CLOUD-BASED SUPERVISION OF URBAN INFORMATION PROCESSING USING AI

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Abstract:

This is concept is going to develop a logging system, which will allow nodes to log data in to MATLAB database. This concept also going to develop web based, mobile based application which will show all logged data on the web page, android app and also providing response action. response action is initiated by both web and mobile application. This has transformed smart city infrastructures, introducing various technologies that enhance sustainability, productivity, and comfort for urban dwellers. By leveraging Artificial Intelligence (AI) to analyze the vast amount of IoT data available, new opportunities are emerging to design and manage futuristic smart cities. The convergence of AI and Edge Computing, emerging a brand-new paradigm called edge intelligence, has been expected to unleash the full potential of intelligent IoT services. The novelty in this work is, incorporation of Edge computing in IoT system, which enhances the performance of the IoT system by reducing the load on the cloud. Wi-Fi protocol is used in the network level for data transmission. Raspberry–pi is used to design edge server. The main motivation of this project is to prevent from unexpected pollution levels in air, water, etc., that causes harmful to the health and also to the nature.

Keywords: Artificial Intelligence, Edge Computing, Internet of Things, Smart city, Wireless fidelity, Matrix laboratory.

Introduction:

A **smart city** is a city that utilizes information and communication technologies so that it enhances the quality and performance of urban services (such as energy and transportation) so that there's a reduction in resource consumption, wastage, and overall costs. In this article, it will look at components of a smart city and its AI-powered-IoT use cases, how AI helps with the adaption of IoT in Smart cities, and an example of AI-powered-IoT solution.

Artificial Intelligence (**AI**), together with IoT, has the potential to address the key challenges posed by excessive urban population; they can help with traffic management, healthcare, energy crisis, and many other issues. IoT data and AI technology can improve the lives of the citizens and businesses that inhabit a smart city.

Smart city and its AI-powered-IoT:

A smart city has lots of use cases for AI-powered IoT-enabled technology, from maintaining a healthier environment to enhancing public transport and safety. In the following diagram, you can see some the of use cases for a smart city:

Fig1: Smart city components

Building a smart city is not a one-day business, neither is it the work of one person or organization. It requires the collaboration of many strategic partners, leaders, and even citizens. Let's explore what the AI community can do, what are the areas that provide us with a career or entrepreneurship opportunity. Any IoT platform will necessarily require the following:

- A network of smart things (sensors, cameras, actuators, and so on) for gathering data
- Field (cloud) gateways that can gather the data from low power IoT devices, store it, and forward it securely to the cloud
- Streaming data processor for aggregating numerous data streams and distributing them to a data lake and control applications
- A data lake for storing all the raw data, even the ones that seem of no value yet
- A data warehouse that can clean and structure the collected data
- Tools for analyzing and visualizing the data collected by sensors
- AI algorithms and techniques for automating city services based on long-term data analysis and finding ways to improve the performance of control applications
- Control applications for sending commands to the IoT actuators
- User applications for connecting smart things and citizens

Literature Survey:

The IoT perception layer that the SCI system relies on provides multiple sources of information with a variety of types and a large volume. It is necessary to build a unified data access and collection mechanism, so as to provide heterogeneous, multi-dimensional, massive, multi-temporal, and multi-observation model information for the social and economic life of people, which has been researched by many scholars. Bresciani et al. (2018) modelled the data of multiple foreign IoT smart city project alliances to realizing close correlation between the development of the company and the rapid development of urbanization; the author emphasized that the knowledge management ability indirectly improves the flexibility of the alliance through the information and communication technology capabilities of the enterprise, and recommended that the managers of multinational companies design knowledge management tools and develop new information and communication technology skills [10]. Qian et al. (2019) used IoT technology to promote the construction of urban infrastructure, which makes the urban economy grow sustainably and people's living standards improve significantly [11]. Chen et al. (2020) used the convolutional neural network (CNN) in deep learning to consider the evacuation function in the design process of smart city public construction; it was found that the evacuation process took the shortest time after the model training, which can have a good effect on the construction of smart cities [12]. Watson et al. (2020) discussed and estimated the big data-driven decision-making process in the knowledge-based city economy by comprehensively analysing the existing achievements and basis of IoT smart city; and it was found that although IoT has made a great contribution to the construction of smart city, it still can't meet the needs of smart city development [13]. To eliminate the need for dedicated expensive computing hardware, cloud computing was introduced. This is a powerful technology that is intended to enhance the Quality of Experience (QoE) by providing on-demand storage and processing capabilities in a cost-effective and elastic manner [8]. The striking features of cloud computing, such as scalability, elasticity, multitenancy, sufficient storage capacity, and resource pooling, have made its adoption possible in different areas [9]–[11]. Recently, cloud computing with virtually unlimited resources has emerged as a promising paradigm to tackle the high computational complexity associated with smart cities [12]. However, its inherent limitations of high latency, non-context-aware behavior, and no support for mobility pose serious limitations on its use in real-time smart environments. Apart from these downsides, cloud computing suffers from processing time inefficiency due to the large overhead of smart city device data. On the other hand, edge computing extends the cloud computing resources to the network edge and offers context-awareness, low latency, mobility support, scalability, to name a few. Hence, to address the limitations of cloud computing for enabling real-time smart city environments, edge computing is a viable solution [13]– [16].

