Design and Testing of Automated Smoke Monitoring Sensors in Vehicles

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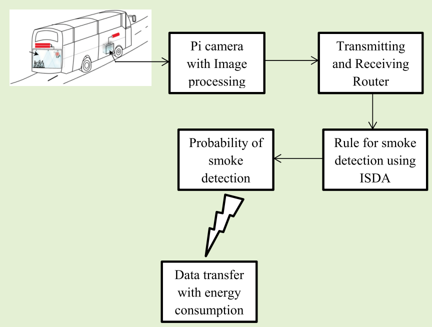
***Abstract*—This article emphases an advanced method for controlling the pollution of vehicles through sensor integration process. All sensor nodes will be connected to a control centre and it will be monitored using Online Monitoring System (OMS) with the help of an Improved Smoke Detection Algorithm (ISDA). The purpose of using ISDA is to monitor the vehicles which are located in different areas under different temperatures where, the ISDA divides the regions into circles. The data obtained in OMS will be aggregated and it will be plotted in MATLAB for better understanding. To test the efficiency of the projected method three test cases which include control of energy, minimization of range and cot have been performed. It is observed that in all three cases ISDA proves to be more efficient in terms of energy consumption, cost and distance when compared with existing methods.**



***Index Terms*—Automated vehicles, energy consumption, pollution, range, sensors.**

I. Introduction

IN RECENT days, there is a huge necessity of wireless devices to monitor the daily needs of human. Even the applications of wireless devices have been growing and it is easy to implement in vehicular systems also. Most of the urban areas are facing the problem of environmental pollution due to the smoke that is emerging from vehicles. Even a lot of people are unable to breathe due to the presence of smoke in the atmosphere. Most of the people are still using old vehicles which are producing more smoke than estimated and even the change in type of engines also does not provide any satisfactory solutions. The only way to overcome from the threat that is caused by the smoke from vehicles is to stop those vehicles which are producing more smoke than the threshold values at a particular place without causing any accidents.

The prevention can be done in two possible ways (i) The driver must install the sensor and should be able to monitor the value of smoke in their vehicles by their own (ii) A detailed information report will be sent to the vehicular department in the concerned areas and they should stop the vehicles automatically where, the safety of the individual should also be safeguarded. Both ways can be implemented in real time but more specifically second method can be preferred because a detailed report will always be maintained by department officials and necessary actions can be taken at prescribed times. Since, the processor to be used is a high speed processor the values acquired from the sensor will be stored and displayed on an Online Monitoring System (OMS). Therefore, it is possible to monitor the vehicles in a continuous manner and the life time security of each individual will be assured by this automated systems. Figure 1 shows the implementation of proposed method.

An Up-to date information about traditional methods of pollution monitoring in vehicles have also been provided [1] where, all different characteristics has been analyzed with their own benefits and difficulties. These characteristic changes will have more update about wireless networks in vehicular applications for monitoring the contamination level. The level information of information provided in [1] is more insistent and it also provides a better way for enhancing the vehicular applications. Also, a sustainable monitoring process is needed for enrichment of all public transportation system

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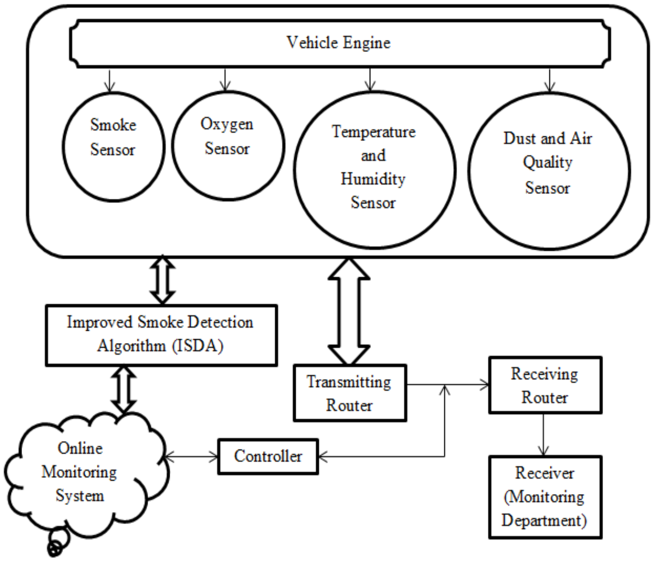

Fig. 1. Operation configuration of the proposed method.

and to reduce the hazards of environmental pollution [2]. More flexible directions with low emission at high traffic congestion can be provided to all vehicles by following the strategy of distributed sensors. The same distribution method is followed in the proposed method but instead of random distribution the area is divided in circles. Even it is possible to monitor vehicles using stationary sensors where more quality of communication will be present at low cost [3]. But the areas cannot be divided and ranges to particular areas cannot be allocated properly.

