M2Smart NewsLetter

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M2SMART PROJECT ONLINE MEETING

ODA White Paper was handed over to the Indian Embassy in Tokyo

by Tsuboi Tsutomu (Project Leader)

Overview M2Smart activities of 2020 and next challenge in 2021

We were in the severe condition under COVID-19 in 2020. The COVID-19 has expanded its influence just after IITH meeting and Workshop in Ahmedabad in January 2020. And M2Smart activities has to be conducted remotely almost whole year. However, we did not stop our activites with all project team membses’ strong efforts and succesfuly conducted 6 times on-line meetings in 2020 for sharing each rserach activities. In 2021, this year will be essential final year of M2Smart and we will do our best.

ODA White Paper has published from Ministry of ForeginAffars of Japan

Dr. Tsuboi had a meeting with Ms. Mona Khandhar, Minister Economic & Commerce, Indian Embassy in Tokyo and handed over the Official Development Assistance (ODA) White Paper Book in which our M2Smart Project has been highlighted as one of the outstanding overseas activities in 2019. The Mister supported strongly our M2Smart Project and she showed high expectation as a good example of the coming years of “Low Carbon” Smart City.

Dr.Tsuboi handed over ODA White Paper to Ms. Khandhar, Minister of Indian Embassy in Tokyo on 29th of December 2020

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Preparation for the Handbook of Multimodal Transport for Smart City-Application of Sensing, Networking and Big Data Analysis

by Atsushi Fukuda (Co-project manager /Group 4 leader) and Hiroki Kikuchi (Group 4)

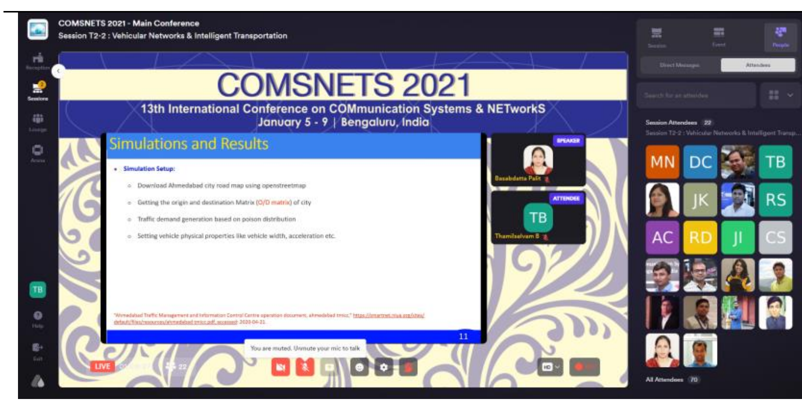
This handbook aims to introduce advanced technologies to realizing smart cities by multimodal transport by summarizing the results of M2 SMART. It consists of two parts of "Role of Multimodal Transport for Smart City" (Part I) and "Advanced Technologies to Realize Multimodal Transport" (Part II). In Part I, the outline of multimodal transport for a smart city will be introduced. In Part II, the developed individual methodologies for the smart cities by multimodal transport will be presented with some case studies. Currently, each research group is writing a manuscript, and Group 4 will proceed with editing work as soon as the manuscripts are collected. Please look forward to our handbook publishing!

Image of Handbook (Part II)

"Scalable Coordinated Intelligent Traffic Light Controller for Heterogeneous Traffic Scenarios Using UPPAAL STRATEGO", COMSNETS 2021

by Subrahmanyam Kalyanasundaram (Group 3), M.V. Panduranga Rao (Group 3) and Thamilselvam B

We propose a new approach for coordinating traffic flows in large cities that helps in reducing the travel time and carbon emissions from vehicles. We use the UPPAAL STRATEGO tool chain that leverages statistical model checking and machine learning for synthesizing optimal traffic coordination strategies. Our approach employs a hierarchical view of the city with two levels — individual traffic intersections and area controllers. While the choice of a phase at an intersection is decided locally, the phase threshold is decided at the level of an area consisting of several intersections.



The algorithm and models that we report in this paper are a nontrivial generalization of previous approaches that used UPPAAL STRATEGO. This generalization allows scaling to large cities with several traffic intersections, with improved results. We compare our approach against other techniques including fixed-time and fully-actuated controllers. Experiments show that the it performs better in terms of waiting time and carbon emissions, especially in scenarios of changing traffic loads. Our approach also reduces overall and individual delays at intersections.

