A Cognitive Approach for Real time Monitoring of CO and CO_2 Emissions in Vehicles

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***Abstract*—** With rise in the amount of heat trapping gases the earth is getting warmer day by day, leading to global warming. CO2 and CO are the major contributors of the greenhouse gases. The Internet of Things (IOT) extends internet connectivity to a diverse range of devices and everyday things that utilize embedded technology to communicate and interact with the external environment, all via the Internet. The main aim of this research is, real time monitoring of CO2 and CO emission in vehicles and industries using cognitive IOT, which in turn can control green house effect. This paper focuses, on the design of an intelligent green gas detector for real time monitoring of CO2 and CO emissions in vehicles using Cognitive Internet of things. The implemented model adheres to cognitive IOT framework and provides information for utilization of vehicular features based on the CO2 and CO levels. The model is cost effective and can be easily produced and integrated with vehicles.

***Keywords*—** Cognitive IOT, CO2 monitoring, Internet centric, Green House Effect, CO monitoring.

I. INTRODUCTION

Our lives are driven by the climate**.** A warming climate will bring changes that can affect our water supplies, agriculture, power and transportation systems, the natural environment, and even our own health and safety. Some changes to the climate are unavoidable**.** Carbon dioxide can stay in the atmosphere for nearly a century, so Earth will continue to warm in the coming decades. The warmer it gets, the greater the risk for more severe changes to the climate and Earth's system. Greenhouse Gas Emissions council has done a survey in 2013 says CO2 has a major contribution of 82% of the total green gases emitted. And the statistics also says 27% of the green gases is due to transportation and 31% is from industries [1]. India is at fourth position and contributing 8.95% of the total CO2 emissions in the entire world. The survey of CO2 emissions from vehicles in India reveals that major vehicle contributor of CO2 are cars, taxis and MUV's. The proposed design is hence based on the cars and taxis.

Although it's difficult to predict the exact impact of climate change, it is clear that the climate we are accustomed to be no longer a reliable guide for what to expect in the future**.** We can reduce the risks we will face from climate change [2][3]. By making choices that reduce greenhouse gas pollution, and preparing for the changes that are already underway, we can reduce risks by continuous monitoring of CO2 emissions.

The new concept of the Cognitive Internet of Things (CIOT) has been used for the creation of innovative applications that integrate the all too familiar traditional digital technologies. The CIOT is about interfacing these autonomous devices to communicate without human intervention and generate integrated data. Intelligence is then required to process this integrated data and make it available to the humans for decision-making. [4] This concept of CIOT has been applied to monitor greenhouse gases released by the vehicles.CO2 and CO sensors are available but no system is available for real time monitoring and thus controlling the CO2 emission levels with the help of the control center. The amount of CO2 emissions have to be reduced by having a check on the transport system or industries with the help of governing bodies.

The major contribution of this paper is development of a cognitive model for real time monitoring of harmful gases. The model developed monitors CO_2 and CO emissions with the help of sensors MG811 and MQ35. The decision making is done using the abstracted data and sent to the webserver for further evaluation. The remaining part of the paper covers, section II covers survey of existing systems, section III includes the methodology employed for monitoring and decision making and section IV covers the results of the implemented model.

II. RELATED WORK

In the Internet of Things (IOT) paradigm, many day to day objects that are around us will be on a network in some form or another and first was used in context of supply chain management [5]. The definition was reframed and included a wide range of applications like healthcare, utilities, transport, etc [6]**.** The main goal of making computer sense information without the aid of human intervention is the gist of IOT. IOT is based on harvesting information from the environment (sensing) and interact with the physical world (actuation/command/control).It uses existing Internet standards to provide services for information transfer, analytics, applications, and communications. Various open wireless technologies have boosted the development of IOT such as Bluetooth, radio frequency identification (RFID), Wi-Fi, and telephonic data services as well as embedded sensor and actuator nodes [7].The research on Cognitive Internet of Things (CIOT) is very limited. A cognitive management framework is presented to empower the IOT to better support sustainable smart city development. Cognition mainly refers to the autonomic selection of the most relevant information for the given application. CIOT is viewed as the current IOT integrated with cognitive and cooperative mechanisms to promote performance and achieve intelligence [3]. The survey reveals that total CO_2 emissions from an average car showed that 76% were from fuel usage where as 9% was from manufacturing of the vehicle and a further 15% was from emissions and losses in the fuel supply system [2]. CIOT serves as a transparent bridge between physical world with general physical/virtual things, objects, resources, etc. and with social world like human demand, social behaviour, etc. The CIOT framework as proposed by [12, 16] has four major layers.

