Article

IoT and Drone Based Health Monitoring of Patients

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Abstract: Without the use of medicine drones, users are responsible for transporting goods at a high cost. The goal of this patient monitoring system is to identify people's health and, if necessary, administer medicine. The transportation drone is capable of finding healthcare information in a 360-degree rotation within the transportation infrastructure. IoT: Drone doctors are critical for the transportation of small gadgets such as drug treatments, blood leakages, and vaccines in the critical conditions of a heart patient, in the event of failure of traffic location infrastructure, highway roads, or hospitals due to intense climate or site visitor congestion, and for the transportation of small gadgets such as drug treatments, blood leakages, and vaccines. When transmission is difficult, the self-maintaining drone is the format for quickly transporting drug treatments to the appropriate locations. The shipping drone equipped with an Ardupilot can drive in autopilot mode, which guides the drone to its destination. It has a 7-minute flying period and can deliver up to 2 kg of medicine. When the detected heartbeat is 94bpm and the fever range is 101 degrees, a method has been presented in which an IoT Drone Doctor (IDD) System distributes the first AID box to vulnerable patients and heart patients.

Keywords: IoT; Drone; Fever; Heartbeat Detection Algorithms; Machine Learning; Artificial Intelligence

1. Introduction

Drones include US-Unmanned Systems, Remotely Operated Aircraft (ROA), Remotely Piloted Vehicles (RPV), Remotely Piloted Aircraft (RPA) [1], and Autonomous Drones, which can take off and land vertically. A quadcopter is a gadget with a severe virtual, mechanical, and normal aviation mixture. Based entirely on the assignment consolation, the quadcopter may be personalized and constructed. Drones have six rotors organized in such a manner that the rotors rotate inside an equal course on transverse ends, and altitude will decide the quadrocopter's movement and role [2].

Unmanned aircraft are manufactured from light composite materials for weight loss and flexibility enhancement. This composite cloth sturdiness enables us to fly at extremely high altitudes with the aid of army drones. The drone includes thermal cameras and a GPS system. The autonomous drones are driven by a ground station controller (GSC)

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and a remote controller with a cockpit. For instance, fixed-wing unmanned aerial vehicles (UAVs) are split into two broad categories: fixed-wing as opposed to rotary-wing, with personal weaknesses and strengths. For instance, fixed-wing UAVs commonly have excessive speed and a heavy payload. But they must keep a continuous forward motion to stay in the air [3]. Unmanned aerial vehicles have turned out to be cheaper due to the fact that many managed features may be applied in software instead of relying on expensive hardware. This even makes it feasible to apply numerous UAVs to a single utility. The current advancements have happened in hardware, generation, and networks, particularly for the drone. For instance, the mild composite materials and international positioning structures allow for green flight. Moreover, solar cells with batteries are unexpectedly enhanced, so drone flight depends on the charge. Drone technology displays and navigates using a cell phone or a tablet device. By tracking weather statistics from all the ground stations and optimizing drone paths, the drone-working machine controls the community. An Internet-of-Things (IoT) [4, 5] webcam on board can also allow contact with a management centre. Drones are devices that can fly for an extended period of time, do not have embedded systems, and are adaptable enough to perform new tasks. Beneficial drone functions involve the distribution of small gadgets in hard-to-reach regions. A timely distribution of drug treatments, blood, and vaccines is critical in health care [6, 7]. Drone innovation aids in the provision of fitness care. Places where people may have hard access because of the negative transport infrastructure, roads blocked by extreme weather, injuries, or site visitors because a drone drives in all directions.

The goal of this work is to do away with the problems and headaches involved in the current time-consuming strategies for medicine transmission as well as to layout and expand a drone for turning medicine with a quick time span through the perfect navigation of medicines along with tablets, blood, and vaccines. The extent of traffic in most important cities may be very excessive at all times. The ambulance reaches the vacation spot with its miles very hard at a particular time, and it is very tough to get into the ambulance in rural areas. Due to these problems, the drugs do not reach the affected person at the proper time. The main contributions of this paper are to detect the body temperature and heartbeat using heart beat detection (HBD) and fever detection (FD) algorithms.

The rest of the paper is organized as follows: The next section discusses the related work. Section 3 discusses the system model and its implementation. Section 4 provides a detailed description of the methodology used. The next section discusses the results and discussion. Finally, a conclusion is drawn.

2. Related Work

The authors in [1] described the falling movement of elder people using accelerometer and gyroscope with GPS technology. This work mentioned the delivery notification of falling movement details with an accuracy of 93.75%. The results may be shown in Server HTTP to know whether the person falls in left side or right side. In [2], the authors described heart rate data using radar with Frequency-Time Phase Regression (FTPR) algorithm. SDBB- Standard deviation of the B-B interval and the RMSSD - root mean square of the successive difference and the root mean square of the successive difference were detected and calculated heartbeat. The authors in [3] described falling detection using Wireless Sensor Network (WSN) with Unmanned Aerial Vehicle (UAV). Low cost Global Navigation Satellite System (GNSS) and Efficient Geometry-based Localization (EGL) technique are involved in this sensor node localization followed by the comparison of GNSS and EGL techniques. The authors researched feasibility analysis of heart bit rate with photo plethysmography (PPG) sensor tracker. This work mentioned the calculation of heart beat and temperature range in analysis. In [9], the authors described the hardware design of a fall detection system using ADXL345 Sensor. Further this work also mentioned the fall detection algorithms. The authors in [10] described a general framework for the heart rate monitoring using wrist-type photo plethysmography data without drone. In [11], the authors focused on the heart rate estimation and temperature estimation. The authors in [12] suggested an Internet-of-Things (IoT) based smart framework for human heartbeat rate monitoring and control system. Further, a first-aid System based on Unmanned Aerial Vehicles and Wireless Body Area (WBA) has been suggested in [13].

The authors are examined [14] drones working with the reading of out-of-hospital-cardiac-arrest. Medical drone utilized in emergency that has been described in [15]. Drone transport in medical described in [16]. The reference [17] authors described data delivery from WBA- Wireless body area network. The health status of UAV calculated and predicted based on a Bayesian Network [18]. The cyber-attacks of healthcare devices analyzed using Drone [19]. In [20], Automated External Defibrillator (AED) connected to finding enhances cardiac arrest response time by drone. The authors elaborated [21] how transport the medicine to practical and legal Aspects. The medical support given by using drone that have described in [22]. In [23], Telemedicine have described by using UAV to completion of the target. The [24, 25] paper described the drone delivery of an Automated External Defibrillator by using simulator of flight with experience of mapping.

