EasyChair Preprint

№ 1535

IoT Based Smart City with Vehicular Safety Monitoring

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September 18, 2019

IoT Based Smart City with Vehicular Safety Monitoring

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Abstract— A definition of a smart city can be defined as a city which works smartly, reduce human effort, and collects data from the various parameters that include students, devices, water supply network, classes, labs, transportation, information system etc. and analysis the data for the future work. Our internet of things (IoT) based stimulated and conceptual model consists of various systems which collects data from the different parameters and send data to the central control room through the access point. Various sensors are used for different environment parameter which is controlled by microcontroller unit (MCU). These systems are centrally controlled and managed. Each system has their limit or levels respectively. If data crosses the limit, then our model activates the alert system which is installed in different location of the city. The alert system also displays the precautions and safety tricks for the public information. The collected data are stored in central repository for the data analysis. The collected data are displayed for public information which is deployed in different location. Our smart city model consists of web & speed monitoring system which includes a radar system to measure the vehicles speed. If speed of a vehicle crosses the speed limit then web/CCTV camera gets activated and captures the video/imagery data of the responsible vehicle and collects the information like vehicle color, vehicle types, vehicle number etc. and sent to the central control room. Central control room broadcast the information to the management so that responsible vehicle can be caught.

Index Terms— IoT, Smart City, Smart Safety, Vehicular Communication, Wireless Sensor Network, Road Safety.

1 Introduction

SINCE time immemorial, precisely the early 1800s, man is visional about the future of machines communicating with each other. The Telegraph was the first machine to be invented that provided direct communications in the early 1830s and 1840s. The first radio voice transmission which took place on 3rd June, 1900 was described as wireless telegraphy and became instrumental for the development of the Internet of Things. That directed the development of computers back in 1950s and gave rise to the new beginning of a future digital era. The Internet which is the fundamental component of the IoT was initially started as DARPA and evolved into ARPANET. Gradually, in the early 1990s, GPS came into existence with the efforts of the Department of Defense which provided a stable, highly functional system of 24 satellites that laid the foundations for setting up landlines and satellites and embarked the onset of basic communications which constitute the basis of IoT.

Internet of Things (IoT) is a system that connects physical objects like sensors node which collects real time data and is accessible through the internet. Objects are assigned an IP address and have ability to collect data and transfer them to the server through a network [35]. The embedded technology in the objects helps them to interact with external environment. IoT should have the capacity to consolidate straightforwardly and consistently countless and heterogeneous end frameworks, while giving open access to choose subsets of information for the advancement of a plenty of computerized administrations [36]. Building a general engineering for the IoT is thus an exceptionally complex assignment, primarily in view of the to a great degree substantial assortment of gadgets, interface layer innovations, and administrations that might be included in such a framework [37]. In this unique circumstance, the IoT worldview is assuming an essential part as empowering agent of a wide scope of utilizations, both for businesses and the all-inclusive community [38].

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2 Literature Review

Jin et. al. [8] Proposed the building blocks of smart city IoT infrastructure. It corresponds to the different domains of IoT network for communications, management and computational requirements of smart city development and deployment. For any smart city application to work properly visualization is the utmost priority for data representation in user understandable forms. It is a challenging thing to visualize heterogeneous sensory data into 3D landscape. Evolution for CRT to Plasma, LCD, LED and AMOLED displays have facilitated efficient data creative visualization where the user has the ability to navigate as well. Nowadays, visualizations have also improved by plugging into other GIS platforms and integrating geo-related information at large.

Zygiaris [3] had the objective to address a smart innovation ecosystem characteristic that elucidated the compilation of all smart city notions into green, interconnected, open-integrated and digitally-instrumented with intelligent and innovative layers to create a planned framework known as the Smart City Reference Model. As all cities and towns have variety of shapes and sizes and different landscapes, the aim is to adopt a model that can be used for a range of smart policy paradigms that constitute of green, broadband and urban economics. They address global sustainability challenges and use a reference model to define the conceptual layout of a smart city and describe the innovations required. This paper exploits all issues of a smart city through map depicting concepts that can

be applicable for a green innovation, broadband economy and innovative urban ecosystems. Thus, they have concluded of having a holistic approach in building a smart city vision by elucidating research agenda engaging in building the city as a founding ground for Urban Intelligent City. It includes resources, infrastructure, utilities, services, stakeholders, and green ecosystems that form a terrain where the readiness of monitoring services is exemplified. The paper raises an important discussion topic regarding the challenges faced at a local echelon, and the important particles for a sustainable planet. It also provides a common understanding that focuses on the investigation of critical city resources that can be preserved and alternative forms of energy that can be utilized by smart city planners to prevent unsustainable investments and to build upon socio-technical complementarities in the smart city course of action. The paper also has a future vision for exploring newer methodologies for implementing a smart inter-network working city with the advanced monitoring and control system.