A. Related Works

Some existing literatures on Internet of Things (IoTs) have been analyzed for monitoring the smoke that has been released by the vehicles. Among those literatures an embedded technology which is designed to monitor the air quality index has been considered for validating the proposed formulations. In [4] the fundamental concept regarding the health of environment is discussed for one particular area whereas, the authors fail to extend the proposed method to all other remaining areas. Therefore, the aforementioned method does not suit well when the vehicles travels to different areas at a particular time period. Another method with basic model formulations has been deliberated for monitoring the detectors response. For the purpose of data aggregation the role of detector is much essential therefore, a time index model has been designed where the threshold values are determined. But, the method uses only a particular zone model which cannot be compared and obtained for different zones [5]. However, the model can be extended to different zones by using an online monitoring system which forms the base of the projected work.

An alarm technique with an intelligent framework has been proposed in [6]. The vendor can be able to directly get the required sensor output values by using the douser framework. But, this method forms the base on detecting the smoke caused by fire where, some useful threshold values have been incorporated in the projected formulations. The major drawback that has been observed in [6] is that the source of smoke cannot be identified and also it is not possible to send the information that is carried by the sensors in a combined way because the authors have conveyed that each different sensor will be located at different positions. To overcome the aforesaid drawback a Zigbee based module has been developed where, data visualization decision has been provided. In addition, the online monitoring system is also used because the main motive is to detect the fire that has happened in forest areas. The authors have explained the use of monitoring system by integrating random forest algorithm but fail to include the placement cost of sensors. Also, the area of forest will be very large and it is difficult to place the sensors in a particular location and to aggregate the data in a synchronized manner. The authors have considered the implementation method only for large area of smoke detection which is explained with basic formulations. In [7] the authors have conversed that the safety will be improved but the values during data processing is not much secured which leads to failure of the process and a detailed security measurements are needed.

The aforementioned works can be applied in all outdoor environments and to larger areas. In line with the above concern, an application for vehicles using sensor technology has been initiated. The prime objective is to reduce the accident of vehicles by placing a highly reliable sensor in any part of the vehicle where, a mobile environment will be considered for installing the smoke sensors. It is noted that in [8], the major problem is that the sensors can never be calibrated and it will not work together when installed in all parts of the vehicles. Even if the sensors are installed at different places in the vehicle, the life time and the capacity will be decreased until proper calibration is made. Also, the security an assessment which includes the mobile number of the vendors has never been discussed. A camera based detection system has evolved for capturing the exact image of the location when any natural phenomenon exists. This technique uses the IP address of a particular location where, the same disadvantage of providing security has been neglected. If security enhancement is provided then, with high end processor it is very easy to detect the smoke with the help of an image and the workers can immediately go to the desired place. Another disadvantage is that there is no latitude and longitude positions which are attached with the image which makes the worker to identify the desired location within a short span of time [9].

Similar to [9] a smart sensor system for two wheelers has been developed by keeping different mechanisms in observance. The authors in [10] have stated that most of the world population is using two wheelers and there is a need to monitor the environmental pollution which acts as a major threat to all humans. So an automated system has been developed but this development has been directly installed in the engine of vehicles which creates complexity for the driver of a particular vehicle because if the bike does not ignite properly then it is very difficult to find which affects the real time situation. Therefore this automated mechanism is very difficult to be implemented in real time and it is very costly. To reduce the critical issue on life time of humans a smart home monitoring system has been developed for smoke detection in case of occurrence of fire inside the home. A unique fire dynamic simulator has been used for the purpose of detecting smoke. However, this method provides high consumption of energy when the nodes are installed at different places [11]. A visual sensor network at a low cost has also been implemented for increasing the accuracy of measurement in overlap areas. This method provides a high quality image where, the workers can exactly predict the cause of smoke incidence. But if such overlapping methods are used then, a high quality pi camera is necessary which is very expensive for a small home. Therefore, this method [12] is not suitable for all indoor and outdoor environments. Apart from these sensor based technologies [1]–[12], a new cognitive radio method has been implemented for monitoring the vehicles under crucial conditions. All the discussed sensor methodologies will have mobility issues which can be solved by using cognitive networks [13]. Even though the mobility issues are solved by cognitive methods, the number of required users at both transmission and reception end will be very much higher which is observed as a major drawback when compared to the solutions provided by the sensors. All the necessary solutions for implementing cognitive networks have been described in [14]. But the cognitive radio test bed provides low quality solutions and the major parameter which is defined as fast information processing has been missing in both methods that are implemented in [13], [14] when compared to the methodologies discussed above.

Even though the sensors are calibrated and designed according to the requirements it is much important to calculate the number of nodes which has been well-defined in [15]. A predefined understanding of the relay nodes is much essential for sensor installation and if the nodes are reduced then, the entire cost of installation can be reduced to a much higher extent. This survey helps to design the appropriate relays for this projected work. Also, another method for optimal sensor placement has been designed for positioning the nodes are proper locations. These two methods [15], [16] if incorporated then, it will be more useful for choosing the optimal location and nodes which in turn reduces the cost of installation with huge benefits. A global survey from International council of green transportation [17] has reported that in 2017 nearly 1 billion people suffered due to various diseases and this transpired due to the presence of air pollution. Since the numbers of vehicles are grown rapidly during the years in 2020 nearly 1.9 billion people have suffered huge loss due to air pollution which is emitted by vehicles. Many people cannot able to inhale the natural air and it is very difficult for drivers during smog spell. Even many ozone attributes are at the verge of vanishing due to smoke created by vehicle. Also the amount of emission crosses nearly 400,000 PM2 which is much higher than expected emissions.