Architecture of AI based IoT-Enabled Smart City:

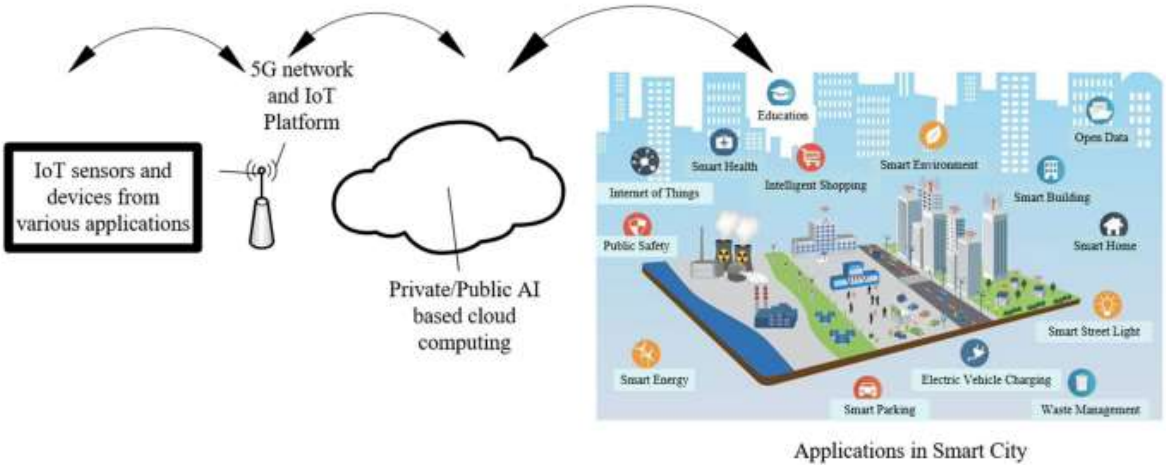

Figure 2. Illustration of the combination of IoT, 5G and AI, which would be the integral components of a futuristic smart city.

The success of a smart city relies heavily on its ability to integrate cutting-edge technologies such as 5G communication, IoT devices, and AI algorithms into its infrastructure. By working together, these technologies can create a more efficient, sus- tainable, and livable city. By integrating AI algorithms with renewable energy sources such as solar and wind power, cities can optimize energy usage and reduce carbon emissions, making the city more environmentally sustainable while reducing energy costs for residents and businesses. By leveraging these technologies, smart cities can become more efficient, productive, and ecologically sustainable, ultimately enhancing the quality of life for citizens. By reducing congestion, improving air quality, and optimizing the use of resources, smart cities can create a better living environment for all, making them an exciting prospect for the future of urban development. Figure 2 illustrates a futuristic smart city that combines IoT, 5G, and AI.

The advancement in technologies could bring millions of intelligent sensors to instrument the infrastructure of the cities, working with speed and network structure equivalent to 1000 IoT devices. Effective management of the data collected from sensors is another crucial aspect. This data's availability and intelligent management play a vital role in the operation of complex smart city ecosystems, ensuring the accurate functioning of city services. A classification based on the application type is essential to establish a solid foundation for smart cities. As previously mentioned, the degree of smartness in various areas such as governance, economy, healthcare, and others must be evaluated within the context of the smart city application.

