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# Introduction

Traffic on roads means all the vehicles and pedestrian. Traffic rules are those rules which govern traffic and regulate vehicles. Traffic is formally organized in many jurisdictions, with marked lanes, junctions, intersections, traffic signals or signs. As the number of vehicles on road increased, need for the traffic rules was realized due to recurring accidents which could be prevented by following simple rules. In 1865, first traffic rule was introduced in Britain. Later as the number of vehicles grew rules were added to increase safety and make traffic efficient. In Kathmandu valley though the number of vehicles grew the road, technology used are still the same. Many people do not know all the rules and many of those who know does not follow the rules. To prevent accidents many traffic rules are enforced. These rules must be followed by all the motorists. [1]

Traffic violation occurs when driver fails to follow the traffic rules that regulates vehicle operation on the road. If any motorists fail to follow the traffic rules traffic ticket is issued to the driver. The main duty of the traffic police is to make motorists and two wheel drivers follow the rules and if they do not follow the rules traffic ticket is issued. A traffic ticket is a notice issued by a law enforcement official to a driver, indicating that the user has violated traffic laws. Traffic tickets generally come in two forms a moving violation such as exceeding the speed limit or non-moving violation such as a parking violation with the ticket also being known as parking ticket.

Any person caught violating traffic rules is slapped a fine between Rs. 500 and Rs. 1,500. As many as 378,927 rule violators were booked in the fiscal 2017-18. Out of them 5,060 motorists and two-wheeler riders were caught with the help of Closed Circuit Television (CCTV) cameras installed at more than 200 locations in the valley. Less than 2% of violators were caught using the CCTV cameras.

Violation of lane discipline is driving recklessly on the road without using turn signals and not following the lane discipline. Violation of lane discipline tops the traffic offence chart with 33,377 violations though many violators of lane discipline are not fined.

Speeding is excessive speed (driving above the speed limit) or inappropriate speed (driving too fast for the prevailing conditions) recognized as a major contributory factor in both the number and severity of traffic crashes. Very few speeding tickets are issued in Kathmandu valley as speed monitoring is only enforced randomly on very few occasions with limited resources.

Some of the traffic rules violation that our system can detect are:

* Violation of lane discipline
* Drive over permitted speed limits

Detection system is a software that is used to monitor the traffic violation. Traffic violation detection system is the software that uses real time object detection to detect the violation committed by the driver. Real-time object detection is the task of doing object detection in real-time with fast inference while maintaining a base level of accuracy. Video footage from the CCTV is used as the data input for the system. Open-CV can be used for real time object detection with the help of frameworks like You Only Look Once (YOLO). [2]

Speed of the YOLO framework is 45 frames per second which is better than realtime. Network understands generalized object representation which allowed them to train the network on real world images and predictions on artwork was still fairly accurate. It is also open source. [3]

# Evolution of traffic detection system

Traffic violation has been one of the major problem since the development of roads and vehicles. On average 3,287 people are killed every day in road accidents. Different remedies have been made through the period. Due to advancement of technologies and increase of population the problem doesn’t seem to be declining. In cities, where the number of vehicles continuously increases faster than the available traffic infrastructure to support them, congestion is a difficult issue to deal with and it becomes even worse in case of car accidents.

## Latest status of traffic violation detection system:

The invention of vehicles dates many years ago but the first car brought to Nepal was in 1958 BS. Traffic control system was formulated in 2007 BS. The first traffic light was implemented in 2023 BS in Kathmandu. Traffic lights weren’t that useful back then since there weren’t many vehicles or we could say we were way ahead of our time. In today’s scenario, traffic lights are not enough in Kathmandu. The latest development in traffic control system is the use of RFID systems. RFID systems overcomes the drawbacks of problems related to image processing. Radio-Frequency Identification (RFID) is the use of radio waves to read and capture information stored on a tag attached to an object. Although traffic violation has been one of the major problem all over the world, very few countries have taken the step towards smart traffic system. For example, Dubai have implemented around 15,000 cameras which is constantly monitored by Traffic police officers but detection is still done by officers themselves. The people who violate the rules are fined digitally especially in Dubai. It is very rare to find these new detection systems. Speed detection system have been implemented in most of the developed countries. Even in Nepal, every now and then traffic comes for speed detection. We have CCTV control rooms for traffic management. [4]

The system we are about to use is called “Traffic Violation Detection System” using image processing algorithm. We are planning to implement HD CCTV cameras as well as sensors at various places of roads (according to the study of road and traffic conditions). Our system should be able to scan the image of cars and its number plate. The violation will be recorded as a proof. The information about the driver will be present in the system so it will be very easy to fine the person.