B. Research Gap and Motivation

All the existing methods that are discussed under literature works grieves from any one drawbacks like high cost of implementation where even installation of GPS based systems with LoRA technique has been discussed [18]. But when compared to sensor devices GPS will be much costly therefore a decentralized remote monitoring system has been developed which is expected to yield precise results at low cost [19]. Even though the expected results are achieved consumption of energy is much higher. Therefore, the authors in [20]–[24] have made a survey for addressing the gaps that are present for low quality solutions and to reduce the cost of implementation where, vehicular networks are integrated with Internet of Things for providing high safety with consistent operation [21]. Also a new biological application platform is formed for ignoring the normal operation in machine learning procedures [22] to perform classification and for improving the performance of vehicular operation. Contrariwise, for directing the humans through desired direction an artificial intelligence technique is formed [23] where real time data is sensed and reported to control center. The authors in [24] have discussed that offline sharing of data is also possible by using a migration mechanism. But in all cases the implementation cost or energy consumed by nodes will be much higher. Henceforth to overcome the aforementioned drawbacks top feature sensors have been calibrated and installed in vehicles. In addition, a gap has been assembled by dividing the regions in different groups which forms the circle. Therefore, under different temperatures the smoke created by the vehicles can be monitored and the distance covered by the sensors can also be maximized that covers the entire area in the circle at low cost.

C. Research Objectives

The prime objective of the proposed method is to reduce the smoke that is caused by the vehicles. The reason behind choosing this objective is that the smoke which is exhausted by the vehicles is observed as one of the major threat of pollution in urban areas. Therefore, the objective can be solved by integrating a sensor technology with an efficient ISDA algorithm which produces substantial results in reducing the smoke of vehicles under different temperatures. Further, the objective is also solved by minimizing the cost of sensor implementation and energy consumption with maximization of distance.

II. PROBLEM FORMULATION

Since, the smoke which is produced by the vehicle has to be monitored it needs to be compared with maximum amount of air quality index which is prevailing in the environment. If the smoke that is produced by the vehicles crosses the threshold limit of environment then, it an alarm will be indicated where, the vehicles will be stopped. This formulation of air quality index will use the resistance of sensor for exact prediction which is given by the formula,

$$R_i = \frac{C_i \times l}{O_i} - l_i \tag{1}$$

where, C_i represents the maximum input voltage to the air quality sensor l and l_i denotes the maximum load offered to a distinct sensor and i^{th} sensors O_i signifies the output voltage that is obtained from each sensor after each iterations

The resistance of sensor is a basic parameter that needs to be calculated at preliminary stage. Once the threshold values are established then, should never be changed. So while designing, the output voltage during each iteration has to be carefully calculated. In the next step the concentration of carbon-di-oxide needs to be monitored where it can be given mathematically as,

$$Conc_i = \frac{1/e_{min_i}}{a_i v_i} \tag{2}$$

where, e_{min_i} denotes the minimum emission of CO_2 content a_i represents the exchange of smoke content from vehicles in air v_i signifies the volume of outdoor environment.

From Equations (1) and (2) the concentration content in air can be found out. Then, the temperature will be calculated because during summer and winter seasons the air content will vary so three different values (Including fog season) needs to provided as threshold levels to the Online Monitoring System (OMS). Since the OMS is used the output temperature can be calculated by using Equation (3),

$$T_i = \frac{T_{max}}{CT_i} \tag{3}$$

where, T_{max} represents the maximum amount of outdoor temperature CT_i denotes the critical temperature that can be tolerated in the implemented sensor

The role of maximum outdoor temperature is much important because mostly under humidity conditions the smoke released by the vehicle will never dissipate which causes the emergent of severe breathing problem to all humans. Therefore, under humidity condition which occurs during winter and fog seasons the designed OMS will continuously monitor the maximum value and it will compare it with critical values. Even if the area has more industries then, the presence of dust particles also plays a major role. Therefore the humidity and dust particles in the air can be monitored using Equations (4) and (5).

$$H_i = \frac{273K}{\log_{10} P_i} \tag{4}$$

where, P_i denotes the pressure of outdoor vapor

The dust particle can be calculated as,

$$D_i = \frac{R_i}{SV_i} \tag{5}$$

where, R_i represents the control value of each sensors SV_i denotes the sample value of all the installed sensors

The next parameter to be considered for calculating the vehicle smoke consumption is the energy consumption of the connected nodes in the vehicles. The energy consumption by both transmitter and receiver should be always lesser which can be established by Equation (6).

