International Journal of Engineering Sciences & Research Technology

(A Peer Reviewed Online Journal)
Impact Factor: 5.164

IJESRT

RESEARCHERID
THOMSON REUTERS

[Ghosh* *et al.*, 11(10): October, 2022]
IC™ Value: 3.00

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

AN APPROACH TO PATIENT SAFETY INSIDE THE AMBULANCE USING INTERNET OF THINGS

Chiradeep Ghosh *

* Dept. of Electronics and Comm Engg ,Calcutta Institute of Technology ,Uluberia ,Howrah 711316, , India

DOI: 10.5281/zenodo.7238646

ABSTRACT

In the Global scenario of communication, Internet of Things provides the better way to interact with. Healthcare system using IoT is the combination of advance conceptual form of multidisciplinary engineering and medical field which benefit the innovations towards health-care systems. At present scenario, IoT is often incorporated with remote health monitoring solutions, for those who require regular attention such as aged patients and patient with severe conditions. Heavy traffic conditions have always become a burden to ambulance services which results sometimes fatal to critical condition patients. By considering the situation smart ambulance is a solution for the remote observation of patient's body parameters. Here, two innovative ideas have been proposed where an IoT based vehicle takes automatic control actions during emergency inside the ambulance which would be a life savior of patients during hospitalization and incorporation of medical drones to supply the lifesaving drugs inside the ambulance tracking from the nearest location at the shortest period of time. After incorporation with several cases the system comes out with the efficiency of 95%. With this proposed system society will get benefitted specially during the ongoing covid19 pandemic situation by maintaining social distancing.

KEYWORDS: Internet of Things, Health Monitoring, Smart Ambulance, Ambulance Traffic management.

1. INTRODUCTION

The modern innovation of today's world of internet is Internet of Things which has makes a remarkable progress in the domain of remote healthcare system by establishing an interconnection between devices and individuals and exchanging information through a shared platform. Blood pressure fluctuations, Arrhythmia, Chest pain, internal organ pain due to carcinogenic conditions, Low oxygen saturation level, High Temperature are the common symptoms irrespective of disease. The objective of any smart ambulance is not to cure diseases but to ensure the sustainability of patient by monitoring vital health parameters in the short period of transit time so that, patient gets proper treatment after reaching the hospital without further deterioration . The healthcare and transport system of remote India is still under developed. Consequently due to heavy traffic-rush and unavailability of experts inside ambulance causes several deaths during the hospital transit. During hospitalization and inter hospital transit, the patients of rural areas are still at high risk especially during this pandemic. The issue is growing graver day by day. The ongoing pandemic demands to maintain certain protocols to minimize the risks of spreading virus.Real-time monitoring of vital parameters [1] of patients helps to scale back re-hospitalizations by detecting early anomalies which allows appropriate and early interventions. Medical devices for Internet of things inside the vehicle are remotely accessed, where sensors like blood-pressure, SpO_2, pulse rate, Temperature and ECG are connected with secured cloud storage via Internet of Things from where the information can be analyzed to provide further remedy from remote locations. In addition to that, this system acts as a self-decision making system. The microcontroller of IoT device is programmed in such way, that it can automatically control the position of final control elements or the electrical actuators accordingly. The set point for the actuators are being set by the experts before leaving the hospitals according to the patient's health condition. There is also provisions for remote control of actuators using mobile application like blynk for injecting emergency drugs by the concerned doctors if situation demands. Consequently the patients with critical conditions will be benefitted with this real-

ISSN: 2277-9655
Impact Factor: 5.164
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time treatment during hospital transit. The traffic congestion in suburban and metropolitans is a common factor in the country like India where getting stuck in traffic for an ambulance is not an exceptional thing. Though this is a self-decision making system and well equipped, Time is a very crucial factor especially during the hospital transit of critical patients. So, by considering this factor this system also keeps a provision for medical drone service which tracks the live location of transit ambulance. If situation demands particular drugs which are not available, the medical drone will response and provide the drugs in the shortest period of time which will definitely acts a life savior of the patient. After considering the other article survey, different methodologies of smart ambulance healthcare system, it can be said that, outcome of this system is significant for its measurement and analysis capability. The self-decision making capability and alternative medical drone support makes the system better than others and proves it's novelty in all aspects.