## Benefits

We have over 1.025 billion vehicles today in the world. [5] If an appropriate system is implemented to manage these vehicles, road accidents will be drastically reduced. It will help all the traffic officers and volunteers who work extremely hard to control the traffic. These following points will help us to show some benefits of traffic management system.

1. Improving traffic safety

Over speeding, inappropriate changing of lanes, heavy traffic can lead to road accidents; traffic violation detection system will help with all of these. Our system can detect the vehicle who violated the rule and fine the necessary charge.

1. Reduce in infrastructure damage

Road accidents not only lead to damage of life but also destroy our road structures. It also hampers the decoration of the road. If we implement our system then we can reduce the expenditure on road repair, allowing it to be allocated somewhere.

1. Traffic control

We can clearly distinguish that today’s traffic system will not be able to huge mass of vehicles. Mostly people try to escape from the situation and traffic officers couldn’t care less. It’s like catching fish in the sea. There are so many of them that if we catch like thousands then other hundreds still run away. So a system is needed in order to keep everyone inside the rule, not letting even one to escape.

1. Improved journey times

Most of the people violate traffic rules so that they can reach to the destination as fast as possible but unknowingly they are creating mesh and disturbing everybody on the road. Our system will make the road traffic condition better and everybody will reach to their destination in time.

1. Prevents road accidents

People claim accidents are unfortunate events but most of the accidents are due to failure of people discipline on the road. There are many causes behind the accidents. Lack of experience, over confidence, overcrowded roads, are the cause of accidents.

1. Serviceable help for traffic volunteers

In the context of developing countries where government doesn’t invest required amount of money for road development, traffic controllers play huge role. We can see their hard work but it seems insufficient and it turns sometimes violent. Increment in vehicles every day make their traffic controlling task burdensome so let the system take all the stress and traffic officers and use their time someplace else.

# Existing System

We have studied the following systems and observed the respective strengths & weaknesses of the system.

## A video based traffic violation detection system

This is a proposal of an improved background-updating algorithm by use of wavelet transform on dynamic background, and track moving vehicles by feature -based tracking method. It is realized in C++ with the help of Open-CV. It proposes Background Difference Method (BDM) & feature-based tracking for the detection of moving vehicles.

Strength(s):

1. BDM proposed in this paper is computationally fast.
2. This paper realizes intelligent traffic management.
3. More fast and accurate detection and tracking.

Weakness(s):

1. The main weakness of BDM is it needs to update the background image in real time when the environment changes.
2. The video module proposed in this system has less frame rate compared to the modern video systems. [6]

## Traffic Violation Detection System based on RFID

This article is published in an International Journal. This article attempts to introduce an intelligent control system based on RFID technology. By the help of RFID technology, vehicles are connected to computerized systems and intelligent light poles. In this project, intelligent control system is capable of tracking all vehicles, crisis management and control, traffic guidance and recording driving offences along the highway.

The methodology employed for achieving the detection deals with introduction of intelligent highway with RFID scanner attached to light poles referred to “intelligent light poles”. An RFID tag is attached to the vehicle while entering the highway, the light poles gathers different disseminating information such as traffic guidance and warning. The information thus disseminated is then sent to the central computer. The offences are then recorded while the driver drives along the highway. After the highway is completed, then the tag is removed off the vehicle.

Strength(s):

1. All of the data that are being sent helps to locate the driver well.
2. The poles can also be used for other purposes than just placing RFID scanners.
3. The method is fast; it has less delay in comparison to JIT method.
4. Can detect multiple offences.