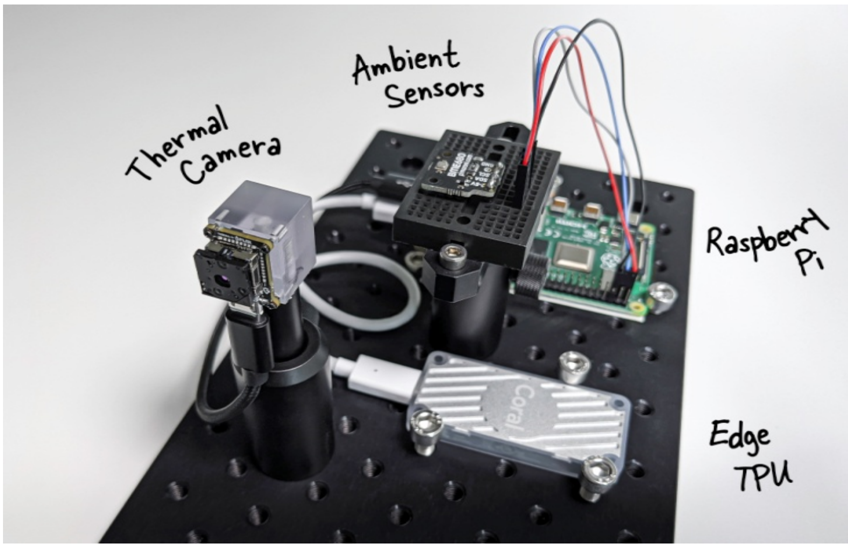

Figure 1 IoT Thermal sensor.

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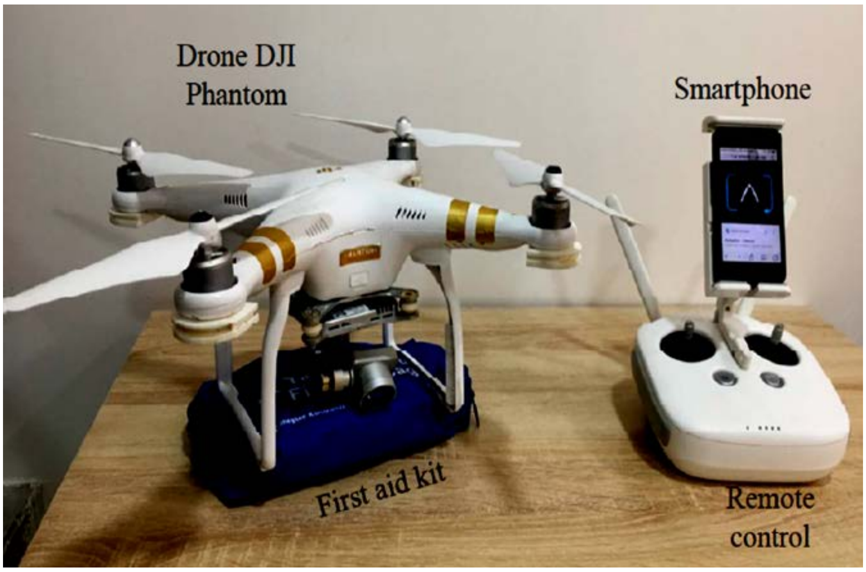

Figure 2 Mechanism of Drone IoT doctor.

3. System Model with Implementation

The prototype of the proposed system having an IOT thermal sensor and a drone (that monitors the patients and hence acts as a virtual IOT doctor) is shown in figure 1 and figure 2. An IoT thermal sensor consists of 3 major parts: a thermal camera, an ambient sensor, and a Raspberry-Pi board. A thermal camera, or thermal imaging camera [26], is a passive device that converts heat energy (i.e. infra-red radiation) into light energy (i.e. visible light) to examine a specific scene or object. The final image obtained is called a "thermogram" and is interpreted through a phenomenon known as "thermography." So, a thermal camera can detect the temperature by the intensity (or strength) of infra-red light.

An ambient sensor consists of 2 parts: a temperature sensor and a pulse sensor. A temperature sensor can examine the temperature of its surroundings and convert the data in any form into electronic data to record and monitor. A pulse sensor is an electronic device that is used to observe the heart rate. The most commonly used pulse sensor is a wrist-worn heart-rate monitor that utilizes light to measure the pulse. It detects the variation in the volume of blood during each heartbeat.

The Raspberry Pi collects the data from both the sensors. As per the programme fed, it transmits the command to the mobile whether there is a need for a doctor or not. If there is a requirement for a doctor, then a drone is sent that acts as a virtual doctor. Besides the abovementioned parts, there is another component called the Edge Tensor Processing Unit (TPU) that is much faster and more powerful than the Graphics Processing Unit (GPU) and Central Processing Unit (CPU) in inferencing. For example, cloud TPU is much better than Nvidia's GPU in terms of performance. The drone software called Pix4dmapper controls the 4 parameters shown in figure 3 and, with GPS, it is able to navigate. The Pycharm software is used on the Raspberry-Pi and programming is done in the Python language. The movement and parameters of the drone are tracked through the mobile and this movement may be controlled with a remote control as shown in figure 2. The direction making plans become accomplished with the project planner software Pix4dmapper with the aid of GPS.

The steps of the implementation are mentioned below.

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Step 1: The Ardupilot controller configures the drone to load the firmware.

Step 2: It is made sure that the proper (i.e. right) COM port is selected and that the baud-rate is about 115200 bps.

Step 3: After putting the baud-rate, the drone is driven to the right side or left side.

Step 4: After capturing the thermal images (minimum 2000 images), the images are shared to the server database using IoT Drone.

Step 5: After locating and finding the patient in a place, the patient is continuously monitored for health issues.

Step 6: The four brushless DC (BLDC) motors are tested and calibrated before being used to lift out and detach the drone. Then path planning (figure 3) is set for monitoring the patient and providing the first-aid kit to the patient.