The environment of a smart city is characterized by advanced communication technologies and an IoT infrastructure, which requires specific communication technologies and systems architecture to enable all the applications and advantages of smart cities. The architecture of IoT-enabled smart cities typically requires an ICT infrastructure that facilitates information exchange among the various stakeholders within the urban environment, regardless of the specific application or service being used. Communication is essential to transmit data generated from various sensors in different applications between devices and information sinks in both directions. To accomplish this, three commonly used communication patterns are utilized: (i) utilizing Cellular Mobile Networks for communication, (ii) using IoT-Dedicated Cellular Networks for communication, and (iii) employing Multi-Tier Networks for communication. **Figure 3** illustrates the main layout for the three different architectures. Therefore, to achieve a proper architectural ground for smart cities, classification based on the type of application is necessary, as the smartness of entities such as governance, economy, healthcare, etc., must be measured in the smart city application.

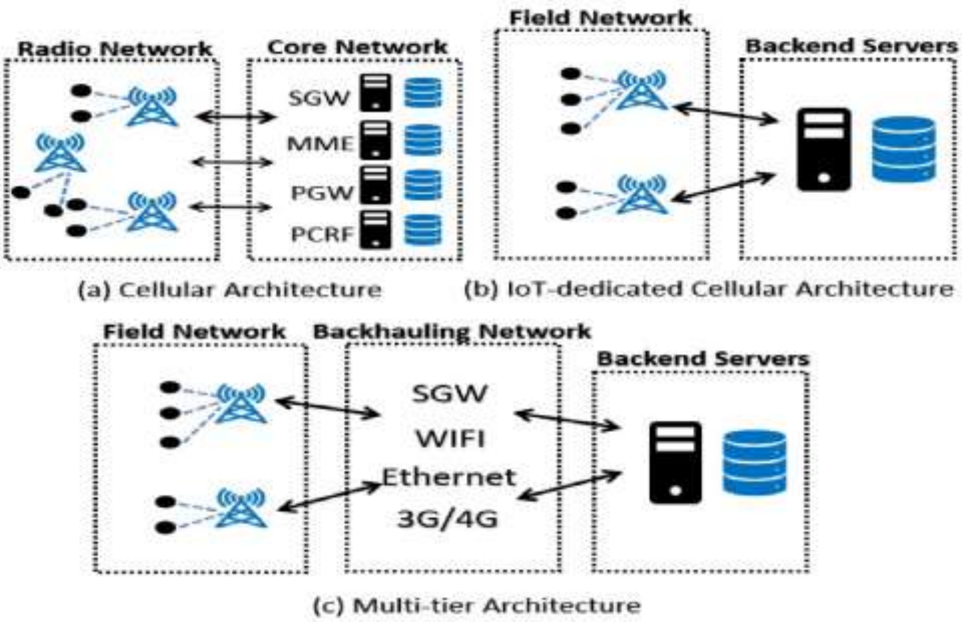

Figure 3. Architectures for supporting the M2M communications in smart cities

Perception or Sensing Layers Components

The components referred to here are the physical objects of electronic devices such as sensors and actuators. These devices interact with the physical world by sending and receiving data, utilizing wireless networks. Various smart city applications include sensors, actuators, and smart device technologies in this context. There is a vast array of commercial devices available that can measure different physical quantities and external variables, i.e., sensors for measuring humidity, temperature, environment monitoring, water nutrient monitoring , etc. Actuators are used for controlling/moving other objects or systems through physical interaction or virtual control. They are usually categorized into pneumatic, electrical, and hydraulic categories. Several software applications and solutions can be used for deploying low-level IoT applications.

Networking and Communication

In the context of smart cities, various communication protocols are available to connect different devices and components of the infrastructure. These protocols have additional features and specifications that make them suitable for specific applications. For example, some protocols such as Wi-Fi, ZigBee, and Z-Wave are ideal for short distances where devices and their coverage areas are limited, while other protocols such as LoRaWAN, NB-IoT, Sigfox, and Long-Term Evolution (LTE) are more suitable for long-range applications. Each of these protocols has unique features that enable them to support various smart city applications. For instance, ZigBee is commonly used for low-power applications with a low data rate, offering a secure network and longer battery life. It also provides network topologies suitable for various applications, such as mesh, star, and tree. On the other hand, LoRaWAN, Narrowband-Internet of Things (NB-IoT), Sigfox, and LTE require devices to be connected through a central gateway to collect information and sink the data, and they operate on licensed and unlicensed spectrums, depending on the applications.