Weakness(s):

1. The methodology proposed by this article can be difficult & time consuming.
2. Materials like metal and liquid can impact RFID signals.
3. Works well on wide highways only. [7]

## Traffic Rules Violation Detection with Computer Vision

This project is made for the third year second semester System Development(CSE-3200) course of Khulna University, Bangladesh. his system can detect most common three types of traffic violation in real-time which are signal violation, parking violation and wrong direction violation. A user friendly graphical interface is associated with the system to make it simple for the user to operate the system, monitor traffic and take action against the violations of traffic rules.

In the methodology, first, the CCTV footage from the roadside is sent to the system. Vehicles are detected from the footage. Tracking the activity of vehicles system determines if there is any violation or not. Different types of violations have different algorithms to determine the violation. Gray scaling and blurring, Background Subtraction, Binary Threshold and Dilation and find the contour are used in the system. Open-CV computer vision library is used in Python for image processing purpose. For implementing the vehicle classifier with, Tensor flow machine learning framework is used. SQLite database of Python is used.

Strength(s):

1. User Friendly Graphical User Interface.
2. Low RAM Usage.
3. Can run on almost any device.
4. Can be extended further.

Weakness(s):

1. Only limited no. of violations is only detected.
2. Requires python.
3. Fails when the violation pattern changes. [8]

## Intersection Violation Detection by Hikvision

Hikvision is a provider of innovative security products and solutions. Intersection Violation Detection is also one of the systems provided by them.

Hikvision manufactures camera equipped with software specialized for violation breaches in the intersection. Hikvision includes software embedded security cams powered by GMOS sensors. It provides two camera choices: 3 MP iDS-TCE300-A6 & 9 MP iDS-TCE900-A.

Strength(s):

1. This system allows high video compression.
2. It can support multiple application modes: eg.: external input, checkpoint vehicle detector, RS-485 radar, mixed-traffic lane and video analysis E-police.
3. It uses wire over the LAN, so is more reliable.
4. Can be activated through both web browser and SADP application.
5. Rich interface and advanced detection system

Weakness(s):

1. This system can be complex for usage by some users.
2. The system can crash sometimes when a lot of the violations take place at the same instance. [8]

# Customer’s perspective

Our customer was Traffic Head from Traffic Police, Satdobato. On the basis of existing systems mentioned above, the customer had an overall positive perspective towards the system. He highlighted following points:

1. There is no any prevailing system and has been none attempts to computerize the traffic rule violation.
2. When a misunderstanding takes place in between driver (referred to both motorists and motorcyclists), the current system of showing CCTV footage proof is both tedious and time consuming.
3. He mentioned how the traffic violence was increasing at an exponential pace and was going out of control with only manual existing system.
4. He highlighted the need for a computerized system in traffic violence control as manual detection and fine to individual breaches are close to impossible.
5. He pointed out the lack of enough manpower in the field of traffic control as a whole, most of the manpower is centralized towards traffic control than traffic violation monitoring.
6. He also pointed out the increasing ignorance of drivers due to incompetency in implementation of rules & regulations well.
7. Less than 2% of the all of the violations are captured through CCTV, thus, the system is necessary. [9]

# Observation of existing or similar systems

## Table of Comparison

|  |  |  |  |
| --- | --- | --- | --- |
| S.N. | Title | Method | Features |
|  | A video-based traffic violation detection system | Background Difference Method | Red light violation, vehicle tracking, speeding, vehicle retrogress, saving & displaying information |
|  | Traffic Violation Detection System based on RFID | RFID technology | Parking in no parking, stop, accident detection, wrong lane detection, speeding, car breakdown probability |
|  | Traffic Rules Violation Detection with Computer Vision | Grayscaling and blurring, Background Subtraction, Binary Threshold and Dilation and find the contour | Signal violation (red light violation)[by drawing line], parking violation [pre-figured rectangle, direction violation [use of lines for regions] |
|  | Intersection Violation Detection by Hikvision | Not specified | Unsafe driving behaviors, speeding, red light violation, Lane violation, overload (motorcycle), parking violation, wrong Lane driving, incident detection, no helmet, targeted vehicle detection, object detection |

## Common Features

The common Features between all the systems are:

1. Red light violation
2. Speeding
3. Direction violation
4. Surveillance Camera

# Problem Statement

According to Metro Traffic Division, there is average of 40-60 accidents per day [11]. The one of the major cause of this is violation of prevailing traffic rules. In the last 10 years, 22,461 lost their lives in Road Traffic Accidents (RTA), according to Nepal Police. Police records blame 95% of accidents in Nepal on negligence of drivers. On a daily basis, 1,500 traffic police officers work to manage the traffic in Kathmandu Valley and in the last five months they penalized 185,436 individuals for violating traffic rules — 1,236 per day. Similarly, 472,407 vehicle drivers and owners were fined in the last fiscal year. A whopping 3 million people have been penalized for violating various traffic rules in the last 5 years and this has resulted in the government earning more than Rs1.238 billion. [12] All of these reports show drivers negligence towards following traffic rules is one of the major reason of these accidents. Manual efforts are basically not enough to control all of these, as well as implant a cognizance in minds of drivers. The major violations include lane violation, illegal parking & speeding.

The scope of this problem is every road user. It can be clearly seen that all of the people will face problems until the problem mentioned above is patched. Pedestrians walking on the road, crossing the road are constantly in threat of being a victim of traffic violation and rash driving. Pedestrians can get hit by speeding vehicles. Similarly, Cyclists and Motorcyclists are also posed to the threat. Large speeding vehicles when comes out of control, or the motorcyclists and cyclists lie on the black spot, then they also can get collided with each other resulting in a fatal accident. Also, cars, buses, truck drivers can collide with each other on lane violation. Speeding can kill many people, almost all of the road users. Red Light Violation also similarly arises accidents. Wrong lane driving can also take away lives. Children won’t be able to walk freely, even in footpath. Old aged, blind are also the ones who get most affected by accidents arising due to traffic violations. Traffic Polices that constantly manage the flow of vehicles also put their lives constantly in danger due to traffic violations, as said by Mr. Rajesh Silwal, Head Supervisor, Traffic Police Division, Satdobato.[10]

Traffic Violation problem is a genuine problem serving to impediment of growth of a country, it’s traffic set of rules & regulations and a serious safety issue. Traffic Violation related issues are growing day by day and so are the fatalities related to it. Living in a constant threat in his/her day to day life is not what someone would want & look forward to. Not only does, this pose a threat to road users, but a traffic violation accident or stopping for a penalty causes a traffic jam around, not if, traffic jam, it affects the smooth flow of the traffic as well as may cause more accident to happen. “In your body; a biological system, all your cells must obey the rules too, like where to be, what to do, when to multiply. Cells which can be free of the rule telling them where to be are Lymphocytes (white blood cells / police cells)”. [13] There is another reason that such behaviour is so prevalent. There is no correlation between the amount of the fine and the magnitude of the crime, fines are ridiculously low. The ability to prove guilt is limited due to shortcomings in the law: it's much more profitable to break the law. Case and point: The Taiwanese MSG factory, which has destroyed the environment and wildlife, that bypassed all environmental controls and promises; thereby making profits in the millions of dollars while the penalties are inconsequential. [14] This is not a static problem, as traffic violations increase, so does the negligence of the driver to follow the rules, psychology states. As the number of vehicles start to grow, and traffic congestion lumps up even more, traffic violation has started to become even more and more serious problem.

The system will try to solve the major problem of speeding. We will try to implement algorithm for detecting & providing an alert about speeding to concerned people. We will try to implement a fine system for so. We will also include a feature to detect lane violation. On lane violation, similar to speeding, fining will be performed. All of this solutions will be tried to achieved with the help of surveillance camera. Our system will detect more violations as feasible in the future. If all violators are fined instantly by the system, they will try not to repeat the same mistake again. It will reduce the cases of violations & it will implant drivers’ psychology to follow rules & regulations properly.

When our system will be ready, it will be most useful to traffic police officers, both on road and sitting in front of CCTV in headquarters. They will be able to catch offenders more effectively than manual way of catching. Both on duty officers and officers staying in the headquarters can get the offense report, and can make required law implementation. It will be also beneficial for students willing to learn more in this field, as code written by a student will be understood by another student easily. Besides this, it will be beneficial to the nation as a whole as it will be able to implement its law easily. This law enforcement will probably change the driver’s psychology and drivers will follow rules & regulations thus making a road a safer place to travel on. Traffic flow can be smoother. Drivers will also be going to have a proper privilege of driving in the roads as with other drivers following rules properly. Next, it will be beneficial to all the research personnel. If a chance is there, then, if an accident detection system can be extended, then it can obviously save lives on the road.