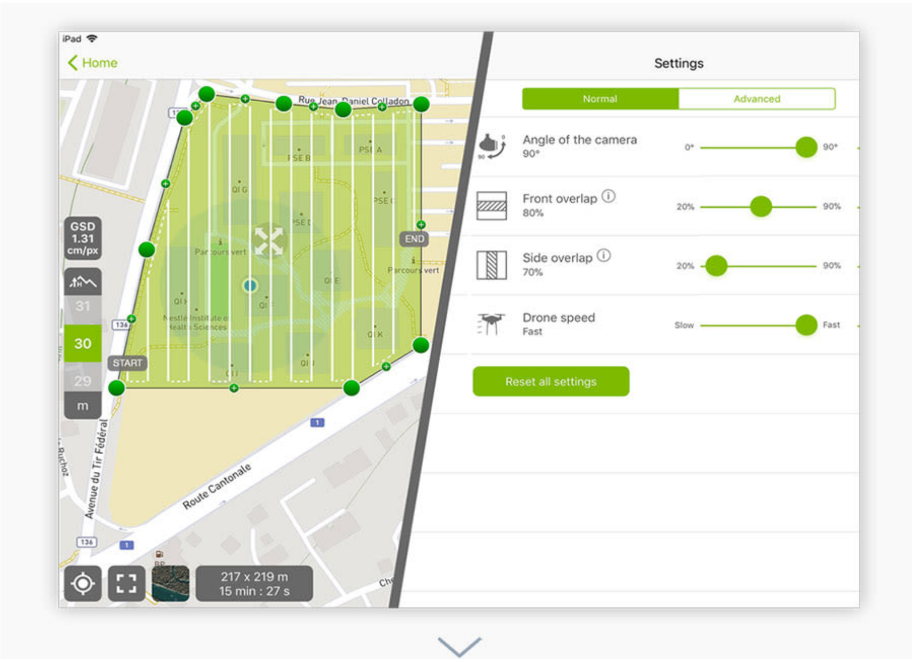

Figure 3 Autonomous Path planning for Searching visited patient.

The system accommodates the drone, hooked up to a medical kit. Every motor, providing 5 kg of thrust pressure, allows the entire drone setup to raise and fly stable in the air with the most payload potential, up to 2 kg. It can fly at a maximum altitude of about 50 meters from the ground with a GPS detection variety and for about 1-2 kilometers with the Ardupilot Mega (APM) controller. Each component of the drone has been tested and proven to work as intended. A number of test flights have been performed, and the effects affirm that the quadcopter can fly in a strong manner.

4. Proposed Method

The proposed method provides health information using the drone automation process. The experiment results are implemented for displaying normal conditions, fever start-up stage, and abnormal conditions, blood pressure, pulse rate, and body temperature variation using thermal images and respiratory rate using thermal images in real time using drone thermal images to alert patients. Figure 11, Figure 12, Figure

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13, Figure 14, and Figure 15 show the real-time experiment results of the drone setup while flying.

5. Heart rate Detection (HRD) using OpenCV AI Camera

The HRD algorithm helps to measure the heartbeat rate and identify the heart rhythms before a heart attack. The proposed algorithm consists of seven steps for detecting the patient's heartbeat rate (as shown in figure 4).

Step 1: A Drone Thermal camera or RGB Surveillance camera is used to capture a minimum of 280 images in the @bin folder for shooting per minute.

Step 2: The 280 images are converted into three categories. The first part is the RGB splitter, the second part is Highlight_faces, and the third part is grayscale images.

Step 3: RGB splitter images are converted into Grab_foreheads and grayscale images are compared with the original images to adjust the contrasted of the images.

Step 4: Contrast_eq of images provides find_faces of patients with grab_faces. Find_faces images can be connected to Grab_foreheads images, Highlight_faces images, and grab_faces images that help measure bpm pulse.

Step 5: Fast Fourier Transform measures the heart rate and bpm vibrations using ROI to show them in a real-time graph. ROI calculates the horizontal ordinate (X), vertical ordinate (Y), height (H), width (W), and inclination angle ().ROI selection is used for face tracking of patients.

$$\overline{\text{ROI}} = \begin{pmatrix} X \\ Y \\ H \\ W \\ \theta \end{pmatrix} = \begin{pmatrix} y_{49} - H\cos\theta \\ x_{49} + H\cos\theta \\ \cos\theta[y_{29} - y_{49} - \tan\theta(x_{29} - x_{49}) \\ (x_{55} - x_{49})/\cos\theta \\ \tan^{-1}((y_{55} - y_{49})/(x_{55} - x_{49} \end{pmatrix} \tag{1}$$

Frequency resolution for FFT is based on length of the Real-time video or collection of Real-time Shooting images. Heart Rate Calculation with FFT best weighted method is given by:

$$\text{Heart Rate pulse } \overline{P}{=}1\frac{1}{\sum_{\omega=1}^{W}\max_f s(\omega,f)}\sum_{\omega=1}^{W} p(\omega, \arg_f\ \max_f$$
$$s(\omega, f)).\max_f s(\omega, f)) \tag{2}$$

The FFT calculation is programmed in IoT controller Drone using python.

Step 6: Find the faces of the patients, connect highlight faces and Bpm_flasher in highlight_fhd (flash image heart beat detection).

Step 7: The FFT calculation provides the heart pulse range. The algorithm calculation depends on the FFT+ measured_heart_beat + highlight_fhd+ find_faces of patient. The system measured the heart beat rate with variation, which depends on blood circulation and pressure.

The normal RGB OpenCV camera is one of the AI IoT devices for detecting the heartbeat of a patient. While capturing emergency images, the AI camera converts pixel values to binary values. It is classified into two files: RGB filter and Gray scale. Gray scale value generates contrast equalization data. The fixed value is used to find the value of faces. This generated value represents grab foreheads, highlight faces, and grab faces. Grab forehead parameters are used to measure the heart rate using the FFT theorem. After the bpm is flashed, the bpm is shown as a graph and value. Gray scale point values are calculated using thermal images and OpenCV images with the IoT Python server. After bpm is displayed, the binary out file is generated for storing the dataset and then connecting to the Thingspeak IoT web server.

