Chapter 17
Transportation and Parking Framework for Pollution-Free AMU Campus: A Case Study

Rafi Akhtar, Mohammad Arqam, Mohammad Saad Alam, Yasser Rafat, and Salman Hameed

Abstract Air pollution and climate change have become one of the major contemporary concerns for the entire world and if not addressed well the challenge is only going to surge in future that may be catastrophic for lives on the planet. Since the number of vehicles increasing rapidly transportation has become one of the major contributors to air pollution. Hence, there is a need to propose and develop a proper yet smart transportation and parking system to minimize the pollution and congestion problems. This chapter reveals the impacts of emission on campus life through providing an estimate of different pollutants emitted from the vehicles coming in and out of the campus. For a campus like Aligarh Muslim University (AMU), a different approach is required as the number of commutators does not vary largely and the major inflow is of two-wheelers. Appropriate locations for vehicle parking facility to be constituted have been identified to optimize the vehicle running time. Moreover, an IoT-based smart parking system framework for the pollution-free AMU campus has been conceptualized.

1 Introduction

From 'saving environment for future generations' to 'saving environment for the current generation itself,' environmental concern has become one of the most-talked issues in recent times. The outrage is righteous witnessing severe damage to lives on the planet caused by different forms of pollution; among which air pollution is the most prevalent in nature. Globally, nearly 90% people are currently breathing impure air and about 7 millions of them die every year because of related diseases (World Health Organisation 2021). Besides industries and construction works, transportation is the primary source of major pollutants emission namely CO, CO_2, oxides of

R. Akhtar · M. S. Alam · Y. Rafat · S. Hameed
Centre for Advanced Research in Electrified Transportation (CARET), Aligarh Muslim University, Aligarh, India

M. Arqam (✉)
School of Engineering and Built Environment, Griffith University, Brisbane, Australia
e-mail: mohammad.arqam@griffithuni.edu.au

I. Ali et al. (eds.), *Computational Modelling in Industry 4.0*,
https://doi.org/10.1007/978-981-16-7723-6_17

nitrogen and Sulphur, etc. As per the government sources, number of all types of motor vehicles in India increased from 55 million to 230 million during the period of 2001 to 2016 that include increase in number of cars from 5.3 million to 25.6 million and two-wheelers from 38.5 million to 169 million (Statistical Year book, India 2015).

Every year India witnesses a huge layer of smog, a phenomena directly related to air pollution, especially in winter. It causes adverse impact on health and economy, temporary effects include irritation, headache, and nausea and in long term lead to chronic respiratory and cardiovascular diseases like asthma (Yang et al. 2017, Zhang et al. 2017). Low visibility slows down traffic on railways and roads leading to significant economic losses. Moreover unwanted noise from vehicles is a well-known reason of annoyance and insomnia (Jariwala et al. 2017). Hence, to mitigate the side effects of transportation, it is essential to implement a smart transportation and parking system framework to reduce traffic congestion that eventually amplifies the pollutants emission.

Several studies have already been conducted concerning pollution caused by transportation and need to develop smart parking system to avoid congestion. Most of them used sensor-based technologies to let customer rider know where to park the vehicle based on the availability of the slots. Researchers in India recently used single board computer Raspberry Pi, GPS module, and ultrasonic sensors to send information to the customers about the availability of parking lots through a mobile application based on google map (Shinde et al. 2017). This approach is significantly reliable but separate sensors are needed for each parking space, hence costlier.

Similarly, another group of researchers used camera-based Raspberry sensors to collect data and utilized machine learning to distinguish between occupied and vacant parking space (Ling et al. 2017). This one-to-many sensor solution is comparatively cheaper and showed 91% accuracy in experiment that can be further improved as machine learning gets matured. The California State University researchers suggested a more versatile system to give more information like topological mapping using single node camera sensors (Telles and Meduri 2017). To ensure shortest path with minimum turns to be covered in the parking complex, Chinese researchers developed an improved ant colony algorithm (Wang et al. 2017). Pampa Sadhukhan also addressed the problem of improper parking and alarming authorities if someone does not park his vehicle properly (Sadukhan 2017). Lukmayang et al. (2018) proposed a system to let the vehicle owner know when and where it has to be parked to enhance security. (Khanna and Anand 2016) have also proposed an application-based smart parking system.

