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**Vehicle Traffic, Provided by City of Aarhus in Denmark**

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**Course:** DS670 - Capstone

**State of Art:**

The urban traffic congestion is transforming into an epidemic all over the world. The brisk increase in vehicle traffic has become one of the critical problems faced by cities all over the world. As a result of the constant traffic congestion, transportation cost has increased significantly due to all the time wasted on the road and the corresponding fuel cost.

**Expected Contribution:**

I plan to analyze how the Vehicle Traffic data collected can be used in making Aarhus a smart city in terms of traffic guidance and management.

**Introduction:**

Diverse, forefront and fun, Aarhus is a champion among a delighted urban zones on Earth. It moreover happens to be the European Capital of Culture 2017. 13% of Aarhus' people are understudies, making Aarhus the most energetic city in Denmark. For the most part, in any case, it's a standout amongst the most settled. 315,000 people live in Aarhus and 1.2 million people live in the more significant Aarhus area, so it's the perfect size for an end of the week break or family getaway. Being young on an essential level infers that the city can offer you an extensive variety of social experiences, from nightlife, social events and shopping to the best restaurants in the region. Aarhus is moreover home to predominant festivals, for instance, food festival, spot festival, and NorthSide Music Festival.

The dataset assigned for the capstone project is the “Vehicle Traffic, Provided by City of Aarhus in Denmark” from CityPulse dataset collection. A collection of datasets of vehicle traffic, observed between two points for a set duration of time over a period of 6 months (449 observation points in total). The data is available in raw (CSV) and semantically annotated format using the citypulse information model. This proposal looks at how the Vehicle Traffic data collected can be used in making Aarhus a smart city in terms of traffic guidance and management.

**Data description/structure:**

A collection of datasets of vehicle traffic in the city called Aarhus in Denmark, observed between two points for a set duration of time over a period certain months (449 observation points in total). The data is available in raw (CSV) and semantically annotated format using the Citypulse information model. There are total four (4) different datasets over different durations available: 1st data set: February 2014 to June 2014, 2nd data set: August 2014 to September 2014, 3rd data set: October 2014 to November 2014, 4th data set: July 2015 to October 2015

**References:**

1. **Yan Qi, Sherif Ishak, (2013) "Stochastic Approach for Short-Term Freeway Traffic Prediction During Peak Periods", Intelligent Transportation Systems IEEE Transactions on, vol. 14, pp. 660-672, ISSN 1524-9050.**

This paper examines and models the fundamental stochastic traits of freeway traffic development direct under a broad range of movement conditions in the midst of peak periods. It then applies the models to short-term traffic speed prediction. The speed move probabilities are assessed from genuine 30-s speed data over a six-year time traverse at three remarkable territories along the 38-mi way of Interstate 4 (I-4) in Orlando, FL.

The limitation of the paper is that it looks the statistical models for short-term traffic prediction during peak periods only. As congestion is not the same under different conditions, such transitions into and out of congestion is probabilistic and thus subject to change. It is important to look at long-term periods of traffic, both during peak and off-peak hours.

1. **Yu Hu, J. Hellendoorn, "Daily traffic volume modeling based on travel behaviors", *Networking Sensing and Control (ICNSC) 2013 10th IEEE International Conference on*, pp. 639-644, 2013.**

This paper looks at a model of traffic volumes in light of mix showing in which the variables contain the information on travel behavior. It first provides a general model to show how the traffic volumes can be estimated by a Gaussian model. The model looks at three interstate volume sets and six traffic data sets from the Netherlands.

We are not sure about the basis of the data about the travel behavior. It would be affected by the procedure of data collection which could hugely impact the overall model.

# Guo-guang He, Shou-feng Ma, "AI-based dynamic route guidance strategy and its simulation", Intelligent Transportation Systems 2001. Proceedings. 2001 IEEE, pp. 28-32, 2001.

This paper looks at the dynamic route guidance system through traffic flow process. Traffic flow process is quite dynamic and complex with lot of uncertainty. The authors attempt to look at a different strategy to determine the route guidance.

*Dynamic route guidance system must be intelligent because traffic flow process is a complex process with the high uncertainty. In this paper, a new strategy for dynamic route guidance based on artificial intelligence is proposed, and its simulation results are given.*

1. **Ran Tao, Yugeng Xi, Dewei Li, "Simulation analysis on urban traffic congestion propagation based on complex network", *Service Operations and Logistics and Informatics (SOLI) 2016 IEEE International Conference on*, pp. 217-222, 2016.**

The point of this paper was to dissect the relationship amongst connections and investigate the impact traffic congestion based on the increase in number of vehicle. The article looks at the Average Journey Velocity (AJV) to measure the degree of link congestion. The study also looks at how the location and the adjacent location links can influence the congestion proliferation.