$$E_i = (E_{max} + E_{min}) - \beta(i) - \propto (i) \tag{6}$$

where, E_{max} and E_{min} denotes the maximum and minimum energy β and $\propto$ represents the degenerated and amplified energies

If the energy consumption of all nodes is reduced then, the transmitter can be fitted in the vehicles suitably and the receiver can be fitted at the control station where, the corresponding departments are available. So to properly attach the transmitter and receiver it is necessary to maximize the range of sensors which can be given from Equation (7).

$$R_i = 1.2\sqrt{\pi r^2} \tag{7}$$

Since, there is an option for dividing the areas in a circular way the range will be calculated by using the formula of area. Once maximum distance is achieved by the sensor then, the cost of placement of sensors will be minimized which is given in Equation (8).

$$Min\ cost_i = \sum_{i=1}^{n} R_i x_i \tag{8}$$

where, x_i represents the weight of individual sensors

From the above Equations (1-8) the objective function can be formulated as,

$$OB_i = min \sum_{i=1}^{n} E_i, cost_i \& max \sum_{i=1}^{n} R_i \tag{9}$$

If the above objective function is solved then, the data aggregation will be properly achieved between transmitter and receiver with minimized energy, cost and maximized coverage range.

III. Optimization Algorithm

It is necessary to integrate the proposed formulation with an efficient algorithm for making the entire system to work properly. Therefore, an Improved Smoke Detection Algorithm (ISDA) with deep learning technique [25] has been implemented for detecting the smoke of vehicles. This algorithm will provide effective solutions during different temperatures to an OMS. The activation function of the projected ISDA can be given as,

$$AF(i) = \sum_{i=1}^{n} S(i) max(0, L(i)) \tag{10}$$

where, $S(i)$ represents the angle of sensor placement $L(i)$ denotes the optimal location of sensors inside the vehicle

The performance evaluation of ISDA which is expressed in percentage is very much higher when it is used for the detection of smoke. This method is compared with [12] where, no deep learning algorithm is used. For both the methods the performance can be evaluated using the following formula.

$$P(i)(\%) = \sum_{i=1}^{n} o(i)/T(i) \times 100 \tag{11}$$

where, $o(i)$ denotes the number of positively detected excessive smoke vehicles $T(i)$ represents the total number of vehicles tested

From Equation (11), it can be seen that the ISDA will check the number of smoke samples at a higher speed when compared to [12] and the number of positive samples will be accurate which makes the performance of ISDA to achieve a rate of 76.8% when compared to [12] which produces only 64.2%. This evaluation has been made this algorithm unique from all smoke detection vehicles. For the implemented algorithm, it is also necessary to detect the number of negative samples so that the misunderstanding in false detection of smoke vehicles can be avoided in case if there is any fault in the sensor.

$$F(i)(\%) = {}^{n(i)}/T(i) \times 100 \tag{12}$$

where, $n(i)$ denotes the number of negatively detected smoke vehicles that occurred during failure of sensors

After a careful check the number of false detection which is calculated from Equation (12) for ISDA is only 1.34% but for [12] it is much higher which resides within 3.7%. Therefore, as a result the accuracy rate can be calculated as a sum of positive and negative samples which can be given as,

$$Accuracy(\%) = \frac{o(i) + n(i)}{T(i)} \times 100 \tag{13}$$

The major reason for employing ISDA with projected model is that sensors are assimilated for observing runway vehicles where, more number of data will be surveyed in everyday and effectiveness of data processing will be improved only when ISDA is integrated. In addition, decision on monitoring smoke data from vehicles will be improved at much higher extent and ISDA is having the ability on improving the efficiency of overall process within a short span of time. Also, it is found from Equation (13) that the accuracy remains very close to 98.5% when ISDA is used. This is taken as one of the best advantage that is provided by deep learning algorithms. The flow chart of ISDA is explicated in Figure 2.

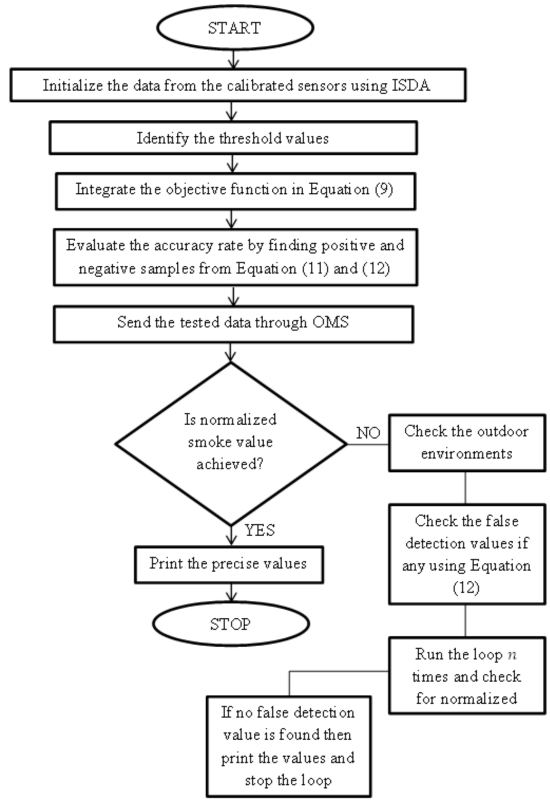

Fig. 2. Flow chart of ISDA.

