporating STEM based modern and efficient solutions to every problem. Therefore, being Engineering students, it is imperative for us to carry out certain responsibility towards the community, society and nation. This competition is on national level having direct government affiliations with an accomplished and experienced jury board. Considering the financial and technical aids available for this competition, this seemed a great platform for us, i.e., the youth to be a part of this triumphant march of progression. We also believe, this competition will popularize STEM education among the youngsters of BD by implementing excellent project ideas setting exemplary evidences for them. Being on the cusp of modern technology in the 21st century, scientific and technological innovations have become increasingly important to hold a significant place in the globalized and knowledge-based economy structure. We believe, to compete with the outside world and to ensure a sustained growth and stability of our economy, our innovative and technologically equipped strategies can play a pivotal role. Using our STEM education benefits, we wish to meet the local, national, and global challenges utilizing the innovative frameworks of big data and artificial intelligence. Preferable inclusion of a female member in team was also a motivating factor for us to join in this competition as this is a really positive gesture to bridge the gender gaps and break the stereotypes found in participation of women in math and science fields in our society.

REFERENCES

[1] https://en.prothomalo.com/bangladesh/Dhaka-s-traffic-jam-causes-Tk-370b-annual-loss

[2] https://www.thedailystar.net/frontpage/colossal-loss-1553002

[3] https://www.rhinocarhire.com/Drive-Smart-Blog/Drive-Smart-Bangladesh.aspx

[4] Acceleration-Deceleration Behaviour of Various Vehicle Types-by P.S.Bokare a , A.K.Maurya b

[5] https://sustainabledevelopment.un.org/sdg11

[6] https://www.newagebd.net/article/18145/the-costs-of-traffic-congestion