The limitation of this study is that the variable used for the theory that is being proposed is not complete. Additional variables/measures could be used to make the model robust.

1. **Wenbin Hu, Liping Yan, Huan Wang, "Traffic jams prediction method based on two-dimension cellular automata model", *Intelligent Transportation Systems (ITSC) 2014 IEEE 17th International Conference on*, pp. 2023-2028, 2014.**

The research article looks at the traffic congestion prediction using a two-dimension cellular model, inspired by the Biham, Middleton and Levine (BML) model. The model is thought to be effective in determining the various characteristics of the traffic network. The model is supposed to accurately position the traffic congestion at the intersection. The key contribution includes a practical method to map the traffic structure into a modified BML and propose a solution to the conflict points.

The limitation of this study is that we are not aware about the data and the length of the study. We are also not aware of the accuracy of the data collection at the intersection.

1. **Yanyan Xu, Qing-Jie Kong, Reinhard Klette, Yuncai Liu, "Accurate and Interpretable Bayesian MARS for Traffic Flow Prediction", *Intelligent Transportation Systems IEEE Transactions on*, vol. 15, pp. 2457-2469, 2014, ISSN 1524-9050.**

The paper looks at an adaptable spatiotemporal Bayesian multivariate adaptive-regression splines (ST-BMARS) model to interpret and predict the interpretability of the prediction model. The authors look to predict the short-term freeway traffic flow accurately. The variables of the model are estimated in the way of a Bayesian inference. The optimal models are also derived using the Markov chain Monte Carlo (MCMC) simulation in this article.

The limitation of the paper is that it also looks the statistical models for short-term traffic prediction. The traffic congestion is a complex phenomenon and requires long-term traffic prediction based on different variables and different times.

1. **Bingnan Jiang, Yunsi Fei, "On-road PHEV power management with hierarchical strategies in vehicular networks", Intelligent Vehicles Symposium Proceedings 2014 IEEE, pp. 1077-1084, 2014.**

In plug-in hybrid electric vehicles (PHEVs), the power administration framework arranges power train operations to accomplish high energy efficiency. With the quick change of vehicular frameworks and explosion of smart phones, real time traffic movement can be assembled by phones from a vehicular framework keeping in mind the end goal to support online PHEV control organization. This paper proposes an on-road PHEV control organization computerized physical structure (CPS) with 2-level dynamic enhancements to restrict the fuel use of a trip.

The limitation of the paper is that it relies on the hybrid vehicles and the smart phones real time data which may not be the case with every vehicle on the road. Any study that looks into the traffic has to account for all variables, not just a limited few.

1. **Hongbin Yina, S.C. Wongb, Jianmin Xua, C.K. Wongb “Urban traffic flow prediction using a fuzzy-neural approach”, *Transportation Research Part C: Emerging Technologies*, Volume 10, Issue 2, April 2002, Pages 85–98**

The paper looks at developing a fuzzy neural model (FNM) to estimate the traffic pattern in an urban street. This is considered a major factor in the traffic control system. The model has two modules, a gate network (classifies the input data into clusters using a fuzzy logic) and an expert network (determines the input-output relation in a conventional neural network approach.) The model looks at both simulation and real observations to determine its effectiveness.

The limitation of this study is that we are not aware about the data and the length of the study. It is also limited by the limitation of Neural Networks.

1. **Yongtao Yu, Jonathan Li, Haiyan Guan, Cheng Wang, Chenglu Wen, "Bag of Contextual-Visual Words for Road Scene Object Detection From Mobile Laser Scanning Data", Intelligent Transportation Systems IEEE Transactions on, vol. 17, pp. 3391-3406, 2016, ISSN 1524-9050.**

The research paper looks at an innovative algorithm to detect road objects like poles, traffic signs, cars, etc. from a 3D mobile laser scanning point. The evaluation of this study showed to achieve a high level of recall, precision, quality and F-scores.

The author didn’t mention the details of data to analyze if it looked through a long-time frame to make sure it was not looking at short-term congestion planning.

# N. Zheng , “ Toward intelligent driver-assistance and safety warning systems ,” *IEEE Intell. Syst.*, vol. 19, no. 2 , pp. 8 – 11 , Mar./Apr. 2004 .

This article looks at an Intelligent Vehicle Platforms project whose aim is to promote the use of intelligent technology for safe, efficient, and smart vehicles, and to prototype vehicular electronic and sensory products and systems. The project plans to advance the utilization of canny innovation for sheltered, effective, and savvy vehicles and to model vehicular electronic and tactile items and frameworks for the Chinese car industry. One of the venture's key targets is to build up a vehicular application-particular working framework (vASOS).