A. Computational Complexity of ISDA

In the proposed method computational complexity of ISDA is calculated by taking positive samples of corresponding objects. Since, the level of smoke is calculated using maximum capability of vehicles it is always necessary that R_i and H_i should be positive constants. Both R_i and H_i should not be inclined by any input parameters. Therefore, ISDA computational properties will be totally calculated using big-O notation which can be given as,

$$f(i) = Og(i) \tag{14}$$

Equation (14) defines the upper bound of the function where, complexity analysis of ISDA will be under complex model that should satisfy the following constraint,

$$og(i) = 1\ if \begin{cases} R_i \geq 0 \\ H_i \geq 0 \\ 0 \leq f(i) \leq R_i g(i) \end{cases} \tag{15}$$

From Equation (15) it can be implied that g_i is the asymptotic upper bound for the given function. To compute the complexity analysis for ISDA in corresponding vehicles a complete data set should be defined clearly then similarity matrix should be calculated using clustering functions which is denoted by n. Since, number of iterations is larger initial cluster center will be defined during each time period. For the projected method cluster complexity is much lesser due to the high stand still distance and cluster areas.

B. Step-by-Step Implementation of ISDA

Step 1: Initialize the calibrated sensor data according to capability of vehicles.

Step 2: Identify maximum threshold value (Strength) of sensors.

Step 3: Integrate the objective function from Equation (9) and monitor precise measurement values.

Step 4: Calculate positive and negative sample values and categorize the successive samples.

Step 5: Direct successive to online monitoring system and check for normalized smoke value.

Step 6: If the normalized value is accurate then, go to step 8. Otherwise go to step 7.

Step 7: Observe all outdoor environments and check the false detection values from Equation (12).

Step 8: Resurrect the loop and go to step 5

Step 9: If normalized values are accurate then stop the loop. Otherwise go to step 2.

Step 10: Stop the iteration and print monitored values.

IV. Results and Discussions

The proposed method using ISDA has been evaluated using an OMS where, all the values that have been attained are plotted in MATLAB. To check the efficiency of the projected smoke detection methods using ISDA the following test cases have been performed.

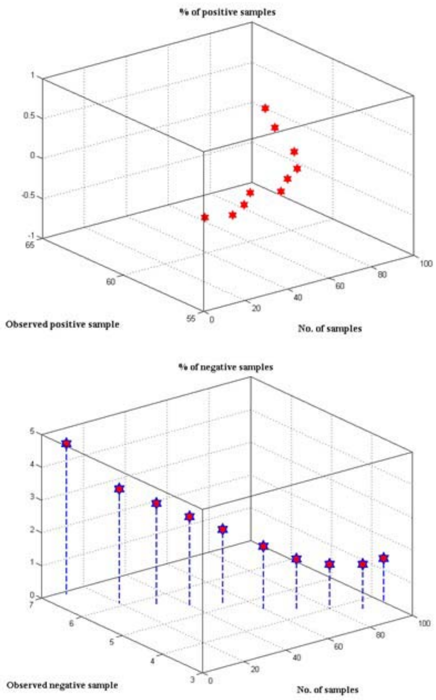

Fig. 3. Percentage of observed Positive and Negative samples.

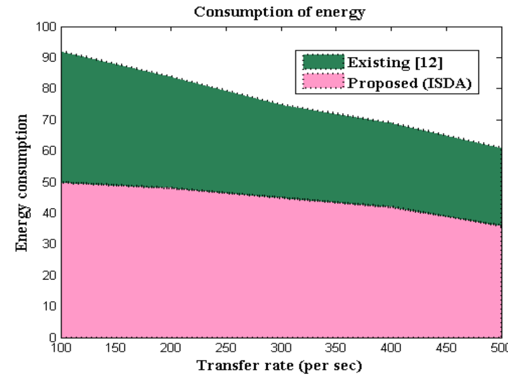

Fig. 4. Comparison of node energy consumption.

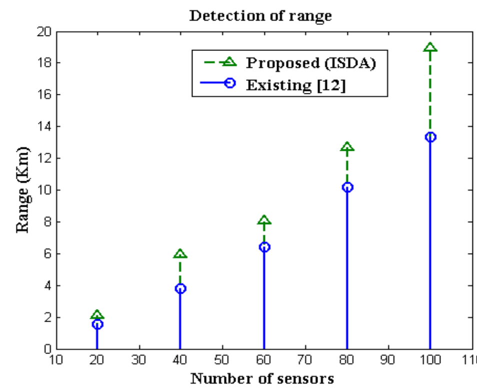

Fig. 5. Comparison of distance covered in circles.