Theodoridis et. al. [6] had developed an IoT smart city framework where they have discussed key findings, technological challenges and socio-economic opportunities in Smart City area. Most of the concepts were conceptualized on the idea of developing a city-scale test bed for IoT and future internet experimentation, allowing provisions for an integrated framework for implementing smart city services. They have highlighted the current developments of a project that explores ICT challenges and opportunities for smart city ecosystem.

Hartung et. al. [7] has presented a paper on a multi-tiered portable wireless system for monitoring weather conditions and fire detection techniques, prevention and control methods. It provides the firefighting community the ability to safely and easily measure and view fire and weather scenario across a wide range of locations and elevations. It enables fire behavior analysts to predict fire behavior better thereby ensuring safety considerations. This system exploits a tiered structure beginning with directional radios to stretch deployment capabilities far beyond current infrastructures. At the end point the system they have designed and integrated a multi hop sensor network to provide environmental data. They have concluded by blending long range wireless technology for bringing communication to remote areas and short range sensor networks for gathering large amount of data from small areas into an actual real world deployment that combines the best of both of these technologies. Thereby they built a system that successfully presents an elevation gradient of environmental conditions in wild and fire environments. It helps to create a more aware environment in the fire community that will help the residential area safer and better monitored.

3 FRAME WORK

The needs of smart things in cities are too high as it decreases the human effort, makes life easy and helps to find different types of information. Our model Smart city, which is a combination of systems like air & noise impairments monitoring & control system, temperature & weather monitoring system, web monitoring & fire detecting system, smart waste bin system and GIS system. Solar power system is used for power supply to all the systems which minimize the requirements any external power supply and helps for the power backup [39]. In this section we discuss about the various hardware which are used in developing this model.

3.1 Air & Noise Impairments Monitoring & Controlling System (A&NIMCS)

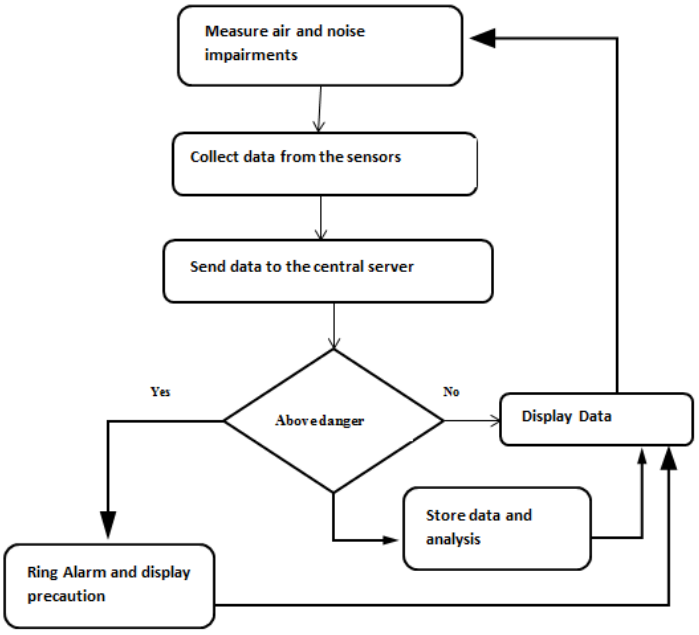

Fig.1. Air impairment monitoring/control system

The Air & Noise impairments monitoring and control system consists of various sensors like humidity sensors, smoke sensors, sound sensors etc. which collect the data from the environment [54]. The collected data are sent to the central control room and being displayed on the LCD/LED screen installed in the entire city. This system monitor and control the impairments present in the environment and its effects on the living things. A smoke sensor (Figure 1) is a device that measure the smoke present in the environment. Sound sensor is a device which detects the sound in DB from the environment.

3.2 Web &Speed Monitoring System (WSMS)

The web and speed monitoring system (WSMS) ensures safety of road passengers by monitoring the parameters like speed which helps to prevent the occurrence of an unwanted accident and loss of life. Radar system which includes infrared Signal (IR) sensor is implemented in different locations of the city, which keeps monitoring the speed of the vehicles. If it is found that the speed of vehicle is above the speed limit of a particular area then CCTV camera associated with SWMS system capture the images of the vehicles responsible and collect the information like vehicle number, vehicle colors etc. and sent to the central control room. A mobile application is developed by the central control room and been installed in every cops mobile. The collected vehicle information is broadcasted to the cops through the mobile app [47, 48].