6. Fever Detection algorithm (FDA) using Thermal AI camera

The proposed work is based on the prediction of the face with falling indication, the detection of fever, and the heartbeat rate. Only the affected persons are monitored after their HBR has fallen between 60 to 100 bpm, the temperature exceeds 1010C; the SPo2 is below 92 and so on. Strange HBR is called arrhythmia (too fast) with a regular sequence of the electric impulses of the coronary heart. Arrhythmia is termed tachycardia for HBR exceeding 110 bpm and bradycardia for HBR less than 50 bpm. It causes fatigue, fainting, dizziness, mild-headedness, and a falling of the body. Tachycardia is greater than bradycardia with 88% of the aged occurring and having emotion, ache, falling, and surprise to connect the odd HBR and falling of the image frame. We have followed a merged set of rules for measuring the HBR and its threshold value. The algorithm is written in a Python programme using AI machine language on the Raspberry Pi. When applying the system in an emergency period, we can set the parameters of the sensors using the threshold value of heartbeat and body temperature.

An HBR is defined as a normal condition of 60 bpm to an emergency condition of 100 bpm. The threshold value is implemented in the Python programme for service to the emergency patient. As shown in figure 5, the Threshold of Activity Acceleration Magnitude [AAMt] is set at 0.5g, the Threshold of Fall Acceleration Magnitude [FAMt] -0.5g, and the Falling Time [FTt]-40 ms. The Activity Counter threshold [Act] -10s is set as shown in figure 5. When the Raspberry pi4 with the GSM/GPS module [27] is completely configured, the system sends an SMS for the physical fitness of the patient. After sending the message, the Raspberry Pi 4 is turned from the first stage to the second stage. The second stage detects the affected person and parameters of heartbeat and temperature using thermal imaging. If HBR is high and body temperature is high, we have used an HB sensor and a temperature sensor for heart beat detection. The system monitors the patient in real time after measuring the HBR and fever value. The IoT board sends an alert only when the HBR and temperature are both above a certain threshold; otherwise, it reports as real-time monitoring.

When HRNHR occurs, the time is delayed by 5 seconds. If the value of a is less than FAMt, then check the fall timing, otherwise it is connected to the maximum value of Activity Counter [ACm]. Then, it takes extra time before the FTT and IoT controller decide that the patient has fallen with an odd HBR. In an emergency, the GPS receiver pinpoints the location of the affected individuals and sends the HBR for normal people and patients to the nearest hospital. The result repeatedly sends the AAMt reading after a time of 20s. Then a past time counter called Act is set. The counter increases the price of AAMt detection. If the IoT controller reveals that ACmACt, the current result of a patient with a duration of 10s is checked and tested. Then, the IoT controller sends the message to the Call Emergency Center that displays "HBR and affected person" and "region statistics". The FD monitors HBR and calls when HBR is back to normal.

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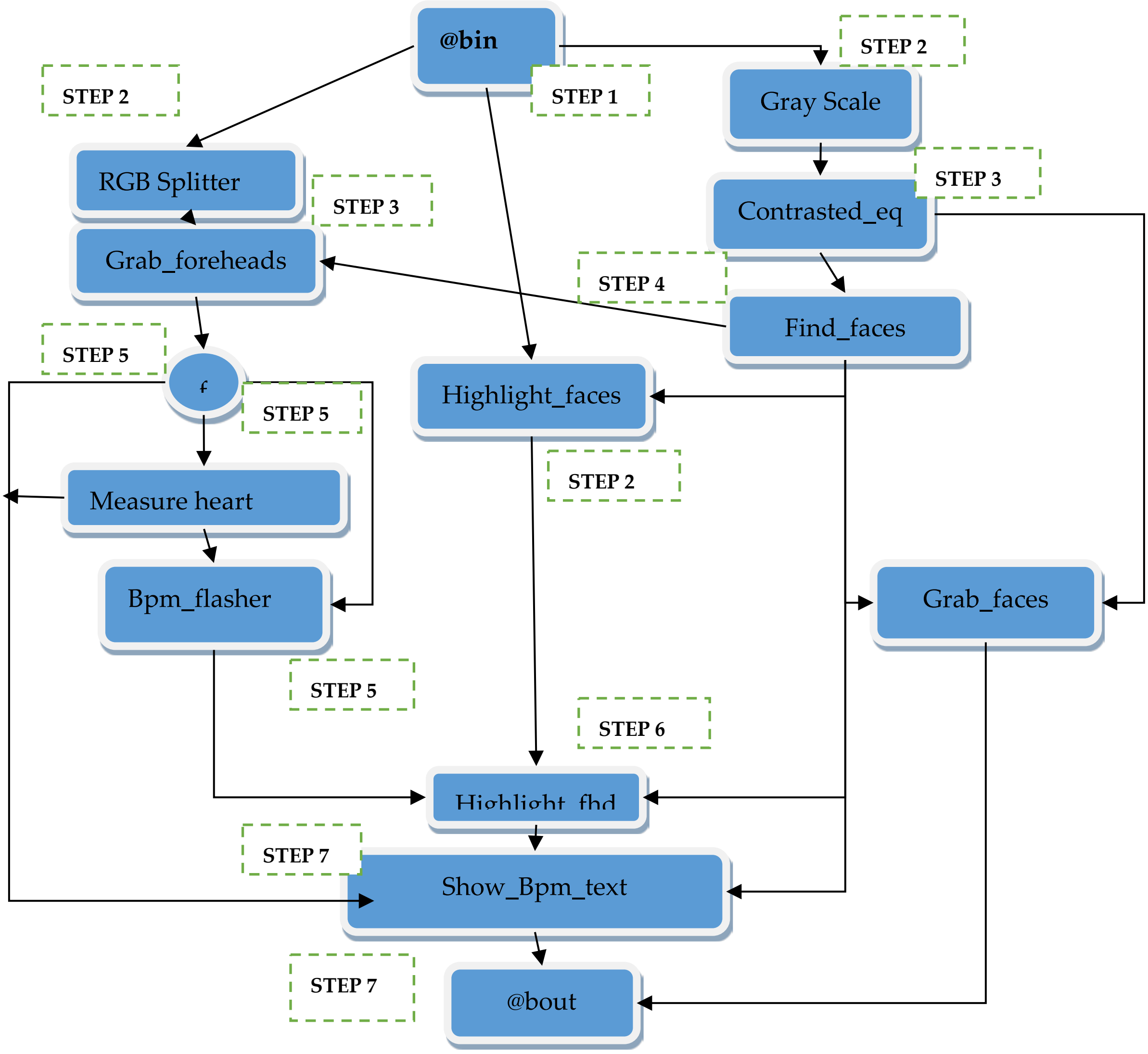

Figure 4. Heart rate Detection [HRD] using OpenCV Camera

7. Call Emergency Center [CEC] algorithm

In figure 5, The CEC Algorithm will use a mobile APK file to get the messages from the FD algorithm. It can be used to monitor the patient's fitness results and patent identity. The FD algorithm sends the messages if the affected person's fitness deteriorates and records the health information and plans the flight direction of the autonomous drone with the cell phone application along with the use of latitude and longitude information. It follows the flight direction planning and attaches the first aid kit to the patient's location with the selected flight direction.

