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DSTUS: A Deep Learning approach for Smart Traffic Updating System in GIS

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Abstract

Real-time traffic information plays an important role in our daily life. Traffic information helps us to understand the traffic congestion situation of different part of the city for various reasons such as traffic flow of a particular area, exact travel time to a destination, road condition, accident information etc. These days many vehicles carry an electronic device called black box to facilitate the personnel who operate the vehicle. Specifically, to find out the reason behind incident for an insurance claim and correct decision making. In this paper, we proposed a deep learning based smart traffic updating system which exploits black box video data. We collect the black box video data, process them and train them using deep learning model for accurate vehicle detection. After vehicle detection and counting the number, we send traffic information to the server for better decision making such as avoid gridlock situation or incident. Experiment result shows that our proposed method is a very cost-effective way to manage and update GIS information with cutting age technology. A Deep learning based GIS database will ease the needs for traffic information related to the perception and decision-making of transportation. DSTUS system will assist to predict model of the travel time of each road section in a specific city.

Keywords: GIS, CNN, Deep Learning, Big Data, Vehicle Black Box.

1. INTRODUCTION

Geographic information systems for transportation (GIS-T) references the application of geographic information technologies to control transportation systems as well as resolve shipment related challenges. GIS-T plays a pivotal role in our lives in diverse areas such as social, economic, geographic by Michael f. Goodchild (2000). It is a highly correlated with GIS applications where much costs of producing data and making decisions. Transportation is greatly related to the geographical information system to manage, visualize and analyze geographic data in order to improve correctness. In recent years, GIS data become part of GIS-T and helping the traffic management system due to the increasing demand, diverse transportation, and accurate information.

Traditional vehicles are converted to smart cars with carrying numerous devices which collect different types of data such as road information, maps, traffic flow, traffic congestion, traffic pattern, and car black box data. All these data are high in demand to provide state of the art quick solution to resolve the ever-increasing challenges. Gridlock and other security issue become more and more significant every day. Old-fashioned traffic management system is unable to solve this growing requirement by Jean-ClaudeThill (2000). Because traditional traffic application data cannot share data with other domains. Simultaneously, rapid urbanization also playing as a catalyst for environmental pollution as well as danger for the sustainable traffic management system. The regular traffic management system failed to provide smart decision making based on the gathered data. Therefore, GIS database for transportation (GIS-T) is important Liu R., Servières M. and Moreau g (2012). Traffic information among other data in GIS-T database is critical since it leads to very accurate result for any spatial analysis such as route finding in a road network. Therefore, these days accessing to update traffic information is so valuable by G. Salvi (2014).

Most techniques for producing updates traffic information have some limitations. Some techniques are so expensive such as installing traffic capture camera in each segment of the road, especially for developing countries. Some methods are so complex for calculating of various traffic big data. So we need to look forward to finding easy and cheapest methods in Yushi Chen, Zhouhan Lin, Xing Zhao, Gang Wang, and Yanfeng Gu, Member (2014).

These days almost vehicles contain a device called black box which captures video data utilize for many purposes, such as tracking the particular event or measure traffic situation in an area. To receive up to date GIS data, we can apply deep learning technique to improve the overall performance of large volume of black box data.

The objective of this paper is to propose a deep learning based method for updating traffic information for GIS database for a GIS-T application. In the next section, we analyze the literature of GIS-based traffic management system in videos data. We describe our method Deep Learning approach for Smart Traffic Updating System (DSTUS) in section 3. In section 4 we describe experiments carried out based on the black box dataset. In section 5 we explained our experiment result and contribution.

2. RELATED WORK

There have been many types of research done by professionals related to various techniques for updating GIS databases especially traffic data. For example, in general usage by Liu, R., Servières, M., & Moreau, G. (2012) and Kadri-Dahmani, H., & Osmani, A. (2003) presents a method for updating Geographic Information System (GIS) data from video. Alkan, M., & Jacobsen, K. (2015), Champion, N., Stamon, G., & Deseilligny, M. P. (2009) and Weis, M., Müller, S., Liedtke, C. E., & Pahl, M. (2005) explained using satellite Imagery for updating GIS database. Also for specific utilizing base on traffic data of GIS databases by Choosumrong, S., & Raghavan, V. (2011) states modified algorithm to searches of shortest path, time and safety route that supports dynamic changes information to develop a routing algorithm used a real-time cost updates based on current traffic condition for solving of the real road network condition. Road Traffic Estimation from GPS Data Using Incremental Weighted Update was introduced in Sananmongkhonchai, S., Tangamchit, P., & Pongpaibool, P. (2008) and Li, C., Liu, Y., Wang, Q., & Tai, Y. (2008) discussed a model for updating the trajectories of moving objects when unexpected traffic conditions occur.