Case 1: Consumption of energy
Case 2: Maximization of range (Circle analysis)
Case 3: Minimization of cost

Before discussing about the case studies it is important to note the number of positive and negative samples that has been obtained at different temperatures. It is required that minimum positive samples should be obtained on an average of about 60-70%. If the samples are not obtained within the aforementioned rate then, all the case studies will result in error and it will provide conflicting results such as maximization of energy, cost etc. So to avoid the errors in measurement the number of positive and negative samples has been observed in OMS and is shown in Figure 3.

From Figure 3, it can be observed that the positive samples are more where, successive samples of smoke in all vehicles have been obtained for testing. Now after a careful investigation, the case studies needs to be performed for validating the proposed formulations with ISDA.

Case 1: The pre-installed nodes at both transmitter and receiver should be able to minimize the energy which is calculated using Equation (6). The amplified energy of the nodes plays an important role in this case. If there is any need of sensor where, energy is maximum then the corresponding energies can be converted to amplified form. In this way the consumption of energy by the sensors can be minimized. Figure 4 shows the consumption of energy by sensor nodes when the data is transferred to the receiver (per second).

From Figure 4, it can be seen that for the maximum data transfer rate which is varying between 100- 500 Megabits per second (Mbps), the energy consumption for the proposed ISDA method will be varying on an average of 32 Joules per bit. For example, for the transfer rate of 300 Mbps the energy consumption of the sensor nodes will be 30 whereas, for the existing method [12] it is found to be 45 Joules per bit. Similarly if data transfer rate is increased to an extent of 500 Mbps the energy consumption between proposed and existing method is higher where for existing method it is observed to be 36 Joules per bit but for proposed method it is equal to 25 Joules per bit. Thus energy is also saved when proposed algorithm is integrated. It is always indorsed that if a system produces low energy level at high data rate then in future it provides more support for monitoring battery operated vehicles. This proves that ISDA is more efficient for monitoring the smoke produced by vehicles at a low energy rate.

Case 2: In this case the most important parameter which is denoted as range (R_i) covered by the sensors is determined. For an efficient working sensor, the distance should be as long as possible. This range is calculated using Equation (7) where, the area of circle of different zones has been taken under consideration. The areas are divided into necessary regions which are covered in a larger circle. Therefore, adequate number of sensors will be placed in the regions that are divided as circles. Figure 5 shows the distance covered by each sensor and it varies according to the divided circles.

From Figure 5, it can be seen that a maximum of 100 sensors will be placed and the region circles will also be divided accordingly. For the existing method [12], the range covered

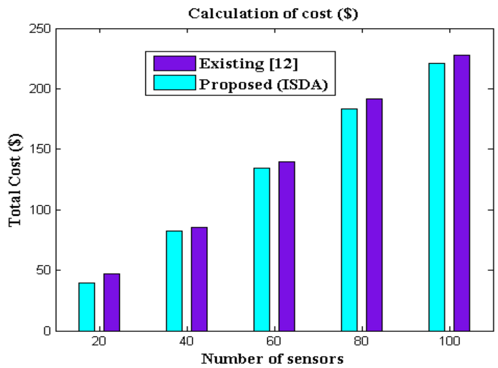

Fig. 6. Calculation of cost ($).

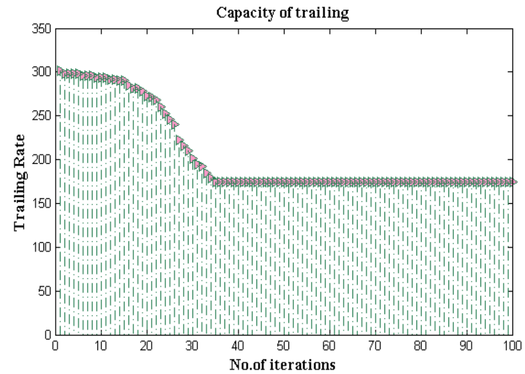

Fig. 7. Trailing rate of ISDA.

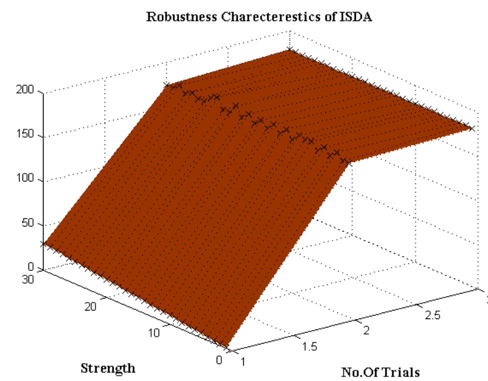

Fig. 8. Robustness characteristics of ISDA.

by each sensor is very lesser when compared to proposed ISDA method because the area has not been divided in circles. For example, if the number of sensors is 80, then the distance covered by the existing method [12] is approximately 10 Kilometers whereas, the proposed method will cover nearly 13 Kilometers. The range of Kilometers will be highly augmented if the numbers of sensors are increased. This can be proved by considering the case when number of sensors is equal to 100 where, the covered range is much higher for proposed method which is equal to 19 Kilometers but the existing method can able to cover only 14 Kilometers. If the range covered by large sensors is minimum then in future it cannot be installed on highways where length of transportations is much extensive. Also the installed large number of sensors will provide high resolution for larger images. This shows that the ISDA performs well and it covers a larger range than the existing method [12].