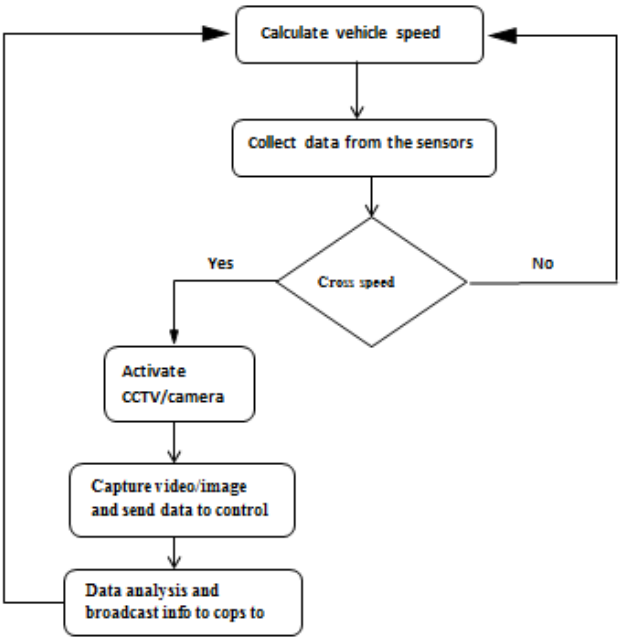

Fig.2 Web & Speed Monitoring System (WSMS)

Vehicle speed sensors (Radar system): A radar sensor is used to measure the speed of vehicles. It measures the vehicles speed by emitting a signal towards the vehicles. Microwave signal is transmitted in the direction of vehicle and it gets strike on the vehicle. Reflected signal from vehicle is used to determine presence, passage, volume, lane, occupancy, speed, and vehicle length depending on the waveform transmitted by the radar system (Figure 2.a).

Web/CCTV Camera: The camera is installed along with the radar system. When radar detects a vehicle crossing the speed limit, camera starts capturing images and video. The collected car information is sent to the control room (Figure 2.b).

Ultrasonic Sensor: This sensor can be used to measure the distance of two vehicles. when the distance between two vehicles is so less or is supposed to collide then an alarm system is generated and message is sent to particular server (Figure 2.c).

3.3 Temperature & Weather Monitoring System (TWMS)

Temperature & weather monitoring system (TWMS) keeps monitoring the temperature and weathers.

Temperature Sensor: A temperature sensor is a device, typically, a thermocouple or RTD, which provides for temperature measurement through an electrical signal [52]. The change in temperature is measured by a thermocouple (T/C) made from two dissimilar metals that generates electrical voltage in direction (Figure 5.a).

Humidity Sensor: Humidity Sensor (Figure 6) is a device that measures the Humidity present in the environment.

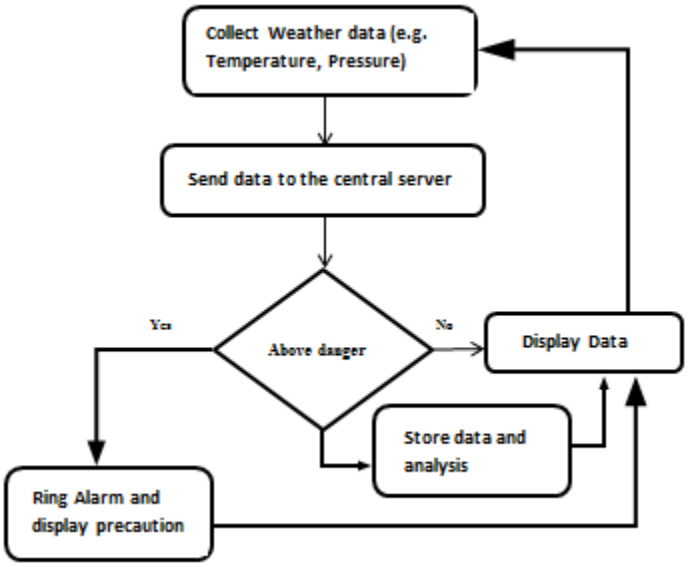

Fig.3 Temperature & weather monitoring system (TWMS)