8. Body Temperature Detection Algorithm in crowd

In figure 6, Using thermal mapping images stored in Tiff format on the SD memory card, when the drone captures the patient places and patient faces, the thermal images are extracted and details of the patient in the crowd can be found and the value of the evaluated temperature represents the face temperatures. When the high temperature in a crowd is detected, the drone can alert the people through speaker sound to maintain the social distance. The thermal image detection helps with the detection of patients and intimates the highest temperature in a crowd.

The thermal camera is not the same as a normal camera. This is important for detecting the temperature to find the highest factor of emission. We can compare the present value with the past value of providing first aid medicine to avoid the fault condition of a crowd. The temperature mapping is based on case 1: Environment People Direction, Case 2: Cold Mode-Model, Case 3: Normal Mode, and Case 4: Fever Mode. During the abnormal condition of a patient, the algorithm gives command to face detection and alerts the IoT Drone to find the patient's location. During the normal condition of a patient, the algorithm sends commands to the IoT Drone to monitor the patient. Figure 6 shows the body temperature detection algorithm in a crowd. When the maximum temperature exceeds 380 degrees Celsius, fever is detected automatically in a rainbow image or a medical image using thermal view. Case 2 refers to the cold option of the patient during the low range of fever and bloodless gadgets in the thermal image. Case 3 is referred to as the normal temperature of the patient, and this model is used for human detection. Case 4 is referred to as a "hot model" when the objects are virtually described. If cases 2, 3, and 4 don't exist, normal mode continues in the process.

We are using FD algorithm and HBD algorithm with the set of rules for paying attention function with Ada-boost cascade. The Kalman filter is used here to identify objects. Haar characteristics are used to detect the window on pixel intensities and calculate the difference between those sums [8]. After use of Ada Boost algorithms, the sequences generate a noise figure of image. To overcome this fault, we have implemented the Kalman filter using python AI.

9. Results and Discussions

IoT Drone Doctor saves time to heart patient during the treatment in emergency periods. This provides First aid to vulnerable patients and diseased heart persons. Figure 7 shows the heart rate Detection using RGB AI Camera. Figure 8 signifies Fever Detection in Standing, Sitting and Crowd using Thermal AI camera. Figure 9 describes measurement of Fever range in crowd using Body Temperature Detection Algorithm

Figure 10 represents fever v/s heart beat ratio. The IoT Drone doctor system took surveillance thermal images on 2016 periods. It takes 280 images for each shooting. All the images are stored in data collection of a folder in server through IoT clouding. The HRD algorithm and FD Algorithm show normal condition, Fever starting Stage and Abnormal conditions.

The Conditions of Algorithms are programmed in IoT controller.

If body Temperature is <980F, Patient confirms Normal Conditions.

If body Temperature is =980F, Patient confirms fever starting stage.

If Temperature is >=1010F, Patient Confirms Abnormal Conditions.

If heart beat rate >100bpm, it confirms Heavy heart attack.

If heart beat rate < 60bpm, it confirms Cold heart attack.

We have analyzed 30 days test using 280 thermal images. Figure 11 shows drone thermal image in hospital We have categorized stages with normal condition, Fever starting Stage and Abnormal conditions as shown in figure 12. The Thermal image can cover 10acre/hour using DJI drone phantom1 with payload of camera up to 5kg. The proposed system analyses the Blood pressure, pulse rate and pulse pressure using IoT

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Drone controller. The result is plotted in the graph as shown in figure 13 from datasheet of patient Excel file. The various parameters are calculated as:

Blood pressure = (Cardiac output [CO] * Peripheral Systemic Vascular Resistance [SVR])
Cardiac output = SVR*Heart rate
Health rate = Systolic/Diastolic=120/81

Pulse rate and Systemic vascular resistance (SVR) are measured from Thermal image. Blood pressure is calculated from CO and SVR. It is proportionally varied and depends on pulse pressure and pulse rate. Figure 13 shows Real-time value changes of Blood pressure, pulse rate and pulse pressure. The proposed system analyses the body temperature using Artificial Intelligence with Thermal image as shown in figure 14. Body temperature varied depends on atmosphere and blood pressure. The body temperature changes as given in equation (4). S is an output signal of Thermal camera described by equation (3)

$$\text{Output signal S} = \int_{\lambda 2}^{\lambda 1} \frac{2\pi h c^2}{(exp\ (\frac{hc}{\lambda kT} - 1)\lambda^5} \text{R}\ (\lambda) * \delta\ (\lambda) \quad (3)$$

Here $\lambda 1$& $\lambda 2$ correspond to spectral band, h is Planck's constant, c is the velocity of light, k is Boltzmann constant, R (λ) is the camera responsivity and T is absolute temperature.

Here temperature range=

$$\text{T}=\frac{\text{B}}{\ln(\frac{\text{R}}{\text{S}-\text{O}}+\text{F})}=\frac{1460}{\ln(\frac{231159.5}{\text{S}-6094.248}+1)} \quad (4)$$

Respiratory rate is calculated from heart beat using thermal image. It measures breathing rate in breaths per minute in figure 15, we have identified maximum Respiratory rate 17 breaths /minute on 8th day and 25th day. This figure shows Respiratory rate a and Respiratory rate b. Respiratory rate a mentions value 16 in14th day and Respiratory rate b mentions value 16 in 8th day and 25th day. All recorded data are analysed and tested using thermal image and Artificial intelligence.