2. LITERATURE SURVEY

During the review of different approaches to smart ambulance in remote health care system it has been found that, the design proposed by Elsaadany *et. al*., based on cloud computing [2] and the user application accessible through mobile computing. The system utilizes a database to store the application data of all the entities. A server handles the back-end data application logic which performs various functions mainly statistics of incoming data. But apart from monitoring and data collection the requirement of counterpart during emergency which has not mentioned over the article.

In recent review article conducted by Kalid *et. al*., researchers' emphasis on off-hospital [3] healthcare, specifically in domestic environment where telemedicine can be implemented by real-time monitoring of physical parameters which are analyzed by intelligent healthcare applications. But this advanced multi layered healthcare system completely depend on the network speed and connectivity. The lag in network connectivity in emergency situation may arise as a flaw in this system.

In the article on smart ambulance with GPS system, the proposed design [4] by Saha *et. al.*, and Gupta *et. al.*, [5] is an IoT based real-time monitoring system for patients with the risk of cardiac arrest and uneven body temperature. During critical condition an alert message with live location will be informed to the hospital monitoring website for emergency hospitalization with shortest route map according to the google. But if a scope of smart drone based emergency drug support was provided, it could have been the life savior of patients during the heavy traffic.

In study of Internet of Things in Smart Ambulance [6] and Emergency Medicine, an IoT device performs as a bridge that links the paramedic to patient and the hospital network which provides support from patient's medical history retrieval for receiving remote support and treatment. Integration of advanced video processing technology along with image recognition will allow hazard detection to provide preemptive alerts to paramedics of any dangers surrounding the scene. A chopper service is also proposed for incorporation during emergency in alternative of ambulance. But in this aspect there is no scope for automatic control actions while critical situation arises.

In a recent article conducted by Dumka *et. al.*, traffic jams and heavy traffic [7] in big cities in accordance with medical vehicles like ambulances which must have a way out and reach destinations in time, was addressed. Algorithm using MQTT protocol prioritizes the emergency vehicles along with alternative route map, which would thus increase the response time and thus efficiency of emergency services. Though the system provide a good response in terms of traffic management, but overall process doesn't focus on alternative counter path during emergency situation or any high demand of emergency drugs during transit .

In study of smart ambulance system using IoT a RFID [8] tag is incorporated for detection of a vehicle. In this context CSMA and MAC protocol has been incorporated to avoid traffic congestion by multi hop communication. Though the system provides a better output but lag due to network lagging.

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In study of E-Ambulance [9] system, prime goal is to provide health parameters and alerts to paramedic. This type of system has become efficient by using Data distribution Service middleware which provides continuous data connectivity between these devices network and cooperative networks.

After reviewing all the articles it can be said that, there are various methodologies which have been implemented in the domain of remote health-care along with the traffic management system. Most of the systems have emphasized on the measured sensor data for further analysis in associate with cloud storage to take the control actions manually. In this context multisensory network with IoT have been implemented to attain the control actions automatically during the transit. It works as a life savior of patients with critical health condition and smart drones are also incorporated as a supply chain of emergency drugs in spite of heavy traffic.

3. MATERIALS AND METHODS

During inter hospital transit the ambulance is being equipped with the necessary invasive drugs of concerned patient. There will be a monitoring screen vehicle which shows the live data of patient's body parameters. Figure number 1 shows the complete block diagram of the system where sensors are connected with the IoT device which acts as a remote automatic decision making system. ECG, BPM, Blood pressure and other vital body-parameters of patient are being monitored and some standard set point values of actuators have set by the discharged hospital. If the parameter's value varies from the set point, the internal IoT device will act as self-decision making system which initiates concerned actuators to get set point value back to normal.