3.4 Fire Detecting System (FDS)

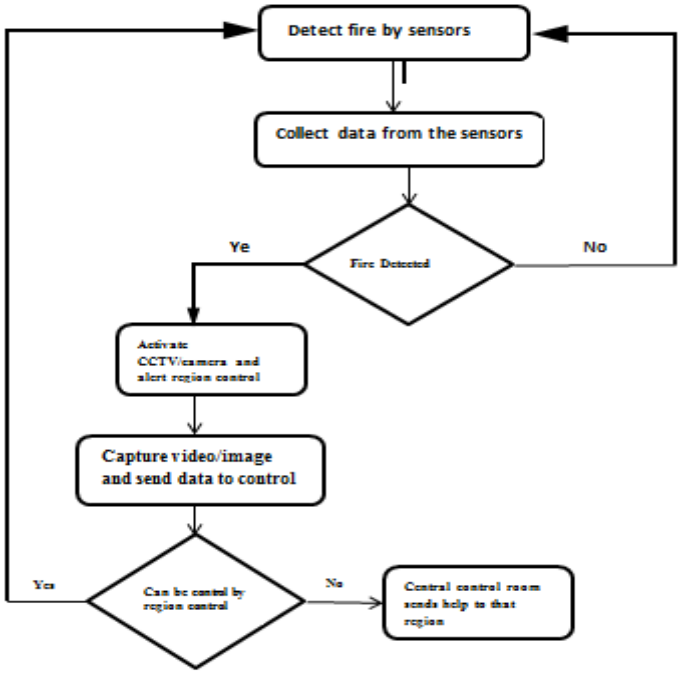

Fig.4 Fire Detecting System (FDM)

Fire Detecting System (FDM) is a system which detects the fire in a particular region. Fire detector sensors are implemented in different region of the city. A CCTV/Camera is implemented with the FDS system which captures the video/imagery when it detects fire so that later the reason of fire and losses can be analyzed.

3.5 Smart Waste Management System (SWMS)

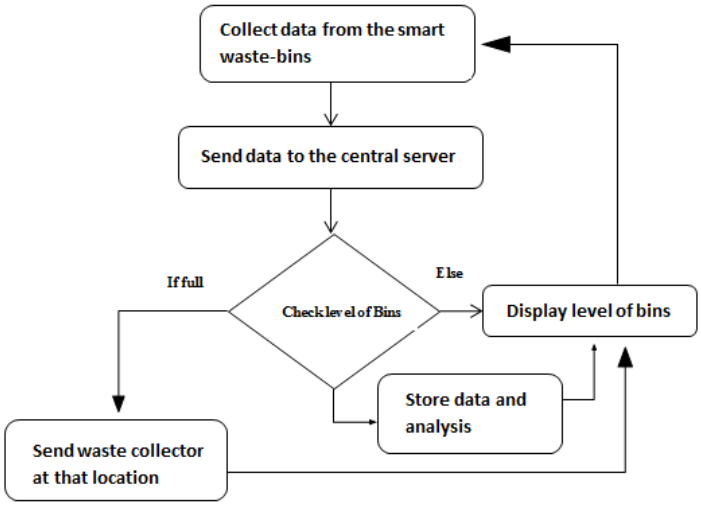

Fig.7. Smart Waste Management System

The SWMS system is implemented throughout the city. This waste management technique is centrally controlled and uses clean energy. The SWMS system helps to find the locations of waste bin and if it found to be full with waste material, it informs the central control room and wastes are collected by the waste collector vehicles [52, 53].

Smart waste-bins: A waste bin in which infrared sensors (IR) is connected to identify the bin level, Ultra Sonic Sensor is used for compacting the waste bin and air quality sensors are used to identify foul smells. These sensors constitute a smart waste bin system. This sends the information like level of smart waste bin and locations of the smart waste-bins (Figure 7). When impairments increase, an alert signal/message is sent which raises an alarm installed in the system. Consequently, all the guidelines and precautions are displayed likewise on the LCD/LED screens throughout the city. All the sensors are controlled with microcontroller and collected data are sent to the control rooms through access points. Solar panels are used for the power supply and for power backup we have solar battery for usage. Our model does not require power supply from any external source of energy. Even if there is a blackout in the city, our model works undisturbed as it is independent of conventional sources of energy. Smart waste bins have been implemented throughout the city. The smart waste bins have the capability to detect the types of waste materials in the bins. If an unidentified object is detected, an alert signal compiled with the location of the waste bin is sent to the control rooms. When the waste bins become saturated with waste matter, again a signal along with the location is sent to the central control room, so that waste collector trucks are directed to collect the wastes from the given area [43].

Every time the collected readings for a certain parameter increase the risk zone, a real time analysis will be done on the data collected by the different sensors available. This will help to detect the exact status of the factors which can be analyzed and proper actions can be taken to minimize the drawbacks and enable Sustainable Development. Our research in this area will focus on developing effective systems for impairments monitoring, traffic monitoring, and smart city innovation with digitalized software for fast and effective implementations. This will include the concepts of The Next Generation Air Impairments Monitoring Systems, Wireless Sensor Networks etc. that have achieved significant breakthrough by utilizing advanced sensing technology.