For this, there are now a growing number of studies and scholarly papers on using Vehicle Black Box (VBB) for various topics. These days more attention is paid to preventing automobile-related violations. That has led to a growing number of VBB by Baker, W. E., & Sinkula, J. M. (2002). Along with VBB simple recording, now evolving into an intelligent one that can act a useful tool to provide convenience for drivers. A VBB system acts as the flight recorder of a vehicle which utilized to record the behavior of a running vehicle as a vehicular digital video recorder system as explained in Lin, C. C., & Wang, M. S. (2010). Most studies applied VBB for the field of accident management and crash data gathering intend to assist drivers to drive safe, and to identify the cause of an accident once it occurs such as Prasad, M. J., Arundathi, S., Anil, N., & Kariyappa, B. S. (2014), Kang, C., & Heo, S. W. (2017), Moon, H. M., Kim, K. H., Lee, M., Kim, P., & Pan, S. B. (2015)

Chung, Y., Song, T. J., & Kim, J. (2017) analyses injury severity in taxi-pedestrian crashes using more accurate crash data by VBBs such as time-to-collision, crash speed, crash angle, and crash region of vehicle and pedestrian. Black box used for proposing a smart vehicle for accident prevention in Mohamedaslam, C., Najeeb, N. A., & Nisi, K. (2016), Chung, Y., & Chang, I. (2015) used to collect crash data obtained from VBB tried to compare and evaluates these type of data by existing road crash data recording method, which has been recorded by police officers based on accident parties' statements or eyewitness's account. Also S. Y. Yi, J. H. Ryu, and C. G. Lee (2010) tried to recognize if a driver is off the lane on a real-time basis using VBB or some time to recognize a dangerous driving style Han, I., & Yang, K. S. (2009).

3. BLACK BOX DATA ANALYSIS BY CNN

A black box is usually attached to a mechanical device to monitor the performance of the vehicle. It is an event data recorder equipment that record and store data that is gathered by different sensor and indicators. This device can generate some alarm based on the video data it records and assists the driver. It also ensures the reason of accident such as driver's awareness, failure of an equipment in a vehicle, natural disaster, and safety issues by Lin, C. C., & Wang, M. S. (2010). Efficient use of this device can help proper maintenance due to its communication ability with the network and alarm system. Black box collects data from external environment using different sensors and camera. If an accident occurs black box can transmit emergency signal for quick emergency rescue by Chung, Y., & Chang, I. (2015). Moreover, the black box provides crucial information for the vehicle lifecycle management. The region-based convolutional Neural Network method R-CNN by Ross Girshick (2015) based object detector applied which achieved excellent vehicle detection accuracy. The R-CNN detector first fine-tunes Convent features then replace the softmax classifier learn by fine-tuning. In each bounding box, regressor training and features are extracted from each object proposals. Black box video data's are ConvNet forward pass for each vehicle proposal. Features are extracted for a proposal by max-pooling the portion of the feature map but performance is sluggish.

Figure 1. Car black box video data

3.1 DEEP LEARNING

Deep learning is a kind of machine learning and more powerful than shallow networks. DL dramatically improve the performance in many different research areas such as visual object recognition, video, audio, drug discovery, genomics [4] etc. There are different types of Deep learning architectures such as deep neural network, deep belief network, recurrent neural network, a convolutional network which gained outstanding results in computer vision, NLP, machine learning, bioinformatics areas.

These days deep learning applied in many GIS research to find out the patterns from a large volume of data that are useful for accurate traffic updating system. Conventional machine learning algorithm cannot process data in raw format however, DL can tackle this issue. In our experiment, we used VGGNet by Karen Simonyan, Andrea Vedaldi and Andrew Zisserman (2013) which is composed of convolutional layers that perform very small (3x3) filters.