AI on Smart City Technologies

Artificial Intelligence (AI) can revolutionize the technology used in smart cities by facilitating instant analysis of vast amounts of data received from various sources, including sensors, cameras, and IoT devices. AI optimizes and streams various city systems and processes, including transportation, energy, public safety, health care, education, and more . No specific number of AI algorithms can be used in a smart city. The choice of algorithms would depend on the smart city's specific use cases and requirements. Several commonly used artificial intelligence (AI) algorithms exist in smart cities . Various AI algorithms can be used in smart cities to improve efficiency, sustainability, and quality of life. Some of the primarily used AI algorithms are discussed in the subsequent sections.

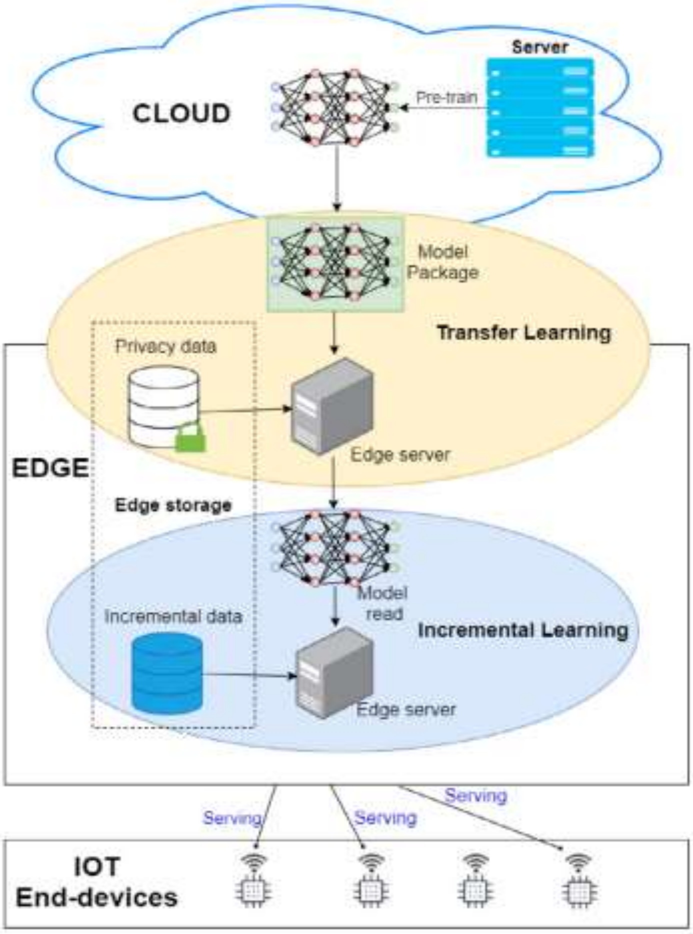

Fig. 4. The overview of the learning phase.

Witnessing the phenomenal growth of edge devices, especially their computational capability (e.g., Raspberry Pi 4, Nvidia Jetson Nano), we believe that these devices could handle more tasks rather than only inference with an effective learning strategy. However, the massive computational power of the cloud is still potentially valuable to enhance the QoE. Only training the AI model in edge is insufficient to provide the high accurate AI services. In brainyEdge, we applied a collaborative edge learning algorithm illustrated in Fig. 4 that consists of transfer learning and incremental learning employed in edge devices to iteratively retrain the models with private and incremental data. The combination of transfer learning and incremental learning significantly mitigates the model performance issues on edge devices: Enhancing the model accuracy for personalized edge contexts: Solely training the model with general data at the cloud fails to achieve the accuracy requirements of personalized edge contexts [8]. Thus, using transfer learning to retrain the model with private data stored in edges is necessary. Maintaining the model accuracy: Because of the high mobility of IoT devices, the contexts and data collected from these devices are frequently changed [10]. This makes the AI models deployed to edges quickly out-ofdate, leading to decreasing its accuracy. To alleviate this issue, instead of deploying a new model from the cloud that may cause device overload and network consumption, we employ incremental learning to update the model with incoming data in edge devices.