3.6 Light Automation

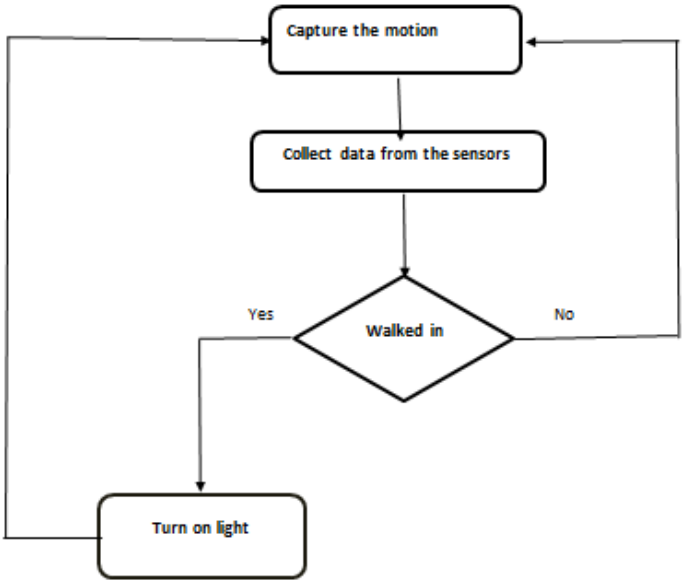

Fig.8. Light Automation

An automatic room-light controller automatically turns on the lights when a person enters into a room, and turns off the lights when the person leaves the room. The sensor detects the duration when the person is within the sensor's measurable area. This automatic room controller can be implemented by using a simple microcontroller and wireless IR technologies. This system is designed to switch the lights on when a person enters in and leaves out of the room. The system also counts the number of persons entering and leaving the room and displays the information. The ultimate objective of this system is to save the energy as well as to design automatic room light controller by turning off all the appliances when nobody is there in the home. When a person enters the rooms the lights are automatically turned on till the person is inside the room and when the person steps out of the room the lights automatically get turned off. This mainly helps in saving the electricity and its whooping cost.

PIR Motion Sensor: PIR motion sensor is a device, which detects when a person enters the sensor's range and then automatically lights glow. More sensors can be implemented to measure the different types of impairments present in the environment. The main aim is to monitor the impairments and to control the pollution after analysis of the data. A centralized control office monitors the data coming from different sensors. A LCD/LED is placed on the street to display the smoke percentage, humidity and noise present in the environment for public information. All devices are controlled by the central office. When noise level, smoke level, humidity level goes above the danger level then street alarm as well as office alarm starts by the alert system. Then, the proper precaution is displayed on the information guide LCD/LED to follow. All data will be saved at central server and all devices can be access remotely.

3.7 Car Speed Sensing Monitoring

Car speed monitoring sensor uses ultrasonic sensors mounted on the front to detect when a person(obstacle) is coming in the way, these sensors can measure the distance between your car and nearby obstacles directly coming in the front of the car. The driver is alerted by beeps or the dashboard display. The beeps become faster as the vehicle moves closer to the obstacle. The basic idea is simple enough: If your vehicle senses that a front-end collision is imminent and you're not using the brakes, it's going to alert you for you to try and minimize or prevent the impact. A collision is imminent when the beeps become a continuous tone. This feature varies among car models. We need to know how the car's system works before driving, especially if it's a rental car. Also, make sure the sensors are clean and not covered by debris or stickers

3.7 Security System

A security alarm is a system designed to detect intrusion – unauthorized entry – into a building or other area. Security alarms are used in residential, commercial, industrial, and military properties for protection against burglary (theft) or property damage, as well as personal protection against intruders. The present system of security is not very efficient as it can be easily faked by the smart larceners as they can get hold of the keys or the passwords. Also it's a painstaking job for the administration of the offices to keep an account of the locker activities as there is no dedicated employee appointed for this. The security system is designed to detect the illegal entrance in the bank or office locker room areas that commonly happens in cases of the robberies. The major concern with current manually supervised security system is that if the robbery occurs then the banks are not being able to identify the robbers due to lack of proof. The system will focus on the safety of the bank locker rooms in an effective way by detecting and controlling unauthorized motion. The proposed security system will save the images whenever the motion will be detected that can be used in future for investigation.

Face Detection and Recognition using open CV: It can be used for security purpose as well for attendance system. To enter inside any office, bank or any place if we use this module we can recognition.