Most of the prior works are for public and paid parking with fluctuating number of customers every day and the availability was the major concern than location of the available space in the complex. For a campus like Aligarh Muslim University (AMU), a different approach is needed since the number of vehicles to be parked do not vary largely on the daily basis. In the varsity campus, availability is not the paramount apprehension rather the utmost anxiety is finding the appropriate space, especially for two-wheelers, from where one can also vacate easily. Therefore, this chapter reveals the impacts of emission on campus life through providing an estimate of different pollutants emitted from the vehicles coming in and out of the campus. Appropriate locations for vehicle parking facility to be constituted have been identified to optimize the vehicle running time. Moreover, an IoT-based smart parking system framework for the pollution-free AMU campus has been conceptualized.

2 Estimation of Pollutants Emission

The AMU Campus is a workplace of almost 28,000 students, 1342 teachers, and 5610 non-teaching staff (AMU website 2021). Most of them use their own motor vehicles for travelling inside the campus. In spite of having adequate space and road networks, unspecified routes and ill-managed parking system still need serious attention.

2.1 The Campus Map

The campus map shown in Fig. 1 is a screen-grab taken from google map and lines are drawn manually to show major routes to the specific faculty building which are, in turn, marked with alphabets. A, B, and C are the three major entrances. Different places are represented by alphabets according to the Table 1. Distance from entrances to any faculty are measured using google map's 'find route' feature.

Vehicle models taken into consideration to calculate the amount of emission are shown in Table 2. All data are for positive ignition, gasoline engines based on BS

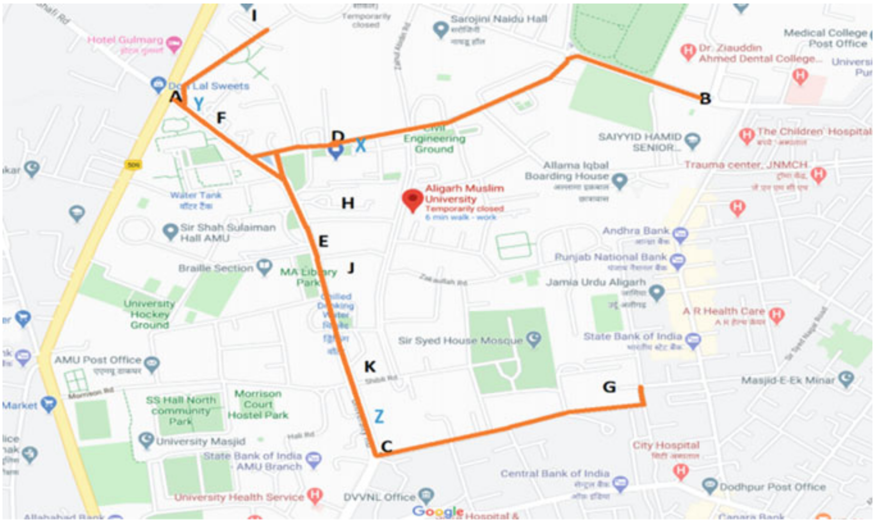

Fig. 1 AMU campus map

Table 1 Different location and their representation

Location	Represented by
Chungi entrance	A
Medical entrance	B
Bab-e-Syed entrance	C
Faculty of engineering	D
Faculty of arts	E
Faculty of science	F
Faculty of business studies	G
Faculty of theology	H
Faculty of commerce	I
Faculty of social Science	J
Faculty of International Studies	K

Table 2 Vehicle models under consideration

Type	Model	Engine capacity (cc)
Motorcycle	Passion Pro	100
Motorcycle	Duke	300
Scooter	Alpha	150
Scooter	Activa	110
Motorcycle	Discover	135
Motorcycle	Apache	200
Car	Alto	800
Car	Wagon R	1000
Car	Swift Dzire	1400
Car	Duster	1600
Car	Safari	2500