The limitation of this article is that it looks from the angle of developing intelligent vehicles and automated driving which could provide driver assistance and safety warning systems. It doesn’t particularly look at the issue of solving the congestion problem from the current available data by suggesting alternatives.

1. **Fawzi M. Al-Naima, Hassan A. Hamd, “Vehicle Traffic Congestion Estimation Based on RFID,” *International Journal of Engineering Business Management*, November-07-2012.**

The paper looks at the use of Intelligent Transportation Systems (ITS) to obtain traffic information. The authors rely on the use of Radio Frequency Identification (RFID) and the proposal for simulation system for the Vehicle Traffic Congestion Estimation (VTCE) based on RFID which could get the information on a Central Computer System (CCS).

The main limitation of this study is that it depends on the VTCE system to be implemented. It would need a larger data to provide the traffic information and ensure robustness.

1. **T. Thianniwet, S. Phosaard and Wasan Pattara‐ Atikom,  ʺClassification of Road Traffic Congestion Levels from GPS Data using a Decision Tree Algorithm and Sliding Windows,ʺ *Proc. of the World Congress on Engineering WCE 2009*, Vol I, ISBN: 978‐ 988‐17012‐5‐1, July, 2009, London, U.K.**

In this article, the authors explored an option method to naturally order the street activity blockage levels that was profoundly steady with street clients' judgments. The system negligibly required information from GPS gadgets. GPS information can be gathered from members through mobile data network. The article looks at a way to identify traffic congestion from the velocity of mobile sensors.

The limitation with this study is that it doesn’t account for the vehicles without the mobile data information. It also looks at human perception to rate the traffic congestion, which is subject to bias.

1. **Anonymous, Waze partnerships help citizens avoid traffic congestion. (2015). *Institute of Transportation Engineers.ITE Journal*, 85(5), 28.**

The study talks about a crowd sourced based navigation app that will gather information from the drivers.

The study’s limitation is the reliance on the drivers using the smart-phone and the related app. It can’t be used in our case as we already have the data from the drivers.

1. **Li Xia, Dong Siyi, Wu Shuhua, Research on intellisense information service oriented to value network model in smart city, *2016 IEEE International Conference on Information and Automation (ICIA)*, 1-3 Aug. 2016**

The article looks at the usage of smart phones, RFID, sensors and two dimensional codes to obtain real-time information. The authors propose to build a value network model and use that framework model of intellisense information service for smart city to accurately interpret the information.

The main limitation of this study is that it depends on the RFID system to be implemented. It would need a larger data to provide the traffic information and ensure robustness. The storage and analysis are difficult to implement.

1. **Dinesh Singh ; C. Vishnu ; C. Krishna Mohan, Visual Big Data Analytics for Traffic Monitoring in Smart City, Machine Learning and Applications (ICMLA), *2016 15th IEEE International Conference on* *Information and Automation (ICIA)*, 18-20 Dec. 2016**

The paper looks at video surveillance for traffic control in shrewd cities needs to analyze the immense total (hours/days) of video footage to locate the overall public who are violating the traffic rules. The standard computer vision techniques can't analyze such a huge measure of visual data created continuously. Along these lines, there is a prerequisite for visual gigantic data analytics which incorporates dealing with and looking at broad visual data, for instance, images or videos to find semantic illustrations that are profitable for interpretation. The paper proposes a structure for visual gigantic data analytics for modified detection of bike riders without a head defender in city traffic. It analyzes the challenges required in visual colossal data analytics for traffic control in a city scale surveillance data and explores open entryways for future research.

The limitation of this paper is that it relies only on the video data. It doesn’t account for the data where there is no video surveillance. That could also be added to the prediction model to make it dynamic.

1. **B. Abreu; L. Botelho ; A. Cavallaro, Video-based multi-agent traffic surveillance system, *Intelligent Vehicles Symposium, 2000. IV 2000. Proceedings of the IEEE,* 5-5 Oct. 2000**

This paper depicts Monitorix, a video-based activity observation multi-specialist system. Monitorix agents are assembled into four levels, as indicated by the sort of data preparing they play out: the sensors and effectors level, the target depiction level, the application aide level, and the client colleague level. The video investigation calculations utilize a versatile, information driven, application autonomous way to deal with concentrate highlights from the video crude information. Regardless of the differing qualities of operator errands, versatile learning calculations are utilized as a part of generally cases. The reconciliation of video investigation calculations and operator technology is made by means of a unique center specialist called Proxy. Monitorix is a completely decentralized multi-specialist system living in a FIPA Platform and utilizing FIPA Agent Communication Language. Tracking of vehicles crosswise over non-overlapping cameras is performed by the Tracker operator, utilizing an activity model and learning calculations that tune the model parameters.