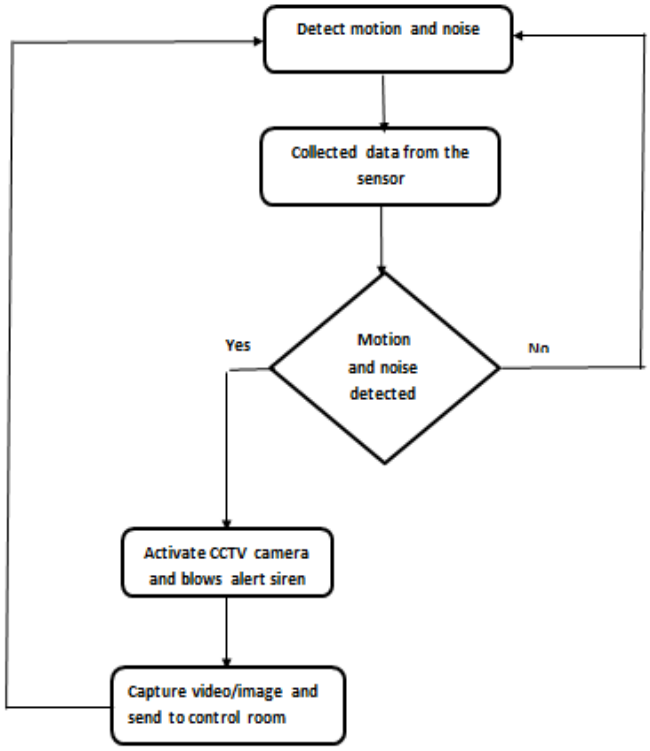

Fig.10. Security System

3.7 Microcontrollers

Arduino is an open source computer hardware and software company, project, and user community that designs and manufactures single-board and microcontroller kits for building digital devices and interactive objects that can sense and control objects in the physical and digital world.

Jump wire is an electrical wire or group of them in a cable with a connector or pin at each end (or sometimes without them – simply "tinned"), which is normally used to interconnect the components of a breadboard or other prototype or test circuit, internally or with other equipment or components, without soldering.

NodeMCU is an open source IoT platform. It includes firmware, which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. The term "NodeMCU" by default refers to the firmware rather than the dev kits.

4 PROPOSED MODEL

Tracing the genealogy of the word smart we can comprehend an understanding of the contribution of this term in the label smart city. Though, in the marketing language, smartness is focused on the user's perspective, however, in the wider general scope smart is more user friendly than intelligent which constitutes a quick mind and being absolutely

responsive to serve smartly for community members. In has the main objective of urban planning that entails strategic directions. The technology that we have infiltrated in our project has permeated into the commercial application of intelligent acting products and services, artificial intelligence and thinking machines. The technology implies the automatic computing principle such as self-configuration, self-healing, self-protection, and self-optimization. We aim at developing smart homes, smart and alert building synchronization and larger smart ensembles such as airports, hospitals or cities which will be equipped with a multitude of mobile terminals and embedded devices and connected sensors.