3.1 Proposed Design

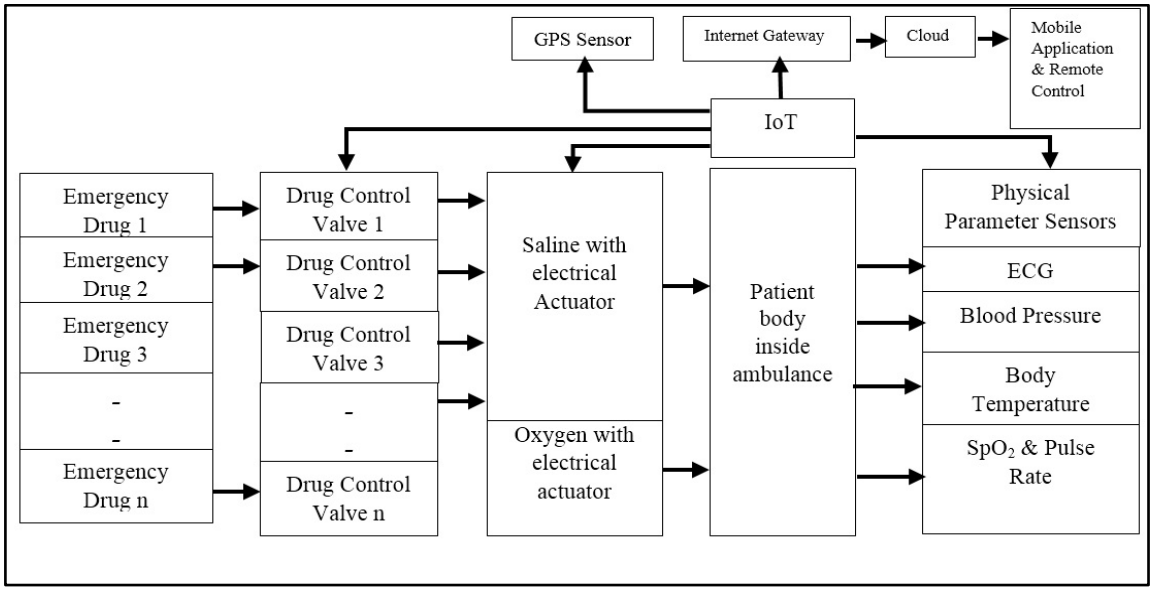

FIGURE 1 block diagram of health care system inside smart ambulance.

There is also a provision for doctors to inject the suitable dose of the life-saving drugs from the remote location by adjusting the final control element. Final control element is nothing but a motorized control valve attached with intravenous saline. There will be a local control unit inside ambulance and a remote decision control unit which send signals to actuators and alarms. So that doctors can take control action from remote locations as well.

The propose design will cover all the parameters of healthcare system of smart ambulance. This system works on the real-time transmission of physical vital parameters of patients and also takes some automatic control actions

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if necessary during transit. This proposed system can be structured by using several sensors, steady cloud connectivity and a remote end application.

3.2 Sensors and final control elements attached to patient's body

Sensors and final control elements are two primary objects any controlled device. As per figure number 2, the flow chart shows that, sensors are attached to patients for obtaining health monitoring parameters which are scaled and calibrate by the microcontroller of IoT device for alerts generation and suggestions for paramedics inside ambulances.

The live saving drug's valve can be increased automatically and also give better perpetration of smart healthcare installations where utmost of conduct inside smart ambulances are automatically taken to save lots of lives under trouble.

Detectors communicate with a control device to transmit data. This accumulates physical status information is also delivered to an automatic decision making unit of the vehicle or to a remote decision unit located faraway.