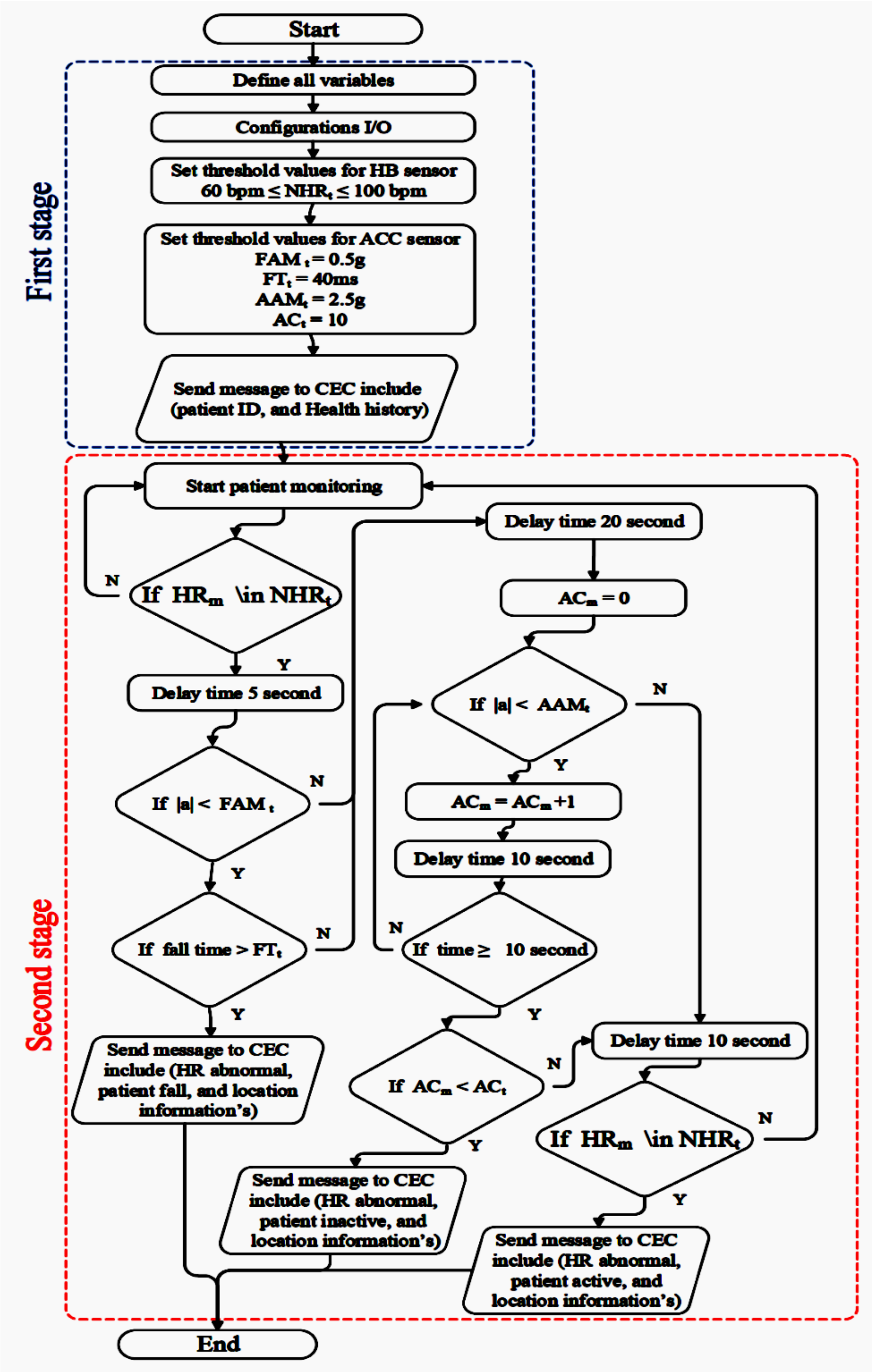

Figure 5. Flow Chart of Heart rate detection in abnormal condition

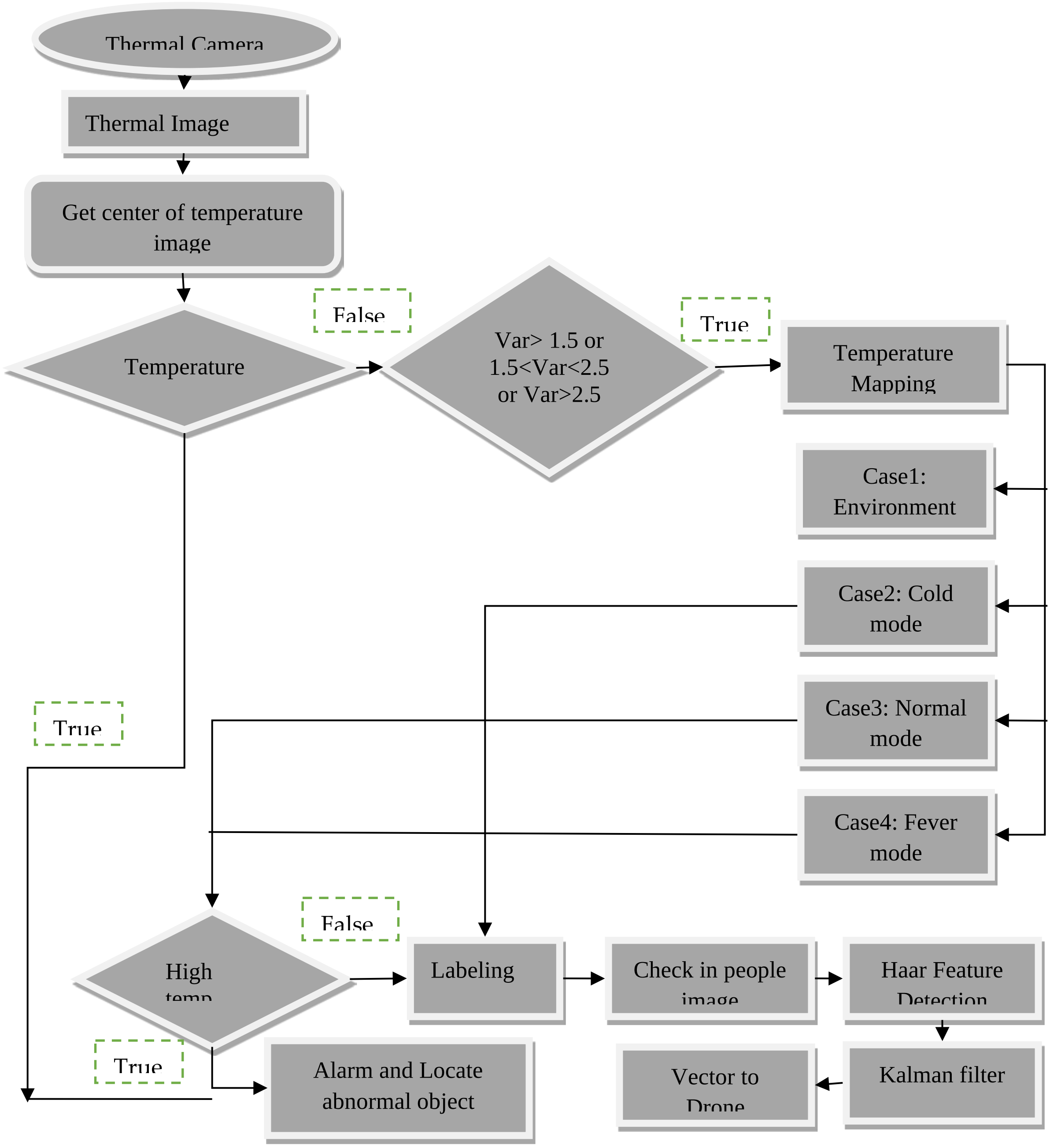

Figure 6. Body Temperature Detection Algorithm

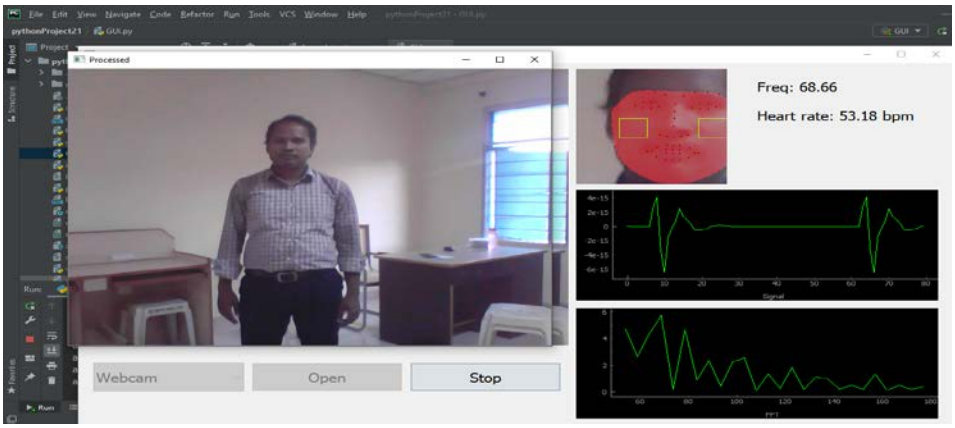

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Figure 