Results:

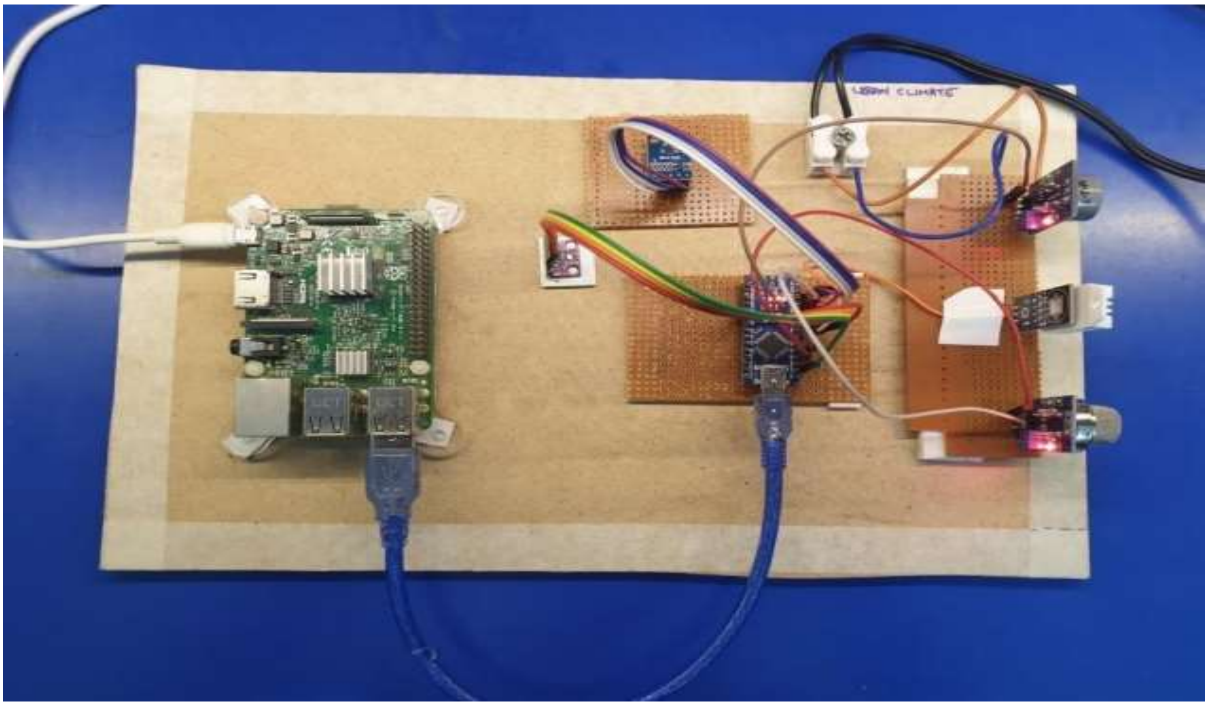

Fig5: Proposed Hardware prototype

Above shown prototype kit represents proposed method implementation for smart city using cloud, AI technologies.

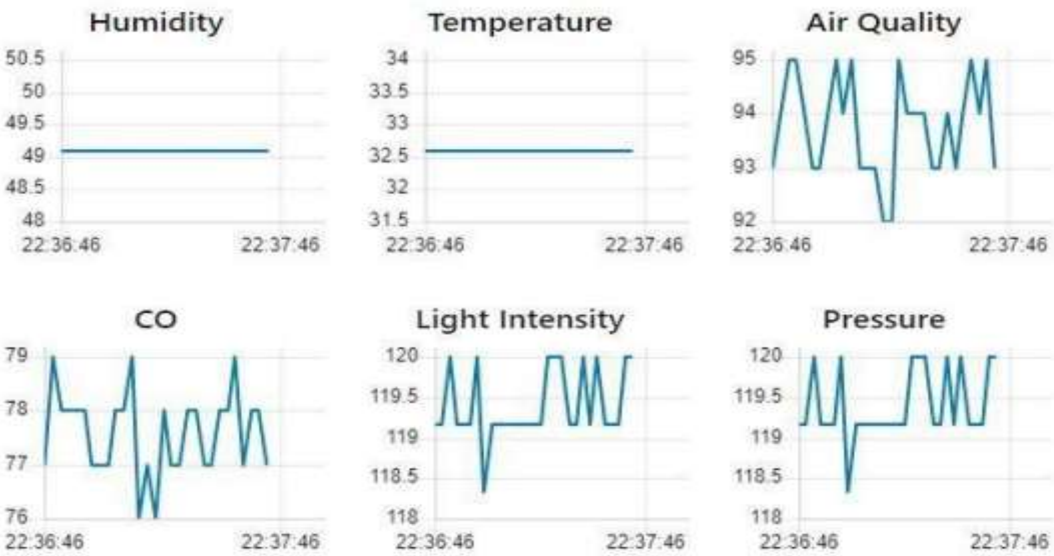

Fig6: Graphical view of the present live data in web based application

Above snapshot represents graphical view of proposed hardware sensors live data in ThingSpeak web application.