# Aims & Objectives

## Aims

Our aim that we have planned in to achieve is given below:

* To develop a complete traffic violation detection system

## Objectives

Objectives of our system that will be there to achieve the above aim are listed below:

* To develop a system that can detect vehicles & track their movements on road.
* To develop a system capable of detecting reasonable number of violations.
* To develop a system that can record those violations & notify to the user.

# Literature Review

Following the many papers, there are many approaches to realization of traffic violation detection system. But, in all of the papers, the common primary aspect is the detection of the object, classification of that object & the nature of violation it commits. Object detection can be achieved using different algorithms like Background Difference Algorithm, Dynamic Background Difference with Wavelet transform (improved background difference) algorithm, Edge Detection with Hough Transform, & numerous other methods. The classification of that object is made by different architectures like Darknet, mobilenet etc.

Released in late 2018, Traffic Rules Violation Detection with Computer Vision is a project that has been implemented on the basis of different algorithms. First the CCTV camera footage from the road side is sent to the system. Vehicles are detected from the footage. Tracking the activity of vehicles system determines if there is any any violation or not. Different types of violations have different algorithms to determine the violation. Image processing technique is used for object detection. Specifically, Grayscaling & blurring is used on the CCTV footage, then this input is fed to Background Subtraction section where desired object’s area is evaluated subtracting the current frame from the reference frame using Background Subtraction Method. For the refinement of the background, to remove all the holes and noises from the frame and get the desired object area accurately, the binary threshold operation is performed by Binarization Method. The thresholded image s dilated to fill the holes and the contour is found from the image. drawing rectangle box over the contours desired moving objects are taken. OpenCV computer vision library is used in Python for image processing purpose. The classification of the moving objects is done into three classes – car, motorbike & non-vehicle. Classification is moreover done with the use of mobilenet v1 neural network architecture constituted in Tensorflow machine learning framework. Transfer learning approach is used to training the model with their dataset; the dataset consists of 500 images per class. Lines & areas are drawn for different types of violations. For example: When the traffic light is red and a car is crossing the straight line, a picture of that car is registered in the database along with some environmental values.[8]

In 2020, from the same university, by a different group of students, Traffic Signal Violation Detection System using Computer Vision has been developed. Input is the same. The vehicles are detected using YOLOv3 model/algorithm, which is a third object detection algorithm in YOLO (You Look Only One) family. Classifier model is built with Darknet-53 neural network architecture also included in the newer version of Tensorflow. Image processing & Object detection as previously is implemented with the help of YOLO which is a constituent algorithm in OpenCV. A region of interest can be defined by the administrator for the violation. After that administrator will need to select two points to draw a line that specifies traffic signal. This system only supports signal violations, and not parking as well as wrong lane violation. An output.mp4 is also generated in the background. [15]

In the completed development of Red Light Violation Detection System (RLVDS) for Indian vehicles under Integrated Traffic Management Systems (ITMS), There are three cameras equipped for detecting the red light violation detection, two are fixed & one is a PTZ (pan-tilt-zoom) camera. The scheme for detection of red light violating vehicles is based on background subtraction technique where the intrusion of any other object into the scene may be obtained by subtracting the non-background image from the background image. 5 successive images’ average difference with the background image generates an average background image & after it, background subtraction is performed on the image obtained by polling cameras available on the site every 3 seconds. The requirement for it arises due to the fact that to detect an object from an image captured at night, if the image is subtracted from the background image of morning then obviously wrong prediction of object will result. Two fixed cameras generate two types of fixed images whose pan angle are corrected internally during processing. For PTZ camera, it captures images in 6 different angles, each angle has a corrected value which is used for correction of angle of all the angles. Mean gray value is evaluated and if the difference image results a high mean gray value then it is considered as a non-background image, i.e. there is a possibility of intrusion of an object in the image. So in the difference image the white stop-line will also become black if it is not occluded by the vehicle. For detection of this occlusion five lines have been hypothetically drawn on the stop-line parallel to the longer edges of the stop-line, with a vertical gap of three pixels between them. The technique successfully identifies vehicle images in 92% cases. Major reason behind erroneous tracking of vehicle images is occlusion on the stop-line by pedestrians, speeding vehicles over the stop-line, erratic changes in outdoor lighting conditions and possible vibrations of the surveillance cameras. [16]