Vehicular exhaust emission under real-world driving conditions: Role of electric -vehicles on reducing pollutant emission

by Digvijay S. Pawar (Group 3 Leader), Chandrashker C, Prashansa Agrawal and Rachakonda Yashasvi

The current study mainly focuses on the development of driving cycle for E-rickshaw, to evaluate the impact of driving characteristics. In this study, real-world driving data for 100 trips of E-rickshaw are collected on a road stretch passing through the rural and urban setting. A high-end GPS data logger was used to collect vehicle kinematics such as continuous speed profile, acceleration/deceleration, heading, and vehicle position coordinates. The driving characteristics representing actual traffic condition are identified and used for developing E-rickshaw driving cycle (ERDC) using random selection and k-means clustering method. Development of final driving cycle is shown in Figure 1. This study insight can be used to understand and model the performance of electric vehicles, in terms of energy consumption and driving characteristics, compared to other fossil-fuel driven automobiles.

The study also measures vehicular exhaust emission under real-world driving conditions from auto rickshaw, to understand the potential reduction of tail-pipe CO_2 by shifting ICEVs to electric vehicles. In this study emissions (CO_2 and CO) were developed for diesel auto rickshaw using a Portable emission measurement system (PEMS) on rural and urban traffic conditions in Hyderabad, India. The study investigates the effect of constant and real-world speeds on emission rate. The results show that the constant speed curve of the emission rate lies below the real-world speed curve shown in Figure 2. The insight from the study can be used to understand the emission factors from diesel auto rickshaws and also the effect of speed on emission rate, which will be helpful for the implementation of congestion mitigation strategies and speed management system to policy decision-makers for better air quality.