IV Pollution Standard. To obtain the amount of a pollutant emitted from a particular vehicle, distance covered is multiplied by the emission factor (emission in grams per kilometre) and then doubled to account for both ways. For instance, 20 Activa Scooters are recorded to come to Engineering Faculty from **A** covering 0.5 km distance **AD**; upon multiplying the distance by emission factor of CO_2, i.e. 33.4 (India GHD Program 2015) and then doubling it, emission of CO_2 comes out to be 668 gram. Similarly, amount of emission are calculated for other paths **BD** and **CD** as 1336 gram and 2338 gram, respectively constituting total of 4322 gram of CO_2 emission by Activa Scooters to and from Engineering Faculty.

The emission factor of CO and NO_X are 1.403 and 0.39 (India light duty and motor cycle emissions 2018) and upon following similar calculation technique as before total emissions come out to be 182.39 gram CO and 50.7 gram NO_X for the exactly same case as that of CO_2. Fig. 2 shows emission from other vehicle models

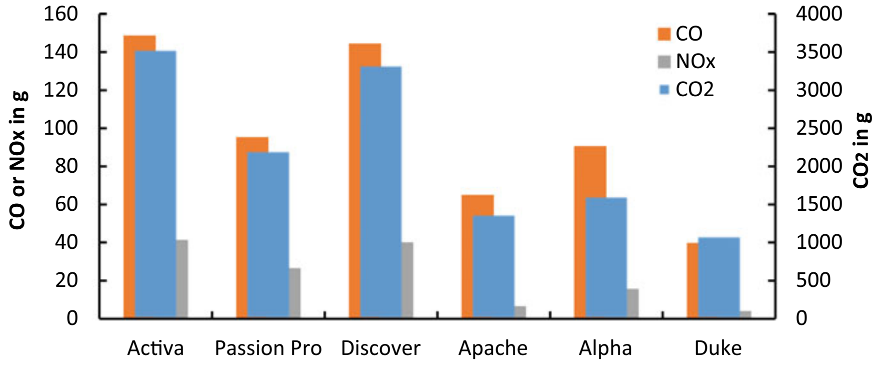

Fig. 2 Emission from two-wheelers for the faculty of engineering and technology

considered. Similar procedure has been followed for the calculation of emission by cars as well and the bar chart made to represent the data is shown in Fig 3**.** Using the data for individual faculties, overall emissions were calculated as depicted in Fig. 4.

As shown in Fig. 4, total CO_2 emission for the Faculty of Engineering and Technology from all vehicles, two-wheeler and cars, coming and going via all the three entrances is 53867.70 grams. For the same faculty, total CO emission is 1023.28 grams and total NO_X emission is 194.21 grams. For the Faculty of Arts, emission of CO_2, CO, and NO_X, respectively are 42459.94 grams, 819.44 grams, and 150.15 grams and similarly for other locations shown in the chart. For the whole campus, constituting all eight faculties inside, net emission of CO_2 is 279036.17 gram, net emission of CO is 5260.25 gram, and finally net emission of NO_X is 972.23 gram in a normal working day.

Overall parking framework for the AMU campus may constitute:

1. Locating the places of requirement

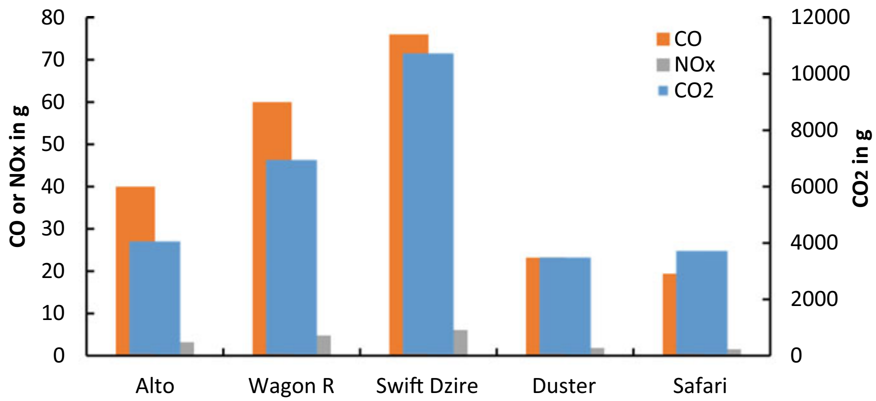

Fig. 3 Emission from cars for faculty of engineering and technology

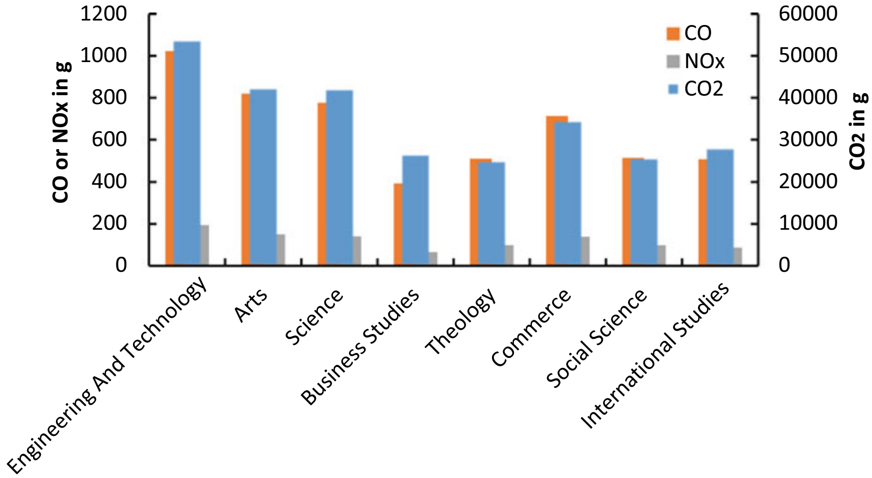

Fig. 4 Total emission from different faculties

2. Cost-effective system installation for smart parking.

To minimize emissions, parking facilities are supposed to be established/constructed at locations where the vehicle has to cover the least distance. Through utilizing optimization techniques and considering commuters' convenience, following places are identified for multistorey parking setup as outlined in Fig. 1. The Location '**X**' represents parking near the engineering faculty that is supposed to accommodate commuters coming from '**B**' and want to go to engineering faculty '**D**', faculty of arts '**E**', faculty of science '**F**', faculty of social science '**J**' and faculty of theology '**H**'. The location '**X**' will also facilitate parking for vehicles coming to Engineering faculty '**D**' from the entrances '**A**' and '**C**' (Fig. 5).

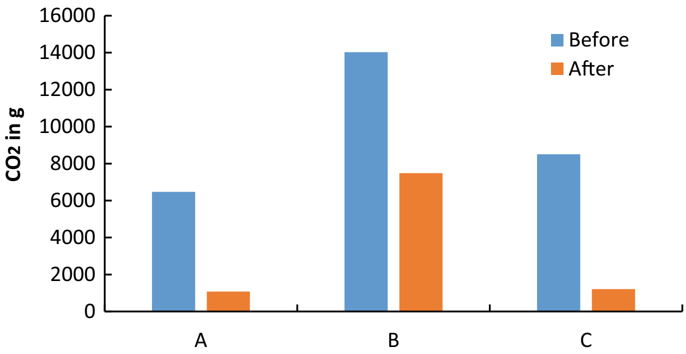

Fig. 5 Comparison of CO_2 emission (in g) by cars coming to faculty of arts from different entrances

In a similar manner, a multistorey parking '**Y**' is proposed near Science faculty '**F**' that will accommodate all the vehicles coming to Faculty of Commerce '**I**', Faculty of Science '**F**' and vehicles from '**A**' to '**H**', '**E**' and '**J**'. Finally the third parking lot '**Z**' is to be established near the Faculty of International Studies that will serve all the vehicles coming towards Faculty of International studies '**K**' and Faculty of Business Studies '**G**'. It will also help commuters coming from entrance '**C**', '**E**', and '**J**'.