Case 3: This case study depends on the previous case that is discussed above where, if the distance is higher then, the cost of sensor to be installed will be very much less. It should always be typical that even for autonomous driving of vehicles the cost of installation should be much lesser with long ranges. Therefore, in this case maximum of 100 sensors will be taken under consideration. The cost of each sensor is calculated using Equation (8). After implementing the corresponding equation the cost values are obtained in OMS and are plotted in Figure 6.

From Figure 6, it can be seen that the cost implemented for the proposed method is always lesser. For example, if the number of sensors are 60 then, the cost of implementation will be 134.5$ whereas, for the existing method [12] with same number of sensors the cost will be around 139.7$. Even if number of sensors are much higher which is equal to 100 the proposed method utilizes much less cost where it can be observed as 221$. If installed sensors grow rapidly it is possible to achieve low cost by connecting infrared image sensors in highways. This proves that the ISDA is more efficient for implementation in real time at reduced cost.

A. Performance Analysis of Proposed Method

In addition to all case studies discussed above it is much important to determine performance analysis of projected sensor based technical method. Therefore, two basic parametric evaluations such as capacity of trailing and associated robustness of proposed ISDA is calculated.

Figure 7 shows the trailing rate of ISDA where numbers of iterations are considered to be 100. It can be observed from Figure 7 that at starting when number of sensors is low the proposed algorithm cannot able to converge at a faster rate. But if number of sensors is high then capacity of trailing starts decreasing to original level and finally a constant rate is reached. This constant rate is also achieved at iteration between 30 and 35 where unnecessary wastages are dropped. Therefore this performance metric proves that the proposed method can able to hold maximum capacity at minimum time periods where effective operation is guaranteed. Similarly the proposed algorithm can be verified by using another metric which is termed as robustness. Robustness denotes the strength of the proposed algorithm where examination of all parametric values will be considered.

Figure 8 shows the robustness characteristics of proposed ISDA which is observed for maximum of 30 trial runs. It can be observed in Figure 8 that base strength of ISDA is 180 millilitres where after integrating the proposed formulations the strength varies between 174 to 180 millilitres. If the corresponding level goes below 174 millilitres then an alarm sound will be produced inside the vehicle which indicates the strength of monitoring process is lesser. Conversely, the proposed method achieves maximum strength of 180 within 15 trials where more efficient monitoring process is achieved. Also the data strength is checked for same number of trials and it has been observed that within short run the data quality is much higher and there is no need for an individual to change the corresponding sensor for a period of 10 years.

V. Conclusion

In this article, the issue on rising pollution by vehicles has been controlled by a new flanged procedure. The focal difference between the existing method and the projected method is that the ISDA algorithm will divide the necessary regions into circles. This separation has been applied in order to monitor the vehicles under different temperatures. This method will create awareness among the people who are living in metropolitan area. When the vehicle crosses the threshold contamination value, automated information will be sent to the necessary department where, the workers will monitor the vehicle and the engine will be switched off automatically. The purpose of providing information to the corresponding department is that the consultant should inform the driver to stop the vehicle at a proper place. This policy is usually followed to prevent accidents in urban areas. Further, the results obtained by ISDA prove to be more effective during this monitoring process with less cost of implementation. Also, ISDA achieves an optimistic performance rate of 76.8% which is higher than existing methods. In future the proposed smoke detection method can be extended by installing multiple sensor nodes at each highway lanes for detecting the smoke of vehicles in addition with detection of new parameters like direction and speed of vehicle.

References

[1] D. Kandris, C. Nakas, D. Vomvas, and G. Koulouras, "Applications of wireless sensor networks: An up-to-date survey," *Appl. Syst. Innov.*, vol. 3, no. 1, pp. 1–24, Mar. 2020.

[2] S. Ullo *et al.*, "Application of wireless sensor networks to environmental monitoring for sustainable mobility," in *Proc. IEEE Int. Conf. Environ. Eng. (EE)*, Mar. 2018, pp. 1–7.

[3] S. Kaivonen and E. C.-H. Ngai, "Real-time air pollution monitoring with sensors on city bus," *Digit. Commun. Netw.*, vol. 6, no. 1, pp. 23–30, Feb. 2020.

[4] A. Biswal, J. Subhashini, and A. K. Pasayat, "Air quality monitoring system for indoor environments using IoT," in *Proc. AIP Conf.*, vol. 2112, Jun. 2019, Art. no. 020180.

[5] Y. Yamauchi, A. Mammoto, M. Dohi, H. Ebata, and M. Morita, "A calculation method for predicting heat and smoke detector's response," *Fire Sci. Technol.*, vol. 24, no. 4, pp. 179–210, 2005.