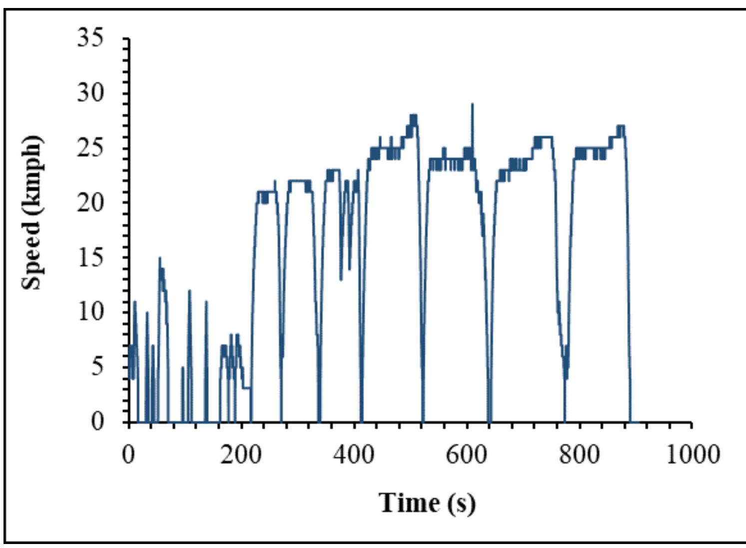


Figure 1. Development of driving cycle for e-rickshaw

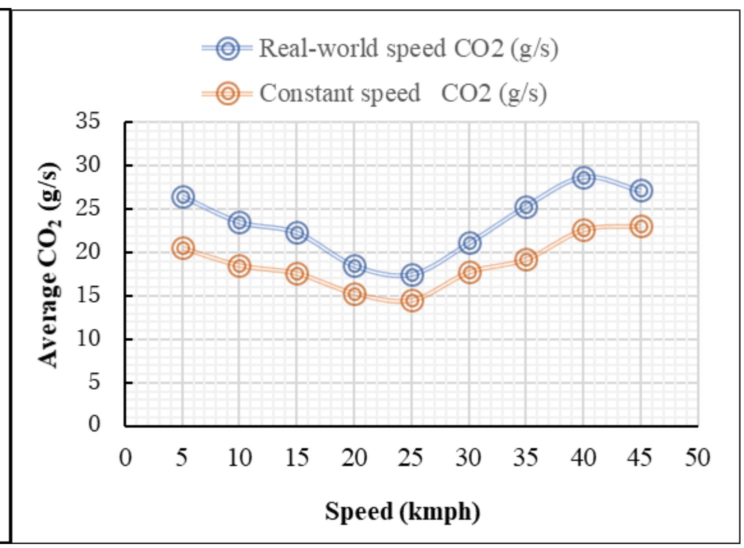
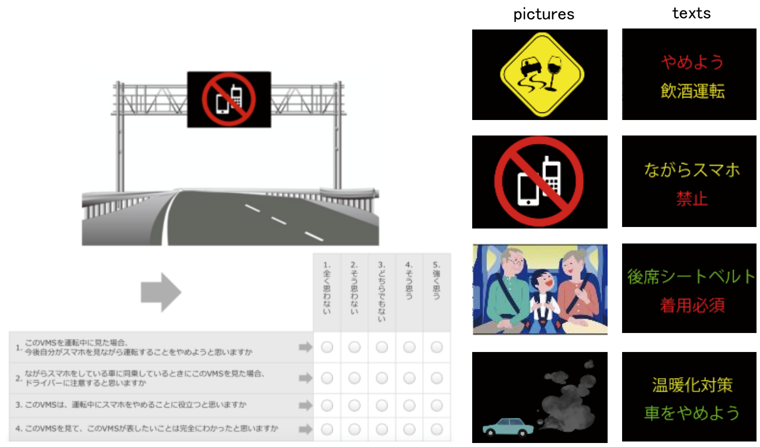


Figure 2. Average CO2 emission for real-world and constant speed

"Scalable Coordinated Intelligent Traffic Light Controller for Heterogeneous Traffic Scenarios Using UPPAAL STRATEGO",

Effective Design of VMS for Drivers' Mind Change

by Tomoya Kawasaki (Group 3)



In Ahmedabad, Variable Messaging Sign (VMS) are installed in 11 locations as a part of the Intelligent Transportation System (ITS). We examine what type of display would be more meaningful to change driver's mind for the sustainable transportation system.

In the questionnaire survey, we indicate two types of displays such as "pictogram" and "text" as shown in the figure. Our proposed VMS varies the color and the number of massage lines. In our research, we examine the effects of color scheme and message lines of VMSs on drivers' phycological intentions to change driver's mind. Collected data are analyzed by statistical tests and obtained following insights.

(1) Possibility of changing driver's behavior: Significant difference between pictures and texts was found only in "wear seat belt." The statistical results imply that low possibility of behavioral change in "eco-transportation".

(2) Understanding of display contents: One of the funfamental peoblems for VMS is to let drivers to understand the intention of displays. From the statistical analysis, text is significantly higher than logo for understaning the contents of VMS.

Further studies on VMS display is to explore the effectiveness on "No Idling Policy" to improve air quality and reduce CO2 emission as well as save their fuel cost. The other is reducing a sudden deceleration and acceleration for the same impact. This is a future work in the final year of the project.

Machine Learning Method for Spatio-Temporal Prediction of Roadside PM2.5 based on Sparse Mobile Sensing and Traffic Information

by Soumya Jana (Group 4 Co-leader) , Satish Kumar Reddy M V and Anand Kakarla

Estimating road-side PM2.5 can be important steps in understanding the carbon footprint of transportation sector. Roadside PM2.5 have been estimated based on readings from road-side static sensors and can be extended by making ambient atmospheric measurements at high spatio-temporal resolution near all road segments at hand so that the dependency between emission and traffic information could exhaustively be modeled. However, the cost of covering the roadways of an entire city with densely deployed sensors would likely be prohibitive even in developed countries. As an alternative, mobile sensing has been suggested, and demonstrated using accurate but expensive portable equipment including gas analyzers. To further bring down the cost, while sacrificing a degree of accuracy, mobile sensing using low-cost imprecise sensors has been suggested. Of course, one must meaningfully interpolate readings from mobile sensing, whose inherent spatio-temporal resolution could be inadequate for practical application. In this connection, a well known spatial interpolation method makes use of land use regression (LUR) models involving certain explanatory variables that empirically categorize road segments according to certain characteristics.