2.2 Potential Effects of Relocating Parking Lots

Upon relocating parking locations, significant amount of pollutants emission can be reduced. For example, CO_2 emitted by cars coming from '**A**' to Arts faculty '**E**' can be reduced from 6475.2 to 1079.2 g which is equivalent to 83% reduction as shown in Fig. 6. Similarly, cars coming from '**B**' to '**E**' show about 47% reduction in CO_2 emissions and from '**C**' to '**E**' same figure goes about 87%. Overall reduction in CO_2 emissions from cars coming to Arts faculty is approximately 66%. Considering the whole university campus, by updating parking locations, total CO_2 emissions come down to 176113.32 g with approximately 37% of reduction. Similar reduction can be seen in the case of CO and NO_X emissions as shown in Figs. 7, 8, and 9. CO emissions were reduced from 5260.25 to 3290.12 g so were NO_X emissions from 972.23 to 604.43 g.

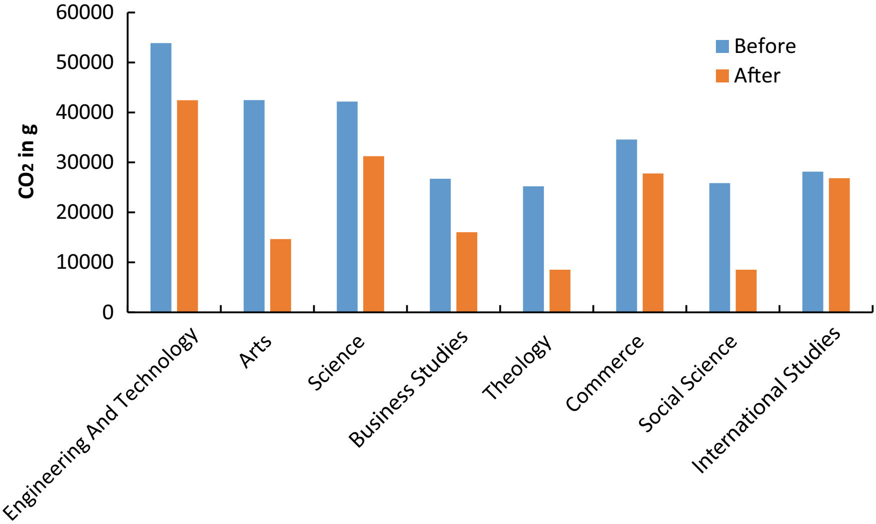

Fig. 6 Comparison of overall CO_2 emission (in g) by vehicles coming to different faculties from all the entrances

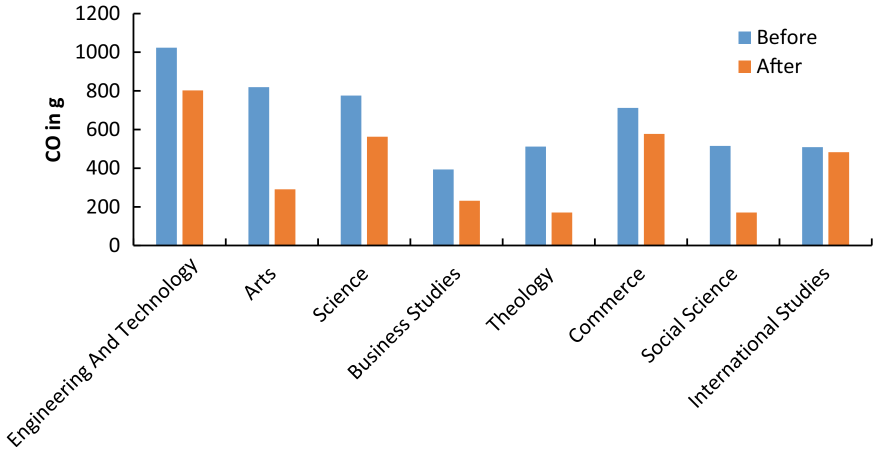

Fig. 7 Comparison of overall CO emission (in g) by vehicles coming to different faculties from all the entrances