7. Heart rate Detection using RGB AI Camera.

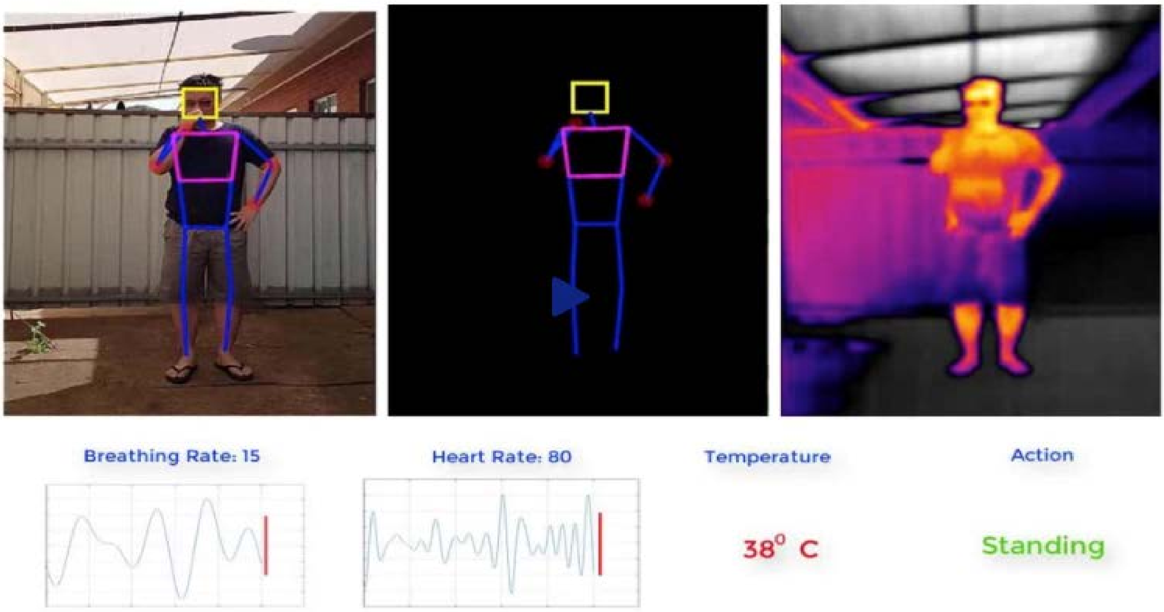

Figure 8. Fever Detection in Standing, Sitting and Crowd using Thermal AI camera

Figure 9. Measurement of Fever range in crowd

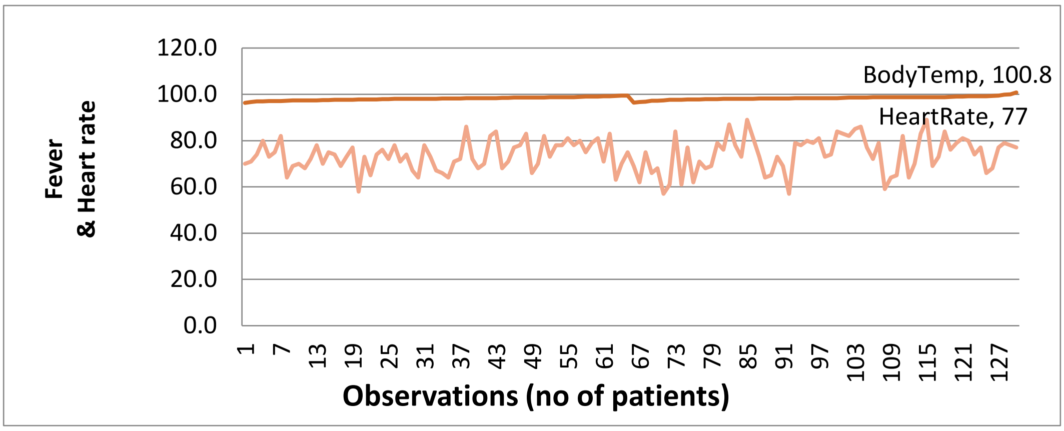

Figure 10. Fever vs. Heart ratio.