1) Sensing control layer has direct interfaces with physical environment, in which the perceptors sense the environment by processing the incoming stimuli and feedbacks observations to the upper layer, and the actuators act so as to control the perceptors via the environment.

2) Data-semantic-knowledge layer effectively analyses the sensing data to form useful semantic and knowledge.

3) Decision-making layer uses the semantic and knowledge abstracted from the lower layer to enable multiple or even massive interactive agents to reason, plan, and select the most suitable action, with dual functions to support services for human/social networks and stimulate action/ adaptation to physical environment.

4) Service evaluation layer shares important interfaces with social networks, in which on-demand service provisioning is provided to social networks and novel performance metrics are designed to evaluate the provisioned services and feedback the evaluation result to the cognition process. The five fundamental tasks in CIOT are Perception-Action, Massive Data Analytics, Semantic Derivation and Knowledge Discovery, Intelligent Decision Making and On Demand service Provisioning.

A. Cognitive Internet of Things

Cognitive IOT is the use of cognitive computing technologies in combination with data generated by connected devices and the actions those devices can perform. Cognitive computing is significant to the Internet of Things for a few critical reasons [4] as under.

1. Rate and scale of data generation: Learning helps optimize processes or systems to make them more efficient based on combining sensor data about the system with other contextual information. The data generated from devices can quickly overwhelm the human ability to analyse for detecting important patterns and learning. Applying machine learning is essential to being able to scale the Internet of Things.

2. Computing movement into the physical world**:** As more people of all ages and technical skill levels interact with Internet of Things systems, we need to move beyond current machine interface paradigms that require humans to learn the abstractions and specialized interfaces needed to interact with machines. And that movement needs to be toward a more human-centric interface. In other words, people need to be able to interact with Internet of Things systems—things—using natural language. The systems have to begin to understand people. Author David Rose from the MIT Media Lab coined the term "enchanted objects" to characterize the seemingly intelligent behaviour that we can infuse into connected devices through the Internet of Things and cognitive computing.

3. Integration of multiple data sources and types: In the Internet of Things, many data sources exist that may provide related information or context for better understanding and decision making. The ability to digest and analyze different types of data, including digital sensor data, audio, video, unstructured textual data, location data and so on, and to identify correlations and patterns across these data types are very powerful capabilities. Understanding the intention of human operators can be greatly enhanced by greater knowledge of the context—physical context, temporal context and even emotional context. Reasoning and decision making can be improved by integrating multiple different data sources—for example, correlating sensor data with acoustic data.

III. METHODOLOGY

The proposed design falls in the CIOT framework. The framework of CIOT, serves as a transparent bridge between physical world like objects, and social world together with itself to form an intelligent system [4]. The cognitive process of the system where harmful gases like CO2 and CO in the vehicle exhaust is monitored consists of four major layers.

A. Sensing control layer

This layer deals with the interfacing of the two sensors MQ7 and MQ135 with the Raspberry pi. As the sensor produce analog values and Raspberry pi recognizes only digital values, we have to use an ADC (Analog to Digital Converter). We have used 10bit MCP3008 as our ADC. The MQ7 and MQ135 gas sensors are connected to Raspberry pi via the ADC.MQ-7 and MQ-135We have board mounted sensor with four pins Analog out, Power input, Ground, and Digital out. Analog out pin is connected to input channel of MCP300. Power to sensor is given by 5v output of RPI. Digital out pin of sensor is not used.MCP3008is a 10 bit ADC that has 8 channels. Analog input from sensor is given to these channels. MCP3008 uses 3.3v as reference and power input voltage from RPI. MCP3008 converts analog voltage to 10 bit binary output.

B. Data-semantic-knowledge layer

In this layer the data from the sensor control layer is put in the data base for future analysis. The Rpi is the main computing device which calculates the emission value from the sensors and stores it in its local database. Rpi can have internet connectivity through Ethernet cable or via Wi-Fi. Rpi can also sends the emission values to the website periodically on day to day basis. RPI has much functionality in this system such as conversion of digital output from sensors into an understandable unit such as PPM, to store the emission values from sensor into the local database and to send emission data to the server periodically. MySQL server and PHPMyAdmin is installed at the backend. MySQL-Db is installed as database interface for python. MySQL-db is an interface for connecting to a MySQL database server from Python. It implements the Python Database API v2.0 and is built on top of the MySQL C API.