3.2 DSTUS

A vehicle usually includes different type of sensors and indicators which acquires different parameters ensures the condition of that vehicle. These sensor and video data are preserved in memory storage such as a flash card. In our proposed method, we take the input video data then pre-process it. We apply our DSTUS algorithm to detect and count the vehicle mentioned in details in figure 2. After that, we send the data such as warning, vehicle condition, and traffic value to a server for decision making. The server contains the database of previously learned GIS information for particular warning and signal. Based on the traffic information such as a number of vehicles and the path information, analyzing the data and computation, server recommends the correct route for the system. Our proposed system also can indicate whether system faced an accident or not based on some parameter values.

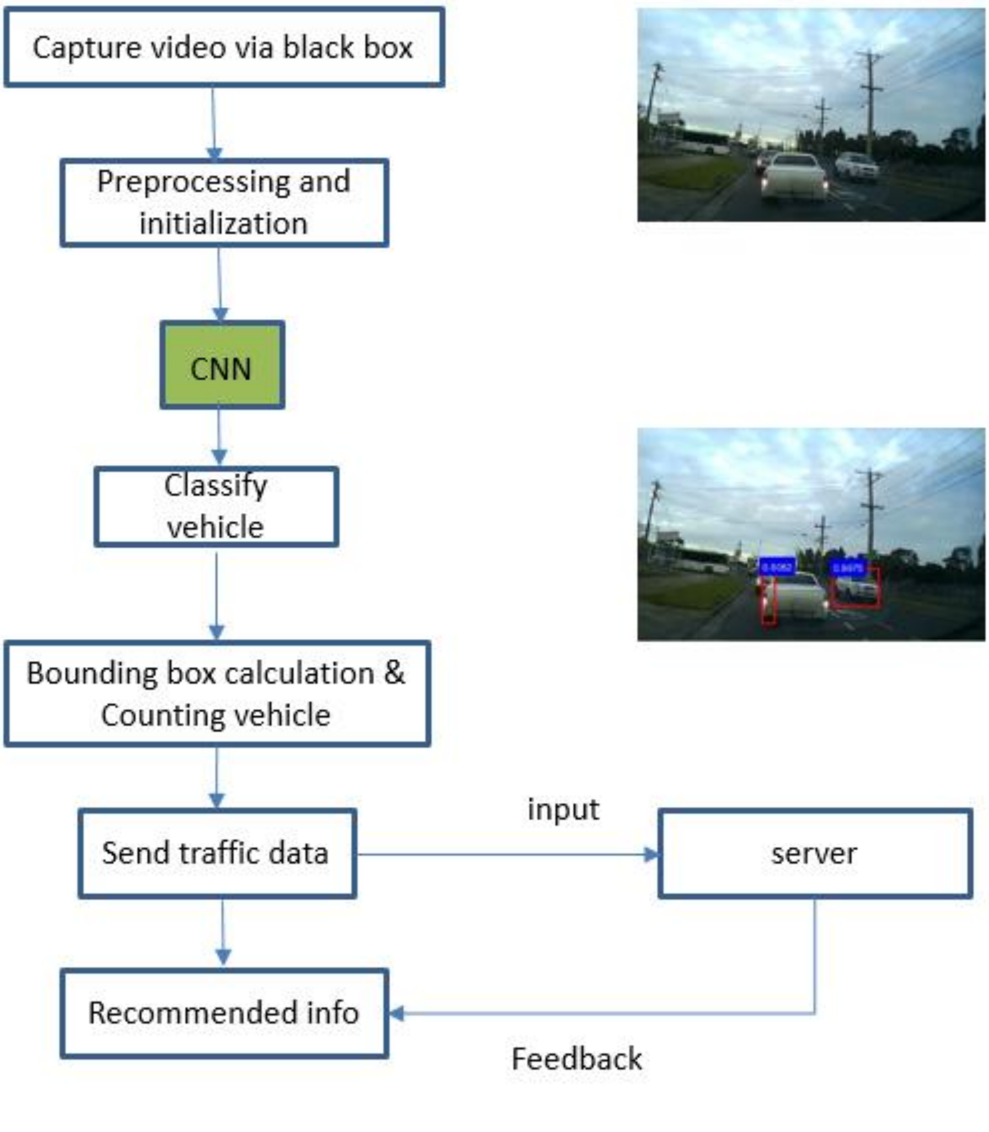

Figure 2. System architecture and design

In a nutshell, the whole flowchart of the proposed DSTUS algorithm as follows.