[6] L. Andrea, R. Abirami, M. Diviya, and J. S. Nancy, "Framework for fire detection and mitigation using IoT," *Int. J. Pure Appl. Math.*, vol. 118, no. 18, pp. 1801–1811, 2018.

[7] Q. Wu *et al.*, "Intelligent smoke alarm system with wireless sensor network using ZigBee," *Wireless Commun. Mobile Comput.*, vol. 2018, no. 2, pp. 1–11, 2018.

[8] K. Arjun, P. Prithviraj, and A. Ashwitha, "Sensor based application for smart vehicles," *Int. J. Latest Trends Eng. Technol.*, vol. 8, no. 1, pp. 526–532, Jan. 2017.

[9] R. Pi, "An IoI based forest fire detection using raspberry Pi," *Int. J. Recent Technol. Eng.*, vol. 8, no. 4, pp. 9126–9132, 2019.

[10] N. Pawne, M. Studies, and G. Deo, "Auxiliary safety systems for two," *Int. J. Novel Res. Develop.*, vol. 2, no. 6, pp. 104–115, Jul. 2017.

[11] F. Saeed, A. Paul, A. Rehman, W. Hong, and H. Seo, "IoT-based intelligent modeling of smart home environment for fire prevention and safety," *J. Sens. Actuator Netw.*, vol. 7, no. 1, p. 11, Mar. 2018.

[12] W. Li and W. Zhang, "Sensor selection for improving accuracy of target localisation in wireless visual sensor networks," *IET Wireless Sensor Syst.*, vol. 2, no. 4, pp. 293–301, Dec. 2012.

[13] A. Paul, A. Daniel, A. Ahmed, and S. Rho, "Cooperative cognitive intelligence for Internet of vehicles," *IEEE Sensors J.*, vol. 11, no. 3, pp. 1–10, 2017.

[14] K. D. Singh, P. Rawat, and J.-M. Bonnin, "Cognitive radio for vehicular ad hoc networks (CR-VANETs): Approaches and challenges," *EURASIP J. Wireless Commun. Netw.*, vol. 2014, no. 1, pp. 1–22, Dec. 2014.

[15] M. Younis and K. Akkaya, "Strategies and techniques for node placement in wireless sensor networks: A survey," *Ad Hoc Netw.*, vol. 6, no. 4, pp. 621–655, Jun. 2008.

[16] M. Maksimović and V. Milošević, "Evaluating the optimal sensor placement for smoke detection," *Yugoslav J. Oper. Res.*, vol. 26, no. 1, pp. 33–50, 2016.

[17] *Status of the Vehicular Pollution Control Programme in India*, Minist. Environ. For. Govt. India, CPCB, New Delhi, India, 2010, pp. 1–114.

[18] R. Salazar-Cabrera, Á. P. de la Cruz, and J. M. M. Molina, "Sustainable transit vehicle tracking service, using intelligent transportation system services and emerging communication technologies: A review," *J. Traffic Transp. Eng.*, vol. xxx, pp. 1–19, Nov. 2020.

[19] J. Wei, C.-H. Chiu, F. Huang, J. Zhang, and C. Cai, "A cost-effective decentralized vehicle remote positioning and tracking system using BeiDou navigation satellite system and mobile network," *EURASIP J. Wireless Commun. Netw.*, vol. 2019, no. 1, p. 8, Dec. 2019.

[20] M. Bernas, B. Płaczek, W. Korski, P. Loska, J. Smyła, and P. Szymała, "A survey and comparison of low-cost sensing technologies for road traffic monitoring," *Sensors*, vol. 18, no. 10, pp. 1–27, 2018.

[21] S. Karmore, R. Bodhe, F. Al-Turjman, R. L. Kumar, and S. Pillai, "IoT based humanoid software for identification and diagnosis of covid-19 suspects," *IEEE Sensors J.*, early access, Oct. 21, 2020, doi: 10.1109/JSEN.2020.3030905.

[22] B. Misganaw and M. Vidyasagar, "Exploiting ordinal class structure in multiclass classification: Application to ovarian cancer," *IEEE Life Sci. Lett.*, vol. 1, no. 1, pp. 15–18, Jun. 2015.

[23] F. Al-Turjman and J. P. Lemayian, "Intelligence, security, and vehicular sensor networks in Internet of Things (IoT)-enabled smart-cities: An overview," *Comput. Electr. Eng.*, vol. 87, Oct. 2020, Art. no. 106776.

[24] S. Ramasubbareddy, S. Ramasamy, K. S. Sahoo, R. L. Kumar, Q.-V. Pham, and N.-N. Dao, "CAVMS: Application-aware cloudlet adaption and VM selection framework for multicloudlet environment," *IEEE Syst. J.*, early access, Oct. 26, 2020, doi: 10.1109/JSYST.2020.3029807.

[25] A. Namozov and Y. I. Cho, "An efficient deep learning algorithm for fire and smoke detection with limited data," *Adv. Electr. Comput. Eng.*, vol. 18, no. 4, pp. 121–128, 2018.