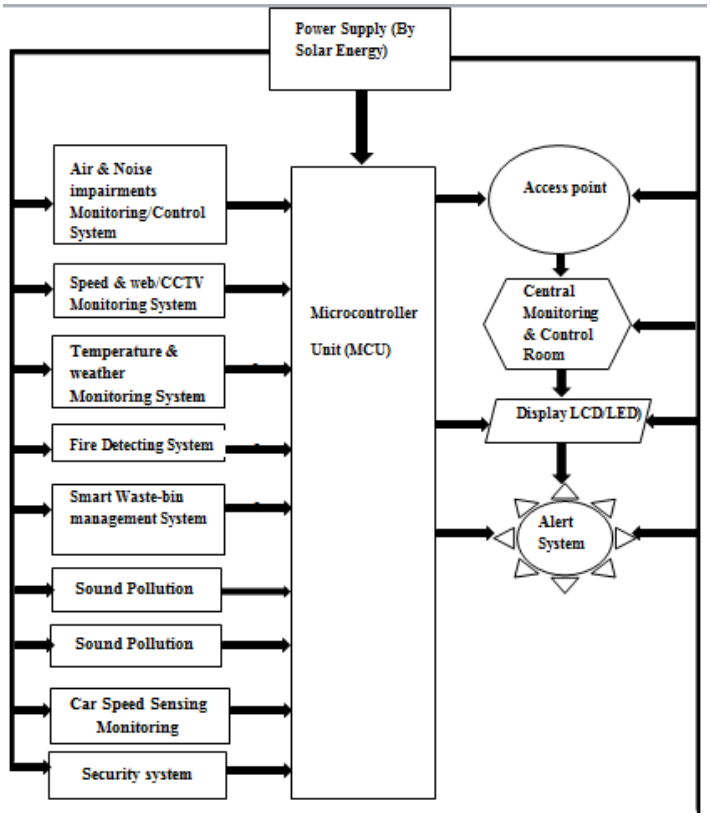

Fig.11. Block Diagram of Proposed Model

The framework of smart city development pyramid: smart interface (dash board, common operational platform, integrated web services), smart control systems (automatic control network, local operating network), and smart database resources (database, database server). Mobile, virtual, and ubiquitous technologies gain importance. Those technologies offer benefits to city dwellers in mobile lifestyle. Smart city application evolves from smart places to networked inhabitants. While the wireless infrastructure is a key element of digital city infrastructure, it is only a first step. A developing concept of smart ecosystem is also a future extension of the smart city project for the progress of the community and the entire city. Fig.11 illustrates the work flow diagram of proposed work.

A smart city is a humane city that has multiple opportunities to exploit its human potential and lead a creative life. Technology is the key to being a smart city because of the use of ICT to transform life and work within a city in significant and fundamental ways. A well-functioning infrastructure is absolutely necessary but not enough to become a smart city. IT infrastructure and applications are prerequisites, but without real engagement and willingness to collaborate and cooperate between public institutions, private sector, voluntary organizations, schools and citizens there is no smart city. Hence, it needs a lot of gratification, wholesome approach and patience along with the benefits of IoT and AI.

5 IMPLEMENTATION AND DISCUSSION

Fig.12 Developed Model

The Fig. 12 shows the deployment model. A virtual city is considered for the working model having same environment as in real environment. Different sensors like temperature sensor, humidity sensor, smoke sensor, piezo alarm, sound sensor, motion sensor, fire monitor, alarm/siren, webcam, smart waste bin, GIS and solar system are connected which constitute a smart city model. All sensors are connected with microcontroller unit (MCU) which controls the sensors. A microcontroller unit (MCU) is a device which programs the sensors to work and fetch the data collected by sensors. The working program for sensors is written in microcontroller. Solar system is implemented with a solar battery which helps to provide power supply to our model and solar battery is used for the power backup. A solar system generates the enough power for the IoT-devices in our model. A radar system associated with webcam/CCTV is implemented in different regions of the city which constitute a Web &Speed Monitoring System (WSMS). A fire detecting sensors along with a webcam/CCTV is implemented in different region of the city and a sub control room is employed in every region of the city. This constitutes a Fire Detecting System (FDS). A temperature sensor and pressure sensors works together which constitute a Temperature and Weather Monitoring System. Smart waste bins are employed in different locations of the city. Sensors like IR sensor, ultrasonic sensors are installed in smart waste bins which constitute Smart Waste Management System (SWMS) and collects data like level of bins, location of bins and types of bins. A smoke, humidity, and noise sensors are implemented in city which collects data from the environment and sent data to the central control

room. These sensors combined together which constitute Air & Noise Impairments Monitoring/Control System (ANIM&CS). Different systems constitute together and make a smart city. A smart need to have everything which works smartly and reduce the human effort. In our model data are collected by the different sensors and sent it to the central repository through the access point. A microcontroller unit which controls the sensors are connected with access point wired or wirelessly. The data processing is done centrally. Fig.13 and 14 represents the simulation response and sensor reading values respectively.