C. Decision-making layer

It uses the knowledge abstracted from the lower semantic layer to make the decisions. The decisions in our system are sending of alerts to the owner, central control board and the social network sites. These decisions are made based on the abstracted data. To send data to web server we have used request library in python to post data to a specific webpage. This library has to be installed and is not present in Python. Requests will allow you to send HTTP/1.1 requests using Python. With it, you can add content like headers, form data, multipart files, and parameters via simple Python libraries. It also allows you to access the response data of Python in the same way.

D. Service evaluation layer

This layer shares important interfaces with social networks and automobile industries in which feedback and the evaluations results in the cognition process. The vision of IOT can be seen from two perspectives –Internet centric and Thing centric. The Internet centric architecture will involve internet services being the main focus while data is contributed by the objects. In the object centric architecture, the smart objects take the centre stage. In our work, we develop an Internet centric approach [8].The four layer framework for pollution detection is shown in figure 1. The

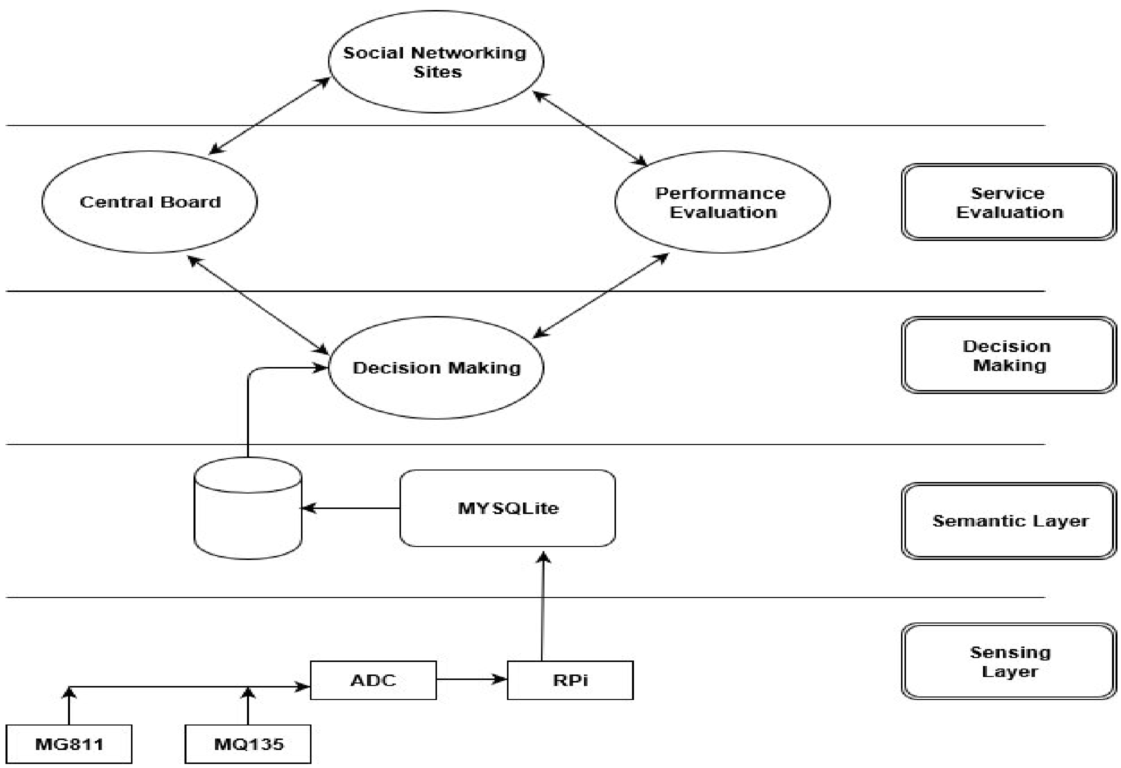

Fig. 1: Framework for Monitoring CO2 and CO in vehicles

The entire system of pollution monitoring can be divided into two modules.

1. Central Board Module

Billions of smart objects will be immersed in the environment, sensing, interacting, and cooperating with each other to enable efficient services that will bring tangible benefits to the environment, the economy and the society as a whole. The central board receives alerts and respective credentials from millions of vehicles. The cost effective solution to this is cloud. The data generated at the central board has to be put on the cloud.