A video-based traffic violation detection system proposes an improved background-updating algorithm by using wavelet transform on dynamic background, and then track moving vehicles by feature-based tracking method. A complete traffic violation detection system is realized in C++ with OpenCV. This paper proposes video streams as the input, compares five of the prevalent methods in detection a vehicle in the video stream. Background Difference Method, which is already described above; subtracting the current image from the background image, binarization which means to take a grayscale image and conversion of the same to black and white image. This method needs to update the background image in real time when the environment changes. Inter-frame Difference Method, which subtracts the current frame from the previous frame, and then changing area can be found by setting the threshold value. Edge Detection Method, applying of edge detection and denoising on the input image for result image. The result image is compared with a template image, after matching. This method is not suitable for real-time image processing. Optical Flow Method, detects moving objects by the change in the time domain of pixel intensity of an image sequence, and the relationship between the structure of objects and movement. This method is, however, computationally intensive and is susceptible to noise. Block Matching Method, splits an image into M×N macro blocks. A motion vector is evaluated by searching for optimal matching of a macro block of the current frame in the next frame. A moving vehicle is composed of many macro blocks.

The paper discusses about the use of dynamical background update based on the wavelet transform, that is combined with background difference and feature-based tracking for detection of moving vehicle. A weighting parameter α is used to adjust the speed of background update within the current image. This method has the merit of avoiding the interference of the foreground, when updating the background. This is required because if the background updates too fast, there are extra holes in the foreground image otherwise, the movement affects detection performance. 2-D discrete wavelet transform is performed, that eliminates trajectory and solves the problem. The advantage of OpenCV is realized in this by use of various image processing functions such as Gaussian filtering function GaussianBlur(), image space mapping function cvtColor()etc. The results are tested for different values of α (0.01, 0.03, 0.05 and 0.1) and it performs best on the α=0.03. Feature based tracking tracks then vehicle by the center, and decide whether they violate or not by thresholding. For every violation, the threshold is compared to the threshold. For e.g.: if Speed < Threshold, it is speeding. [6]

High-Level Traffic-Violation Detection for Embedded Traffic Analysis on the other hand uses background segmentation and novel road model for obtaining candidate traffic participants. A region-based tracking system equipped with static occlusion-reasoning, tracks the positions of the objects in the scene. Experiments show that they have achieved the processing rate of 63-150 Hz, with high average correct road detection, object-type classification rates of 93-94% and event detection accuracy of 85%. This paper emphasizes a road model used with the background difference algorithm. Also, a series of consistency test are performed in-order to prevent false foreground regions i.e., false vehicle objects in the scene. Earlier proposed systems couldn’t prevent vehicles that enter the scene and stop for a relatively long period of time from identifying as a default background object. They don’t know whether the visible object in the background is correct. A Road Detection Algorithm for estimation of model for pixels in the background that belong to the traffic roads is used, vehicles dominantly moving on the road, forms the training set and the pixels thus are classified as a road, forming a road model. Previously, static objects occlusions were just implicitly handled using heuristics. For e.g.: a tree that is occluding the background is just implicitly by simple formulae. The system presents an approach for handling it by obtaining the regions in the background that frequently occlude. For Thin-Structure Occlusions (TSO) by a thin object such as a thin light pole, sign pole, by splitting the vehicle, e.g. when the driver moves behind, vehicle gets split into two parts. A vehicle is enclosed by a bounding box, one side (back) of the tracked object remains static, while the opposite side moves in the direction of the object motion. These two observations are combined to obtain occluded regions. A naïve Bayesian classifier is used for the classification of objects. Different other 5 semantic elements such as vehicle or object length, width, object’s maximum speed, etc. The authors added the possibility of enhancement by inclusion of shadow handler for splitting more falsely merged objects. [17]

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