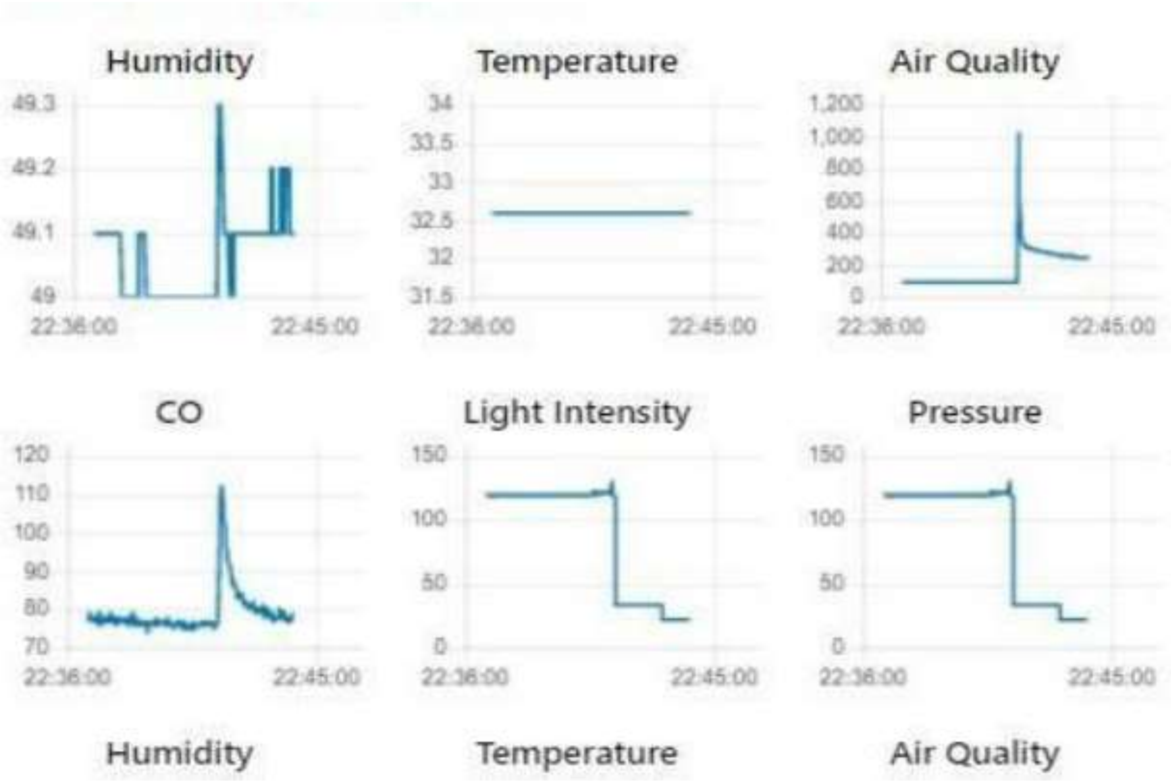

Fig7: Graphical view of the future estimated data in web based application

Above snapshot represents graphical view of proposed hardware sensors estimated data in ThingSpeak web application.

Conclusion:

The understanding from this study will, in the future, contribute to a number of other research opportunities, such as optimal urban network design, advanced sensor systems in smart cities and any microclimate work. This work would assist Environment Departments, Urban Planning Authorities etc. in formulating their smart city policies. The proposed system provides the remote monitoring data witha lightweight, low power, and low-cost system. The use of the low-cost Raspberry Pi mini-computer makes it powerful and effective. The program allows the city to expand sustainably and enhances people’s lives. The ubiquitous availability of dynamic datasheets on the dashboard and the graphical representation from time to time will help to prepare control measures against increasing levels of pollution and build awareness among the people. The system is very hardware efficient and effective, since the sensors used are highly accurate. With the help of this data, appropriate steps can be taken timely to regulate the deteriorating environmental conditions

Feature scope:

These proposed models could be further worked upon and accordingly brought to real life in our cities. There would be lot of assimilation of technology and management in the similar mentioned processes. AI and sensor networks along with recent trends in technology would be a boon to these rapid emerging cities. There are few limitations in the following study such as pilot run, compliance with government and costing for such a mega project. There would be lot of challenges when these smart systems come to live but sill their adoption would be always a boon to mankind. All the aspects considered on the mentioned study such as smart traffic management system, smart parking management and smart waste management based on AI tolls would be a great support to build smart governance.

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