2. Owner Module

The car owner has to install a designed system at the exhaust to sense the level of gases emitted in terms of PPM. The sensors are communicating with the PI in the vehicle. If the gas level exceeds the normal PPM level [3] the PI sends an email notification to owner. This notification is like a warning message given to the owner so that owner is allowed to rectify the vehicle. If the owner does not take any action to reduce the emissions, an alert is sent to the central board. We have built a website that collects emission data from all devices and stores it in a database. The vehicle owner can log-in to the website to check his emission values. Also, the emission values are visualized into graphs of time and emission of two gases. Website also provides monthly and yearly emission of specific vehicles. It also gives graphs, bar charts and pie charts of emission based on vehicle's manufacturer, type of vehicle and year of production. One of the important functionality of the website is to send mail alerts to vehicle owners if they do not follow emission norms. The schematic for pollution monitoring is as shown in figure 2 .

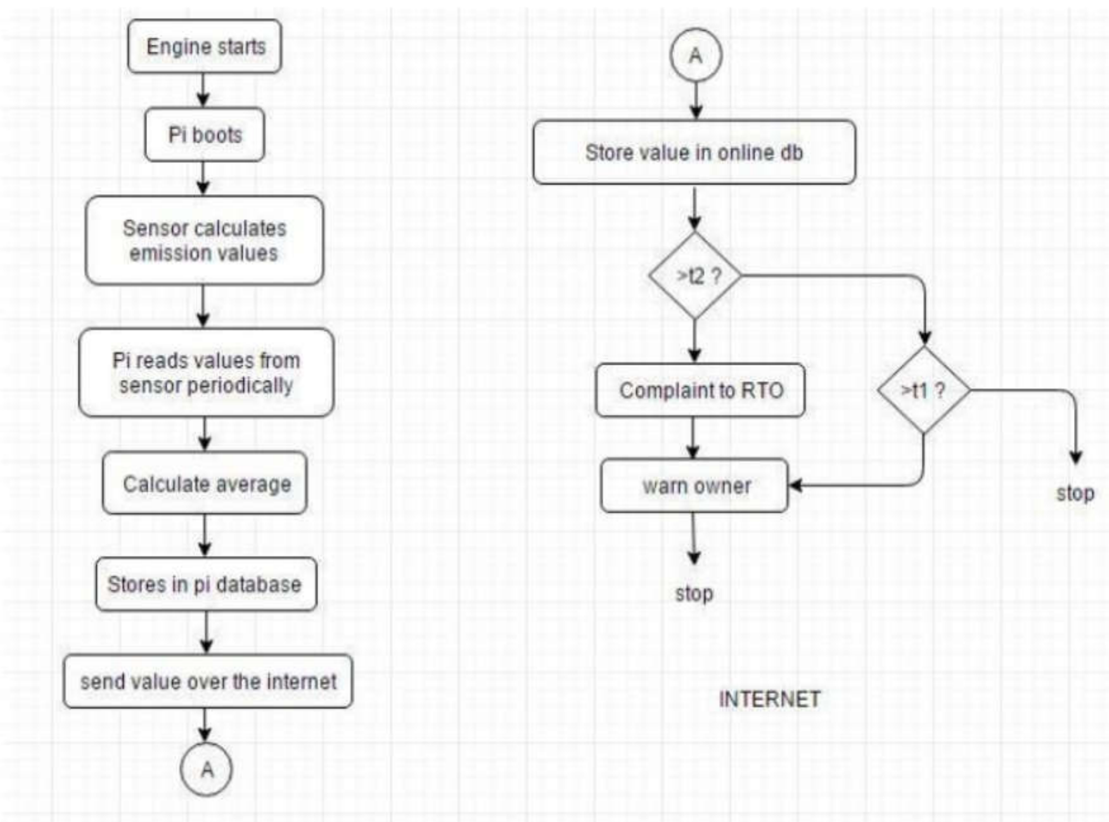

Fig. 2 Schematic flow for pollution monitoring

IV. RESULTS AND DISCUSSION

A. Calibration of sensors

The gas sensors produce analog output which in turn is converted into digital form for RPI. But, these values are mere voltages and are unit less. To convert these voltages into PPM (unit for gases) we have to calibrate each sensor. The given charts are sensitivity characteristics of the gas sensors. The PPM values are derived with the help of these curves. The X-axis of the curve is defined by RS/RO and Y-axis by PPM, where RS, is sensor resistance and RO is sensor resistance at 100 PPM CO_2 for MQ135 and 100 PPM CO for MQ7.