Algorithm 1. Vehicle Detection and Traffic Updating with DL feature

Input: Captured video clip

Output: Number of vehicle, Update traffic data

Initialize the video reader

For each video frame

Identify regions with intensity values above threshold

Compute CNN features

Classify vehicle

Count total number of vehicle

If number of vehicle > Max

Send traffic data and update

Else If

Continue

End If

End For

4 EXPERIMENTS

In this section, we present our way of experiment with algorithm design. Our proposed algorithm work in several steps. The video reader function reads video file in the first step which provides video properties such as height, weight, frame rate and video format. In the second step consider each frame and convert the color image to grayscale image. We suppress all the objects in the image that are not light-colored cars. In the third step, we apply Fast RCNN by Ross Girshick (2015) to detect the vehicle and remove noise such as small lane marking or other structures. In the fourth step, calculate area and centroid of each object are calculated. Finally, the entire procedure is continued until the N number of frame completed.

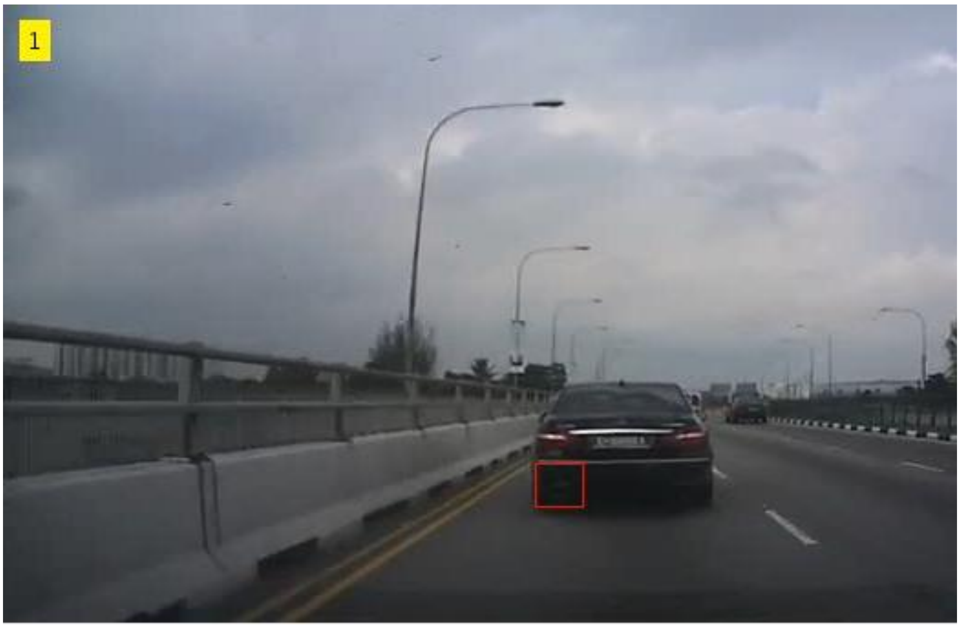

Figure 3. Number of car detected and counted based on foreground detector

Figure 3. Shows the number of cars detected from the video frame where the number of the vehicle is two but the foreground detector the only lower portion of the vehicle and counts one.

Figure 4. Number of car detected and total number of vehicle is two.

In figure 4. Shows the total number of the car in a video frame and detects the cars where the detector is based on fast RCNN algorithm. Our experiment uses publicly available VGG net model by Karen Simonyan, Andrea Vedaldi and Andrew Zisserman (2013) that has 5 convolutional layers and 3 fully connected layers. For the vehicle detection, we use Fast RCNN by Ross Girshick (2015) that is convolutional neural network based object detector with deep learning library Caffe. All implementations are done on NVIDIA GeForce GTX 970 graphics card. We use Matlab 2017b as a programming language with matconvnet by Andrea Vedaldi and Karel Lenc (2015) library using Windows platform in our experiment.

5. CONCLUSION

Our approach efficiently provides update traffic management information in a cost-effective manner due to use the black box video data which already exist with each vehicle. Both video and sensor data gathered automatically from the black box. It is straightforward than the traditional method we can also use the mobile network to communicate at the time of emergency. Our approach still needs to apply to the different type of dataset as well as benchmark dataset. For the experiment, we transfer the data from flash memory to computer hard disk drive. In future, we want to make it more efficient vehicle detection with higher accuracy.

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