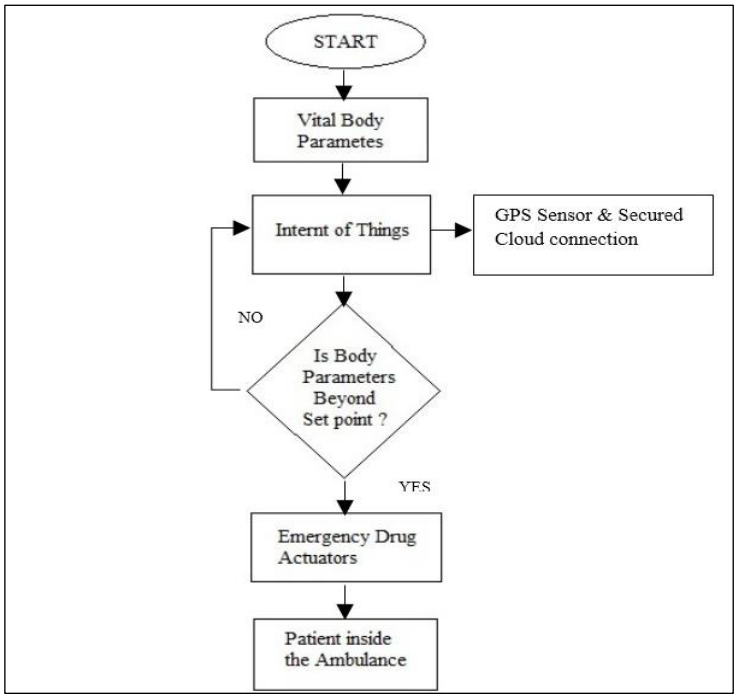

FIGURE 2 Flow Chart of the System

In this context, NodeMcu is a brain of the system. The device consist of [10] 32-bit processor which operates up to 160 MHz frequency and contains with 128kb of RAM, 4mb of ROM and in-built Wi-Fi. AD8232 ECG Sensor is proposed along with ESP8266 within the system. This is a neat little chip particularly applied for measuring the potential activities of heart muscles and the charted output of that bio-potential activity which assist to diagnose various heart conditions like pulse, cardiac rhythm and other information.

The sensor module consists of nine connections as solder pins, wires and control pins which is used to interface it with ESP8266 for the consistent acquisition of important body parameters as per program logic to send data to cloud and medical professionals.

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MAX30100 measures the percentage of hemoglobin in the blood which carries oxygen. The time difference between increase and decrease of oxygenated blood flow determine the pulse-rate. More infrared light get absorbed by oxygenated blood and less red light are being passed than the deoxygenated blood and vice-versa which reads the absorption levels. By this way it will to measure the BPM and SpO_2 level of patients and take necessary control action accordingly.

AMS 5915 sensor [11] is incorporated to monitor the blood pressure in the ambulance. To achieve the accuracy, Arduino-nano module along with the NodeMcu merged and uses an inflatable cuff with a pressure- detector and an Arduino-nano microcontroller. After the cuff was inflated with the particular pressure it's sluggishly [11] deflated while the pressure detector measures the raised pressure- cargo within the cuff. While pressure of the cuff decreases gradually, a korotkoff sound pulsation sensed by the pulse induces pressure oscillator inside the cuff. The amplitude of those oscillations depends upon the cuff's pressure and may estimate systolic and diastolic.

To detect the temperature of patient, DS18B20 [12] is incorporated. This Digital Thermometer provides up to 12-bit temperature readings from -55°C to +125°C which is quite capable to measure body-temperature of the patient. Alarm is a simple element in the system which is used along with actuators in parallel. Servo motors [13] act as actuating devices. A servomotor allows for control accuracy of velocity and acceleration. It works upon final position feedback after actuation. Here, several number of servo motors are being mounted at output of emergency drugs and oxygen cylinder's output as flow control actuators so that flow can be manipulated accordingly to minimize the sudden health risk of the patient.

3.3 Cloud Server

The cloud [14] is a large set of heterogeneous database that appear as a cluster of data from a distance. The healthcare industry is continuously upgrading and so are the technologies used. Hospitals with different legacy systems have now migrated towards digital systems such as EHR [14]. In this context all body parameters of patient's body are being updated to concerned cloud server through NodeMcu. Data are being transmitted to another smart ambulance or a medical center. This proposed system can be used for logging message interchanging of internal vehicle local network data and remote network data and recording body parameters data.

3.4 GPS with traffic monitoring system & Google Map to detect fastest route with low traffic.

The ambulance driver typically needs particular attendants while transporting cases from the place of origin to a medical center. GPS [15] provides co-ordinates with graphical representation of the Ambulance's location which can help the driver by showing the best accessible charts and routes consequently. Google Maps [16] is the satellite and network based map application which presents several displays in form of road maps, traffic status and route selection. In this context we propose u-blox NEO-6M GPS module, a cost-effective and high-performance GPS module built with a right-hand circular-polarized ceramic patch antenna. If necessary drone service may be incorporated from certain medical drone points which will carry the necessary drugs from nearest location & cover the shortest distance to reach.