However, LUR models, being temporally invariant, cannot satisfactorily characterize urban road segments as dynamic environments. We presently attempt at filling the gap by proposing a spatio-temporal prediction technique, which, instead of mapping road segments to explanatory variables, obtains a direct relationship between emittant concentration and location, time and traffic level and related information using machine learning (ML). In the process of prediction, the

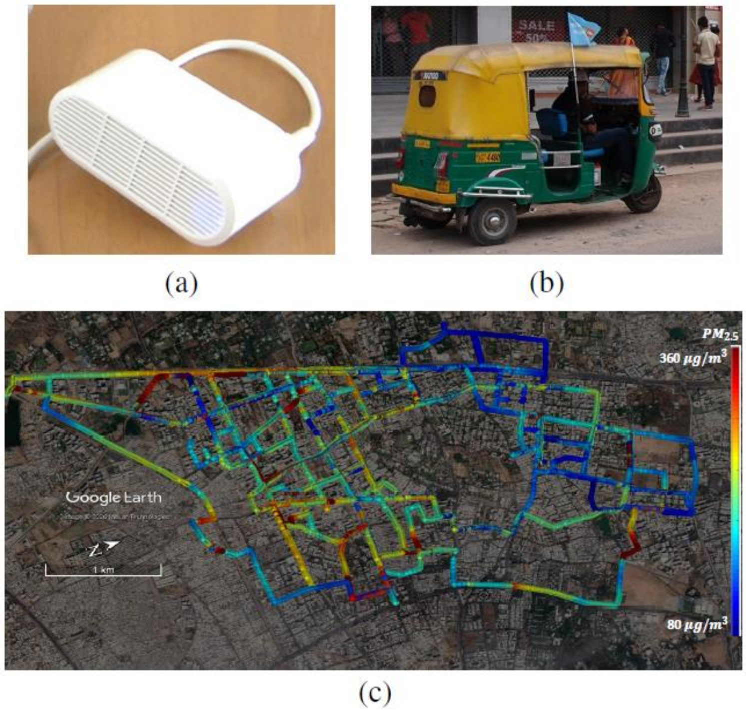


Figure: (a) Compact PM2.5 *sensor; (b) Auto-rickshaw used for data collection; (c) Google map of ROI showing the chosen routes along with the corresponding color-coded* PM2.5 *concentration values*.

proposed technique does not merely interpolate, but tends to suitably modify the readings to ensure consistency among predicted values in terms of suitable criterion.In our work, we elaborate on the proposed prediction principle, and demonstrate it by relating traffic information with low-cost readings of PM2.5, a source of health hazard, with significant contribution from vehicular emission.

In our experiment, each of the volunteers recorded PM2.5 readings at different time instants using a compact sensor (Figure (a)), while traversing road segments located in a commercial area of the Indian city of Ahmedabad in a three-wheeled vehicle (auto-rickshaw, Figure (b)). The overall trajectory thus described is shown in Figure (c). Along with each reading, traffic levels were subjectively recorded as well. Based on collected data, we pose a regression problem to predict the PM2.5 level as a function of location, time and traffic level.

Subsequently, we develop candidate solutions based on select well known ML models, including ensemble methods such as Random Forests (RF), Light Gradient Boosting Machine (LGB), Extreme Gradient Boosting (XGBoost, XGB), and categorical Boosting (CB), as well as Support Vector Regression (SVR). We compare test performances based on root mean-squared error criteria, and pick the superior model as our proposed method. As expected, we observe that the prediction is more accurate, when information about traffic level is considered.

	Training of models						Testing of trained models						
Metrics	SVR	CB	LGB	RF	XGB	Ref*	SVR	CB	LGB	RF	XGB	Ref*	Gain (%)
RMSE (μg/m^3)	7.38	5.17	4.00	4.12	1.22	**1.20**	13.19	12.57	11.95	11.30	**10.38**	10.62	2.31
R^2 (%)	96.01	98.04	98.83	98.76	**99.89**	99.89	87.26	88.43	89.55	90.65	**92.11**	91.74	0.4
MAE (μg/m^3)	1.87	3.32	2.19	1.90	0.74	**0.72**	5.59	6.89	6.16	5.20	**4.87**	5.15	5.74
Comp. time (sec)	45.65	3.24	**1.35**	2.13	2.49	1.58	0.06	0.05	0.07	0.06	0.05	**0.03**	-40