The Sensor are very sensitive that it can sense the gases emitted from other vehicles while stuck in Traffic this can disturb the integrity of the system. This can be overcome by reading the samples over a period and then based on the average value the system will take an action. The curves are logarithmic in nature and are given by the function:

$$PPM = (SCALING\_FACTOR * RSRO\_RATIO)^{EXPONENT}$$

To calibrate the sensor, we have to find RO. RO can be found by getting steady values from sensor in a known concentration of gas. Ro is determined by the formula.

$$RO = RS * (SCALING\_FACTOR / PPM)^{1/EXPONENT}$$

The PPM value substituted for MQ135 is 400 PPM for CO2 and 2 PPM for MQ7 (CO). These are the outdoor concentration of gases. RS is the sensor resistance which is calculated using the below formula.

$$RS = (1023 \div ANALOGVALUE - 1) * RL$$

RL is the load resistance attached to the sensor.

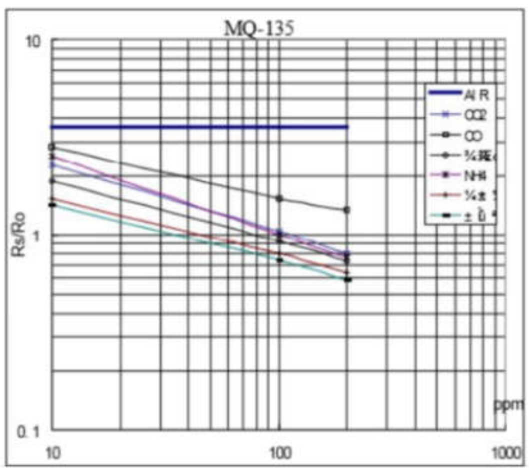

Fig. 3Sensitivity Characteristics of MQ135

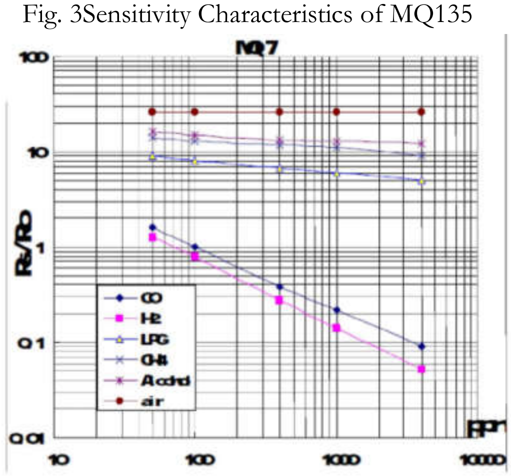

Fig. 4Sensitivity Characteristics of MQ7

B. Test Cases with PPM values

The implemented model is tested with two different vehicles namely BAJAJ XCD 125 and HONDA ACTIVA 110. The device recorded PPM values of Carbon mono-oxide (CO) and Carbon di-oxide (CO_2) for both the vehicles are shown in Table 1. The results are sampled 3 times and are averaged. We were also able to store these values in RPI database using MySQL db connector for python. The device also sends the values to a web server using REQUESTS library. When the program stores the PPM concentrations of gases into Raspberry pi database, it runs a Request script to send these values to the internet onto the website. The website database has PPM concentration, vehicle details and date as the attribute.

	CO_2	CO
BAJAJ XCD 125	4124	58
	4120	57
	4122	57
Average	4122	58
HONDA ACTIVA 110.	3256	45
	3258	46
	3260	47
Average	3258	46

Table 1: PPM values recorded for the vehicles

V. CONCLUSION AND FUTURE DIRECTION

Pollution Check must be done every 6 months and hardly people get it done. The implemented model adheres to real time monitoring of CO_2 and CO which can reduce the effect of harmful gases in the environment. The system effectively sends email alerts to the owner if the emissions exceed the set threshold PPM. In the future direction the data from various vehicles collected at the central server can be abstracted using Data Analytics Algorithm. The abstracted data can reveal the number of alerts of a vehicle over a period. If the alerts of a vehicle exceeded the threshold in the fixed time slot, heavy fine can be levied on the owner via online payment gateway. The abstracted data can also provide service to social networks and automobile industries for evaluation. This system can cut down and control the emission considerably and gradually reduce Global Warming, if implemented on global scale.

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