3.5 Mobile app to control over IoT & final control element

In today's modern healthcare system it's quite feasible that, mobile applications are constantly running to look after the readings from the sensor and checks whether body parameters goes beyond the nomal rate. In our proposed model we incorporate Blynk [17] application platform to execute end user job. It [17] operates in automatic and manual mode. In automatic mode, all actuators & final control elements are automated to operate as per the surrounding environmental conditions sensed by the body sensors of the patient. During manual mode, doctors can able to operate each of the actuators via smart phone or from PC accordingly.

3.6. Secondary medical support system with drone

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The application of multi-sensor data [18] in wireless networks are widely used in healthcare domain to collect the data wirelessly. Drones have different applications in civilian society along with healthcare field. Medical drones usually can help to increase access of medical-aid [19] during the covid19 situation by delivering possible medical facilities to patients at faster speed.

In this context Wi-Fi connectivity is established using NodeMcu modules. The drone contains memory, RTC module, and an ESP8266 which acts [20] as data server for ground nodes to transmit and receive data from the cloud in the specified format. The nodes send the data and location values as per the program logic. As the road and traffic condition of rural India is not up to the mark, medical drones provide cover to the emergency situations during hospital transit.If the required drugs prescribed by the doctors are unavailable at that moment inside ambulance or ambulance stuck inside a heavy traffic, IoT send another signal to cloud for the requirement. Figure 3 is depicting that as the Medical drone points in between transit path of the ambulance are connected with cloud, they get signal and the medical drone will be out for the service within the shortest period of time. This feature for the health-care system is unique and essential in the country like India. This proposed system helps to quick movement of ambulances to different locations for treatment of on-board patients with the intervention of remote healthcare personnel.

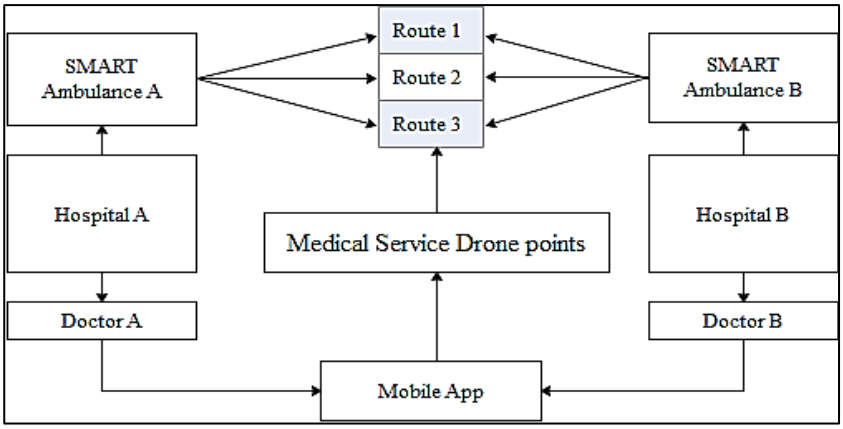

FIGURE 3 Proposed diagram of route management and medical drone service.

4. RESULTS AND DISCUSSION

The prime objective of the system is to maintain the steady health status of patients by monitoring and controlling the vital health parameters during the transit time so that, patient get proper treatment after reaching the hospital. The proposed system has a self-decision making capabilities and IoT device of ambulance is able to control the final control elements. For performance analysis 100 local cases of patients with high blood pressure and with several other health conditions have been studied in this scenario. During this study it has been observed that 55% of patients doesn't require additional medication apart from oxygen and other normal prescribed intervenes saline during transit. But it has been observed that 45% of patients especially with cardiac conditions and high blood pressure and abnormal pulse rate required this automatic treatment function of IoT. By considering such a case, during hospital transit of a patient with cardiac condition blood pressure raise to 160/120 mmHg in place of 120/80 mmHg with pulse rate of 139 bpm and 90% SpO_2 level. As per program logic IoT finds the sensor values as in abrupt conditions so that, it takes automatic control action by opening up the actuator of intravenous Enoxaparin and Deriphyllin for 2 seconds of time which inject .5ml of each of these intravenous drugs through saline . In addition to that the IoT also opening up oxygen supply actuator by 10% accordingly. Enoxaparin acts as a preventer of deep venous thrombosis and Deriphyllin relaxes the muscle and clear the air passages of Lungs. As a results the diastolic pressure reduced to 87 mmHg and systolic reduced to 128 mmHg within next 30 min of time. The pulse get down to 79 bpm along with 97% oxygen saturation level. By this way IoT takes automatic control actions to keep the situation under control. The patient is now safe enough to reach the hospital for further treatment.