*STP by XGB model trained based only on location and time excluding traffic level information

Table: Performance comparison (superior value in boldface)

Chemiresistive Gas Sensor for Monitoring of low ppm CO gas with high Selectivity at Room Temperature

by Shiv Govind Singh (Group 4) and Venkata Ramesh N

In recent years, the development of gas sensors has attracted attention due to the air pollution caused mostly by in combustion of fossil fuels in automobiles, fuel-based home appliances and various industries. At present, 90% of the world's population lives in areas that exceed the world health organization (WHO) limit on air pollution. Air pollutants include carbon monoxide (CO), nitrogen oxides (NO_2), sulfur dioxide, and volatile organic compounds (VOCs) have caused harmful effects on human health. Among the various toxic pollutants, CO and NO_2 causes greater concern to human health in the sub-ppm concentration level. Thus, public health and safety controls are much needed for environmental monitoring to protect them against toxic pollutants, and therefore low cost and highly effective sensor system are desperately needed. Generally, the toxic air pollutants are being detected with the conventional techniques such as gas chromatography and mass spectroscopy, involving tedious measurements which make expensive and may take a longer time for analysis. However, low-cost gas sensor systems often display promising sensing characteristics such as high response, short response time and recovery time, long-term stability, excellent reproducibility, and operating at low temperatures. Nevertheless, these gas sensors have numerous limitations include low selectivity and high detection limits, which reduces the usage in practical applications. In this aspect, we have fabricated graphene-cerium oxide-based CO gas sensor, which has a superior selectivity over many atmospheric gases (NO_2, NH_3, SO_2, CO_2) and displayed excellent performance to detect the low concentrations of CO gas. The schematic diagram of the fabricated gas sensor and sensing characteristics are as shown in figure below.

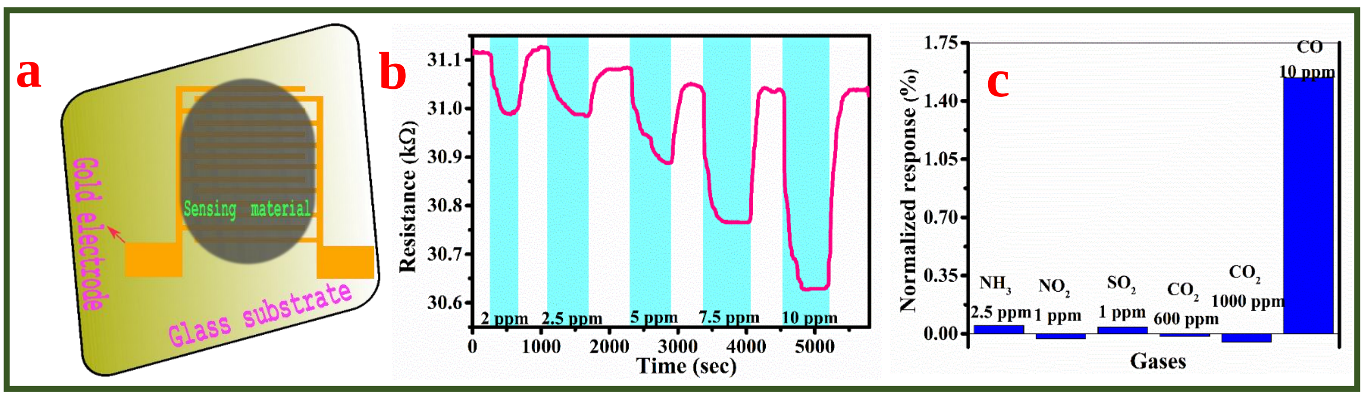


Fig. (a) Schematic diagram of gas sensor. (b) Dynamic sensing response of the sensor from 2 ppm to 10 ppm.

(c) Selectivity of the sensor over other interfere gases in the air pollution.

Message from Graduating RA

Traffic forecasting using Deep Learning

by Shounak Kundu

I would like to thank Dr. Maunendra Sankar Desarkar and Dr. Srijith P.K. for giving me this opportunity and their guidance.I also would like to thank M2Smart Project, JICA and JST.