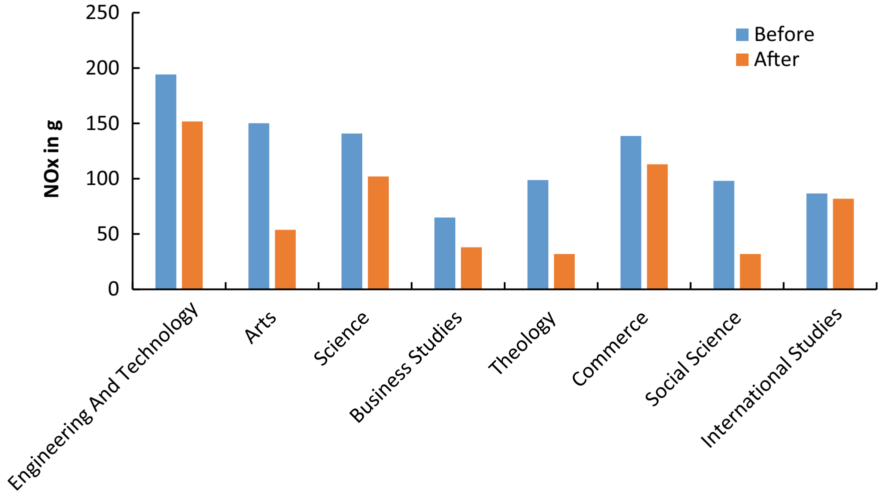

Fig. 8 Comparison of overall NO_x emission (in g) by vehicles coming to different faculties from all the entrances

3 Smart Parking System Framework

The proposed smart parking system for the pollution and congestion-free AMU campus is depicted in Fig. 7. The idea proposed by (Telles and Meduri 2017), SParkSys Vision, to let vehicle owners know where to park on the basis of available slots was became the basis of conceptual framing. This is simple to implement and cost effective having reasonable real-time accuracy. For the purpose, Raspberry Pi-3

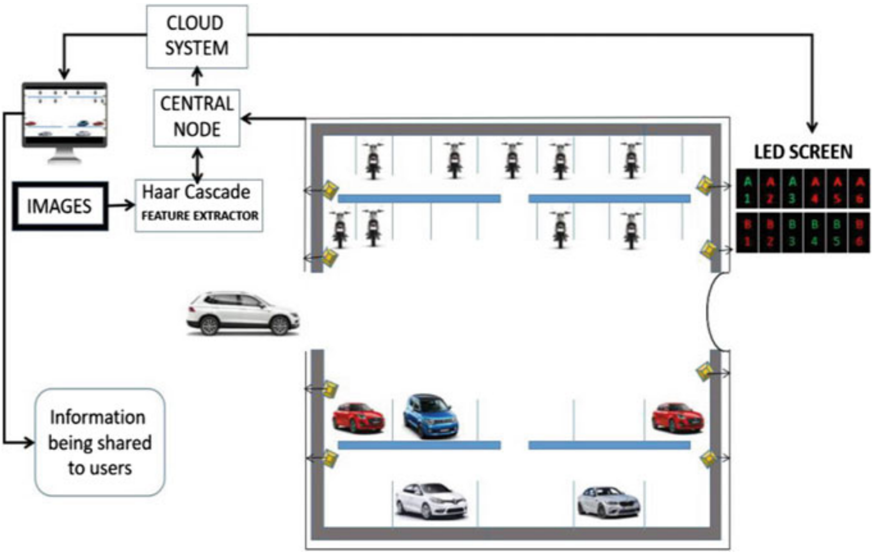

Fig. 9 Proposed system architecture

model B accompanied with a Pi Camera and ARM Cortex-A53 processor can be used to collect inputs from the parking area. The camera will take images that will be processed in the server to harvest required data like number of spaces available and their locations. The parking spots can be assigned names using numeric and alphabets. The status of each space will be sent to the central node from camera nodes where required information of the surrounding will be detected using a machine learning algorithm (MLA) that will help identifying empty and occupied spaces. To enhance cost optimization, a single camera node may be utilized to take images of multiple parking lots, and identify empty and occupied spaces after training the data on Haar Cascade algorithm. After collecting data at each node, the information will be sent to network and stored in a cloud server from where information can be shared/accessed. To filter duplicate data, each node will share data within nodes and with central node. Then the data will be shared from cloud server to LED screens at the entrance of each parking lot. Vacant spots can be displayed on the screen by its unique number preferably in green colour and occupied ones in red colour. A mobile application can also be developed to provide information to commuters before they come to the parking facility. In case one forgets where the vehicle is parked and to enhance security, an OCR technology is embedded to the overall system to screen vehicle number from the images taken and will share information via mobile application.