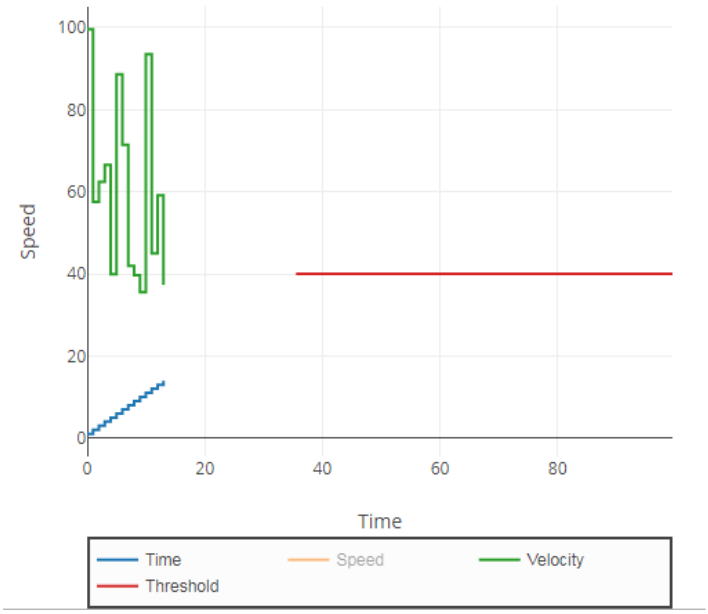

Fig.13. Data Display About Vehicle Speed

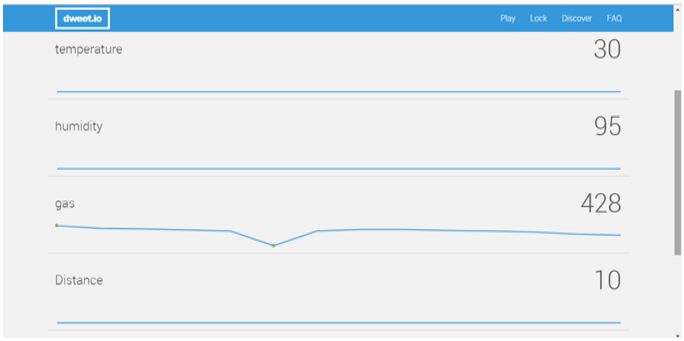

Fig.14. Responses of Other Sensors

6 Future Scope of Enhancement

Automatic parking management system: By collecting the information regarding parking bay occupancy wirelessly, our model can provide parking vacancy information to the city people through a visualization platform like a smartphone. Fines can also be imposed in case of parking infringements. These models will work on a 3 tier mode, where the lowest tier motes will be attached to sensors, the middle tier motes will contain forwarders which will be attached to light poles and the upper most tier mote will constitute the base stations connected to the internet enabled devices. The information about the parking vacancy, location is broadcasted in mobile application. It will provide the information like parking vacancy nearby.

Structural health monitoring system: Further we have structural health monitoring provisions, where wireless sensory networks for smart city monitoring will be used. Since we have variety of structures in a city which can be large, small, old, new etc., which mostly includes dams, buildings or bridges, mostly used by humans, living or working in those areas, the health and structure monitoring of these objects is a major concern. As negligence can be fatal and critical, long lasting damage that can cause life threatening possibilities and casualties. Therefore, we have the proposed the idea of passive wireless sensors that will be embedded in a concrete structure, and send radio signals of optimum amplitude and phase periodically using the radio frequencies in the unlicensed Industrial Scientific and Medical bands. The data that will be collected at the destination will then be utilized to determine any anomalies that could be an alert for danger possibilities for early detection and prevention.

There are many such advancements can be possible with smart city model. Here, we have been mentioned few such as: **Advanced Security System, Smart Water Systems, Traffic surveillance and management applications, Energy Conservation, Supply Chain and Logistics**

7 Conclusion

SN	Test case name	Pre-condition	Test Procedure	Excepted Output
1	Air & Noise Pollution Detection, Temperature & Weather Monitoring , Smart Waste Bin Management	Different Sensor Should detect the different impairments and send the collected information to server	After collecting data from sensor it should give response and send information to server or to database	Sensors collected data successfully Sensor sends the data to server or showed output As per requirement different response generated
2	Home /Light automation, Security Management, Fire Detection , Sound pollution, Transportation speed monitoring,	Different Sensor Should detect the different actions and send the collected information to output monitor	After collecting data from sensor's it should give response and send information to produce responses	Sensors collected data successfully. Sensor sends the data to server or showed output As per requirement different response generated

Table 1: Testing Results

In this paper, we highlighted the various design and developments to build up a Smart City framework. Keeping this as an objective, we tried to present some key IoT based technological findings, their challenges of an IoT based Smart City ecosystem. We have conceptualized the smart city with various variables like environmental impairments; some of these impairments are humidity, temperature, noise, etc. This paper yields out with multiple conceptual dimensions of smart

city followed by organic connection among technological, human, and environmental components. This model helps the concerned authority for the enhanced usage of "smart" domains in a very innovative and transformative way, driven by new technologies. With rapid development in the emerging Internet of Things technology, we have identified the key IoT building blocks of smart cities, as well as provide the approaches and resolutions to meet their respective communications, computing and computation requirements. Furthermore, IoT enabled noise mapping work is presented to highlight the practical usage and merit of our proposed framework. Finally, in order to push the development forward, the proper IoT based model of smart city is believed to be equally important as technological advancement. Table 1 represents accuracy of deployment state.

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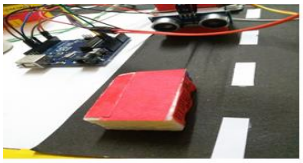
8 APPENDICES

Table 2: It represents the types of hardware and sensor used in this work.


Smoke Sensor and Sound Sensor




Deployment of Ultrasonic Sensor



Flame Sensor

Humidity Sensor

Arduino Module

Node MCU