I have explored the Ahmedabad dataset and used several deep learning techniques. I have explored the Social LSTM and Deep Transformers model apart from other Deep Learning-based models. I have taken the Ashram Road junction (Figure: 1) for the experiment. The data is collected from August 1 ,2018, to August 31, 2019. It contains 5,19,556 data points.

Transformers model is extensively used in Natural Language Processing tasks (like Text Translation, ChatBot, Text Summarization etc.). I have also used the Transformers based model on the Ahmedabad dataset to predict traffic count. I found out that the Deep Transformer model has out-performed other approaches (except on the MAE evaluation metric).

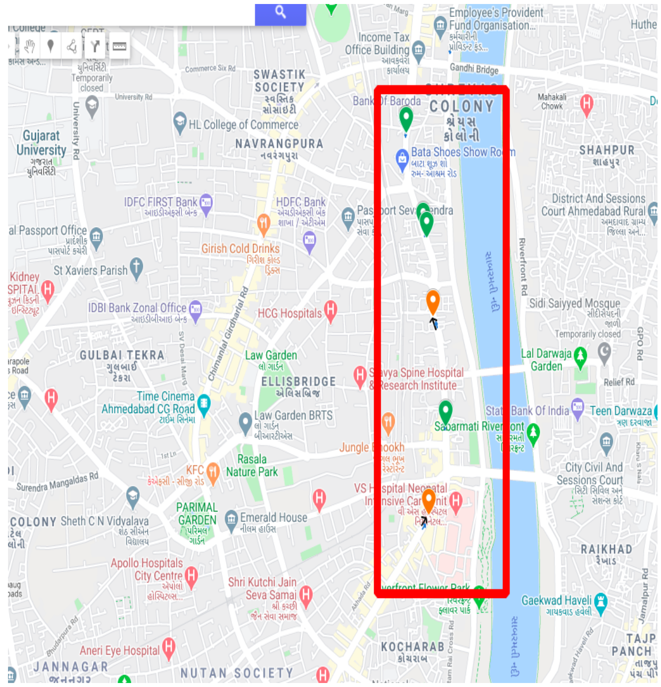


Fig 1 : Ahmedabad Junction

Model architecture is shown in Figure 2. I found out that the Deep Transformer model has out-performed other approaches (except on the MAE evaluation metric). (Figure 3 and Figure 4)

Models	Evaluation metrics on Ahmedabad dataset		
	RMSE	*MAPE*	*MAE*
LSTM	16.44	33.38 %	12.19
Conv. LSTM	15.73	23.60 %	11.10
Social LSTM	15.45	20.97 %	**10.69**
Deep Transformer	**15.43**	**20.08** %	10.76

Fig 3 : Comparison for various models

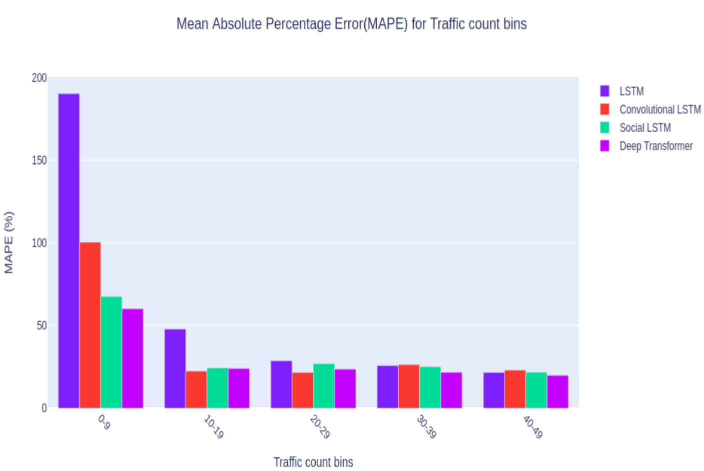


Fig 4: Mean Absolute Performance Error (MAPE) for various traffic count bins for various models on Ahmedabad dataset