4 Conclusion

This chapter presents a detailed analysis of current transportation system and different pollutants emissions by motor vehicles coming in and out of the Aligarh Muslim University (AMU) campus. Pollutants emitted from different two-wheelers (scooters and bikes) and four-wheelers (cars) entering and exiting the campus on a daily basis were calculated based on distance travelled from entrances to desired locations. Through considering vehicles inflow and outflow, appropriate parking locations have been identified and a decent amount of pollution emissions (up to 37%) was found to be reduced through proper implementation. Moreover, an IoT-based smart parking system is proposed to update daily commuters about the availability of parking spaces by displaying on the LED screens fitted outside the parking facility/lots. To ensure its competency, use of one-to-many camera sensors and data processing on a methodical machine learning algorithm is suggested. The proposed system also facilitates users to trace vacant spaces and parked vehicle locations through using a mobile application.

Acknowledgements The authors gratefully acknowledge the overall support provided by the Director and all other staff of Centre of Advanced Research in Electrified Transportation (CARET), recognized and supported by the Department of Heavy Industries (DHI), Government of India as a Centre of Excellence for Electric Vehicle Charging Infrastructure.

References

Jariwala HJ, Syed HS, Pandya MJ, Gajera YM (2017) Noise pollution & human health: a review. Indoor Built Environ 1–4

Khanna A, Anand R (2016) IoT based smart parking system. In: 2016 international conference on internet of things and applications (IOTA). IEEE, pp 266–270

Ling X, Sheng J, Baiocchi O, Liu X, Tolentino ME (2017) Identifying parking spaces & detecting occupancy using vision-based IoT devices. In: 2017 global internet of things summit (GIoTS). IEEE, pp 1–6

Lookmuang R, Nambut K, Usanavasin S (2018) Smart parking using IoT technology. In: 2018 5th international conference on business and industrial research (ICBIR). IEEE, pp 1–6

Sadhukhan P (2017) An IoT-based E-parking system for smart cities. In: 2017 international conference on advances in computing, communications and informatics (ICACCI). IEEE, pp 1062–1066

Shinde S, Patil A, Chavan S, Deshmukh S, Ingleshwar S (2017) IoT based parking system using Google. In: 2017 international conference on I-SMAC (IoT in social, mobile, analytics and cloud) (I-SMAC). IEEE, pp 634–636

Telles E, Meduri P (2017) SParkSys: a framework for smart parking systems. In: 2017 international conference on computational science and computational intelligence (CSCI). IEEE, pp 1396–1399

Wang M, Dong H, Li X, Song L, Pang D (2017) A novel parking system designed for smart cities. In: 2017 Chinese Automation Congress (CAC). IEEE, pp 3429–3434

Yang LE, Hoffmann P, Scheffran J (2017) Health impacts of smog pollution: the human dimensions of exposure. The Lancet Planetary Health 1(4):e132–e133

Zhang J, Liu Y, Cui LL, Liu SQ, Yin XX, Li HC (2017) Ambient air pollution, smog episodes and mortality in Jinan, China. Sci Rep 7(1):1–8

https://www.who.int/news/item/02-05-2018-9-out-of-10-people-worldwide-breathe-polluted-air-but-more-countries-are-taking-action

https://www.who.int/health-topics/air-pollution#tab=tab_1

http://mospi.nic.in/statistical-year-book-india/2015

https://www.amu.ac.in/fct.jsp

https://shaktifoundation.in/wp-content/uploads/2017/06/WRI-2015-India-Specific-Road-Transport-Emission-Factors.pdf

https://www.transportpolicy.net/standard/india-light-duty-emissions/

https://www.transportpolicy.net/standard/india-motorcycles-emissions/