The limitation of this paper is that we are unsure about the accuracy of the tracker operator. Also, the algorithm might not be suitable all the time based on the vehicle tracking.

1. **Kirchner ; C. Ameling, Integrated obstacle and road tracking using a laser scanner, *Intelligent Vehicles Symposium, 2000. IV 2000. Proceedings of the IEEE*, 5-5 Oct. 2000**

Autonomous vehicles require material commitment from the earth. Here, a laser scanner mounted on the front bumper is used to give expand data of a level profile before the vehicle up to the biggest partition of one hundred meters. Diverse vehicles are detected and followed in dynamic breadths yielding their position and speed vectors. As far as possible involving crash limits and reflector presents is used on gage the parameters of a clothoid model. The blend of question taking after and constrain estimation realizes both an all the more capable and accurate estimation and updated learning of the general traffic situation. By considering prior assumptions a way stamping of vehicles is possible. Results are showed up with recorded honest to goodness traffic data.

The limitation of the paper lies in the detection of the obstacle and the overall working ability of laser scanner. There can be situations when laser scanner might not be able to work properly or need maintenance.

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1. **Kai Zhu, Jiangxiang Li, Haofeng Zhang, "Stereo vision based road scene segment and vehicle detection", Information Technology and Electronic Commerce (ICITEC) 2014 2nd International Conference on, pp. 152-156, 2014.**

A stereo vision-based road scene bit and vehicle detection method were proposed in this paper. In the method, First, dynamic programming was used for stereo organizing, and after that bewildering pixel were cleared by left-right-consistency check; Second, V-uniqueness was worked by handling the disparity map, and a snappy projection based line detection method was used to detect lines in V-dissimilarity map, starting their ahead, the road surface and vanishing line was extracted, and the meeting point of road and vehicle was enlisted; Third, the U-distinction map was attempted to detect the level position of vehicle. The test happens have exhibited that our method can extract road region successfully and can detect vehicle position precisely too.

The paper limitation is the technical ability of the vision detector and its ability to correctly detect the position of the vehicle.

1. **M. Finnefrock, Xinahua Jiang, Y. Motai, "Visual-based assistance for electric vehicle driving", *Intelligent Vehicles Symposium 2005. Proceedings. IEEE*, pp. 656-661, 2005.**

This paper presents an uncommon help system for driving a vehicle. It develops a flawless smart vehicle that recognizes hindrances utilizing the mounted sensors, which give sufficient visual-based guide. To this end, it utilizes an infrared camera, a laser go pioneer, and a gyro sensor so that these sensors give some helped visual signs to a driver to recognize astonishing obstructions. In this proposed vehicle, it develops a couple of charming modules. For example, despite a 2D warm map gave by the infrared camera, the system offers significance to the map by utilizing the accompanying results of the whirligig. The significance values in the locale of interests are figured in a consistent video frame rate by development stereo from a lone far-infrared camera, in light of standard pinhole point of convergence show. It develops a graphical representation of a virtual camera so that the driver can see the field of view showed by the mounted sensor. The laser develop sensor will compensate the camera by growing the field of view and offering accuracy to perceived things. Indoor-based test comes to fruition using a helpful electric scooter show the likelihood and advantages of this new sensory approach on the driving partner system.

The limitation of this paper is the question of accuracy of the sensors is in identifying the unexpected obstructions. Furthermore, it is also important to look at the maintenance of the sensors regularly.

1. **Claudia Pantiruc, Mihai Negru, "FPGA based CAN Data Visualization", Intelligent Computer Communication and Processing (ICCP) 2011 IEEE International Conference on, pp. 245-252, 2011.**

In the latest years the urban road traffic got the chance to be full, requiring higher watchfulness from the driver. Remembering the true objective to ensure an unrivaled road security, the auto makers fight to offer obstruction detection and representation capacities with respect to driver help with troublesome conditions. The fast planning speed and diminished power usage offered by FPGA contraptions help overcome the issue of ceaseless obstruction detection. This paper shows a system that uses a FPGA-based hardware use for articles representation. The information about the outside environment is obtained from a stereo vision system set inside a vehicle, through the CAN (Controller Area Network) transport. The system is fit for rendering low down inquiries dynamically, helping the drivers to take speedy decisions while going up against troublesome conditions and keep up a vital separation from setbacks.

This paper takes into account that the driver will take decisions through the FPGA hardware about the object representation. The limitation of the paper is the impact of human errors. The driver may not be able to read the interpretation correctly from the FPGA hardware and end up taking wrong decisions.