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Table 1 shows how the blood pressure, Bpm and SpO_2 values tends back to normal with shorter period of time after IoT automatic control action activation. The corresponding graphs have been depicted over figure 4, 5, 6 and 7.

Tables:

Time Duration (min)	Initial Blood Pressure (mmHg)	Applied Intravenous Medicine and Actuator response status	Blood Pressure after Medication (mmHg)	Initial Pulse rate (bpm)	Pulse rate after medication (bpm)	Initial Oxygen Saturation (SpO_2) %	Oxygen Saturation after medication (SpO_2) %
0	160/120	Deriphyllin .5ml with actuator response time 2sec.	160/120	139	139	90	90
3			160/120		131		91
6			145/115		125		92
9			142/110		118		93
12		Enoxaparin .5ml with actuator response time 2 sec.	137/ 102		110		94
15			135/92		101		94
18			133/91		96		95
21			131/90		91		95
24			131/90		87		96
27			130/89		83		97
30			128/87		79		97

Table 1 Case study of IoT based automatic response with respect to time

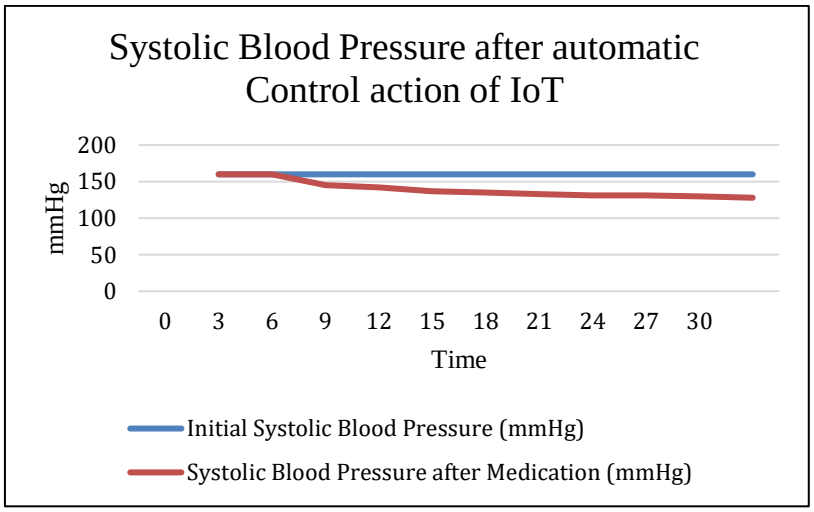

Fig 4 Systolic Blood Pressure comaprison of IoT automatic control action.

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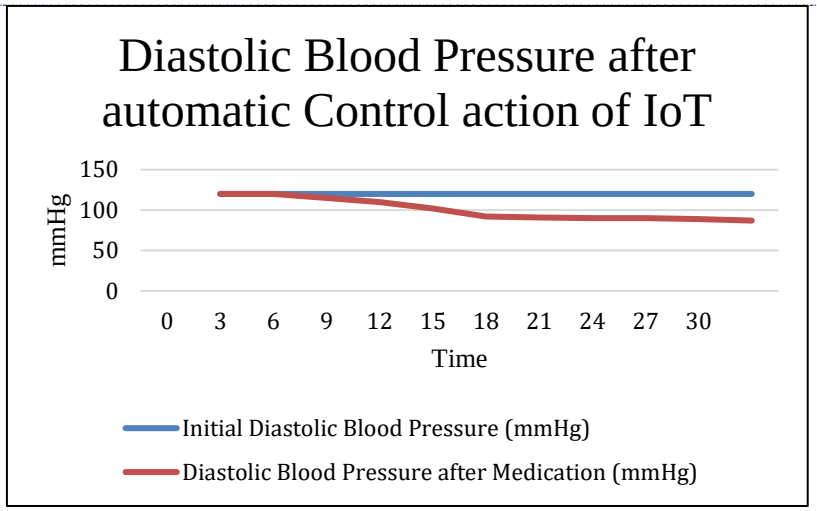

Fig 5 Diastolic Blood Pressure comaprison of IoT automatic control action.