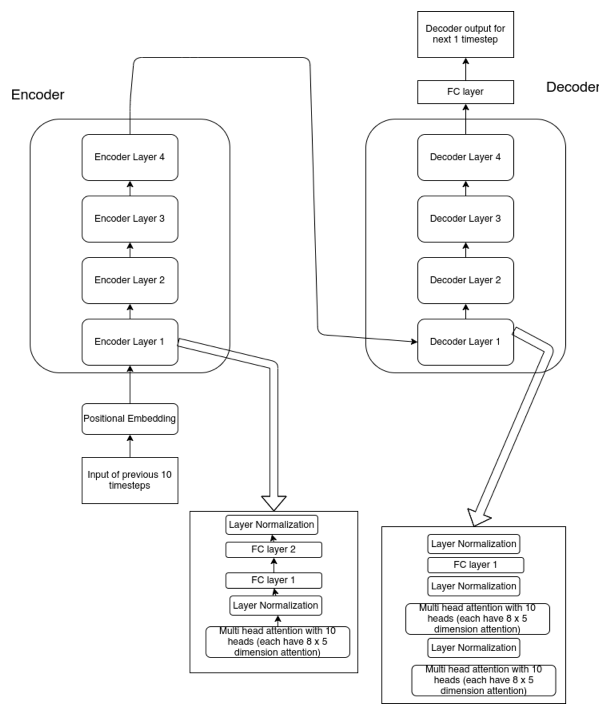


Fig: 2 Model architecture

Publications

Journal

- Tsutomu Tsuboi, “Traffic Congestion Triangle based on more than one-month real traffic big data analysis in India”, Advances in Science, Technology and Engineering Systems Journal Vol. 5, No. 6, pp.588-593 (2020).
- Tsutomu Tsuboi, Testuhiro Ishizaka, Hiroto Seki, Daisuke Nishiwaki, Roy Debaditya, Satoshi Takahashi,”Detection of Multi Type Vehciles under Mixed Traffic Flow Using Deep Learning in Inida”, pp.54-57, Traffic Engineering Vol.56 No.1 (2020).

Conference presentation

- Bhaskar Anand, Vivek Barsaiyan, Mrinal Senapati and P. Rajalakshmi, "Region of Interest and Car Detection using LiDAR data for Advanced Traffic Management System," 2020 IEEE 6th World Forum on Internet of Things (WF-IoT), New Orleans, LA, USA, 2020, pp. 1-5, doi: 10.1109/WF-IoT48130.2020.9221354. (Virtual presentation date: 2 June 2020)
- Bhaskar Anand, Vivek Barsaiyan, Mrinal Senapati and P. Rajalakshmi, "An experimental analysis of various multi-channel LiDAR systems," 2020 IEEE International Conference on Computing, Power and Communication Technologies (GUCON), Greater Noida, India, 2020, pp. 644-649, doi: 10.1109/GUCON48875.2020.9231195. (Virtual presentation date: 3 October 2020)
- Mrinal Senapati, Bhaskar Anand, Vivek Barsaiyan and P. Rajalakshmi, "Geo-referencing system for locating objects globally in LiDAR point cloud," 2020 IEEE 6th World Forum on Internet of Things (WF-IoT), New Orleans, LA, USA, 2020, pp. 1-5, doi: 10.1109/WF-IoT48130.2020.9221162.(Virtual presentation date: 2 June 2020)
- Bhaskar Anand, Anuj G. Patil, Mrinal Senapati, Vivek Barsaiyan and P. Rajalakshmi, "Comparative Run Time Analysis of LiDAR Point Cloud Processing with GPU and CPU," 2020 IEEE International Conference on Computing, Power and Communication Technologies (GUCON), Greater Noida, India, 2020, pp. 650-654, doi: 10.1109/GUCON48875.2020.9231067. (Virtual presentation date: 3 October 2020)
- Thamilselvam B, Subrahmanyam Kalyanasundaram, Panduranga Rao Marella,"Scalable Coordinated Intelligent Traffic Light Controller for Heterogeneous Traffic Scenarios Using UPPAAL STRATEGO", COMSNETS 2021, January 6-8, 2021, Virtual Conference. (Virtual presentation date :6 January 2021)
- Anshika Chourasia, Bheemarjuna Reddy Tamma, and Antony Franklin A. "Wi-Fi based Road Traffic Monitoring System with Channel Hopping”, COMSNETS Workshop on ITS , Virtual Conference. (Virtual presentation date :9 January 2021)

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