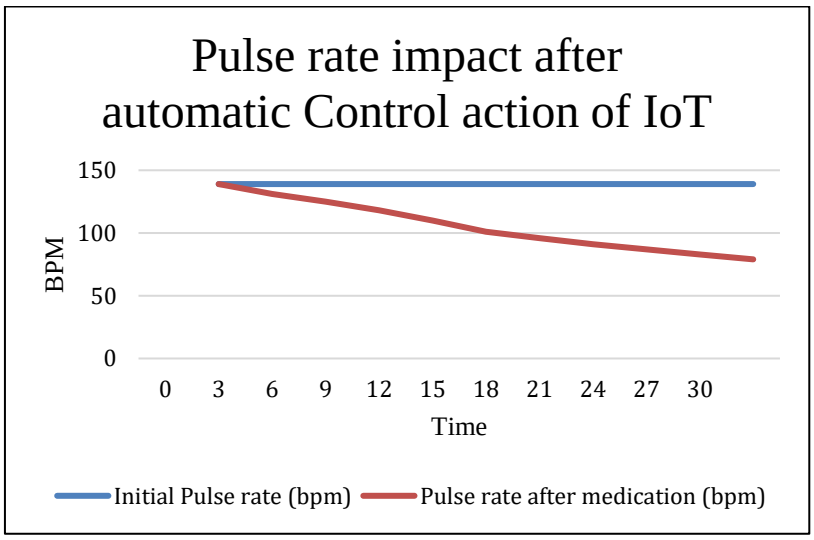

Fig 6 Pulse Rate comaprison after actuator activation by IoT.

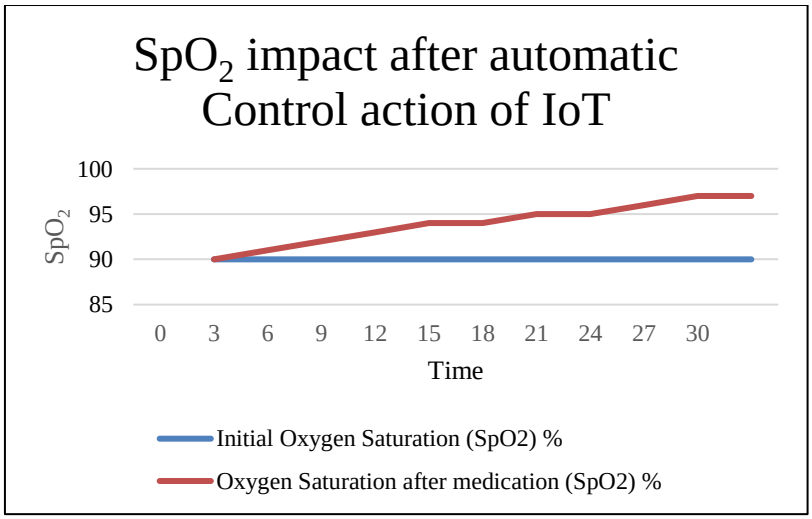

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Fig 7 SpO_2 stabilization comaprison of patient after Internet of Things control action.

In other conditions paramedics may take decisions accordingly which may takes some time to get the situation normalized. But in this aspect the system acts upon automatically with the situation which takes lesser time to get the situation under control which is better for the patient during transit.

5. CONCLUSION

This proposed work is the first time effort in terms of its scope, and focus. In particular, we have emphasized on the latest concept to collaborate IoT with drones for smart applications ambulance and medical facility. In persuasion of so, it has been presented a thorough study on the most topical works on drone and IoT alliance, its significance, and use. The usage of advance electronic gadgets proves an additional advancement and effectiveness of such system.

This perspective on to add on a counterpart on control action over the measured data within an emergency service over a wide area, a completely secured network with minimum latency is required. Consequently it takes lesser time to take control action from remote location for saving lives under critical condition inside smart ambulance. This can be the way of contribution for the benefit of society in the domain of healthcare.

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