10. Conclusion

The proposed work is implemented by using heart beat detection (HBD) and fever detection (FD) algorithms. These IoT algorithms provide real-time monitoring and real-time remote sensing images while detecting emergency images captured in patient places [28]. When a detected heartbeat of 94bpm and a fever range of 1010c are reached, it provides a first aid box. Thermal images are analysed and compared with RGB images for fever and heartbeat detection. After confirmation, the doctors give prescriptions to those who are taking treatment in a hospital or at home. The IoT Drone Doctor System follows the scanned patient, detects fever or heartbeat value using thermal image, and provides more accurate service. In bad weather conditions, this system can adjust the thermal camera to detect fever images and heartbeat values for servicing the patient. Also, the comparison of IoT readings is done in emergency and normal conditions. The physical and thermal values of the same person are compared, resulting in higher accuracy for fever detection and heartbeat detection. We used IoT Drone Setup in heart patient surveying locations and hospitals to provide first aid. The Experiment results are shown for normal conditions, fever start-up stage, and abnormal conditions, blood pressure, pulse rate, and body temperature variation using thermal images and respiratory rate using thermal images in real time using Drone Thermal images to alert patients.

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Experimental Results and Graphs

Resource of Drone camera	: https://www.apollohospitals.com/
Image Type	: Thermal image captured from FLIR camera
Results	: BP, PR, PP, Body Temperature, Respiratory Rate

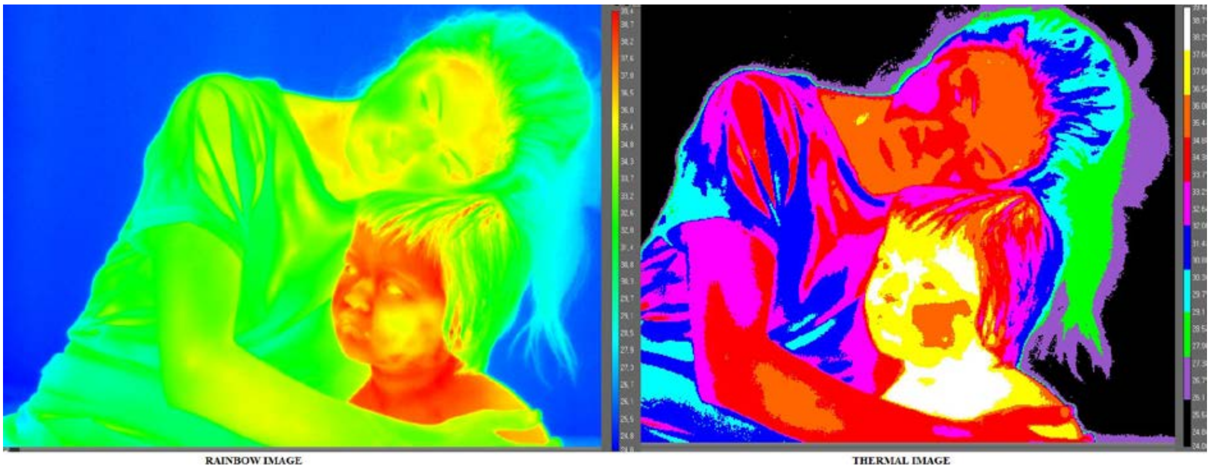

Figure 11. Drone Thermal images in hospital

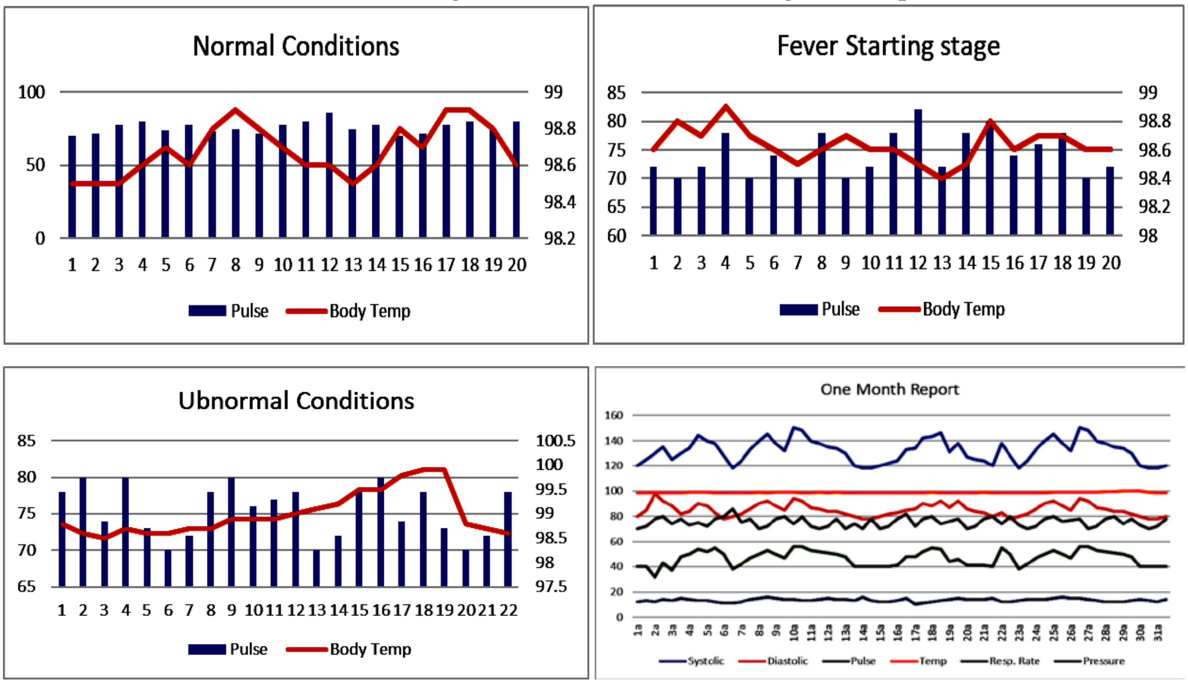

Figure 12 -. 31 days Analysis of normal condition, Fever Start-up stage and abnormal condition

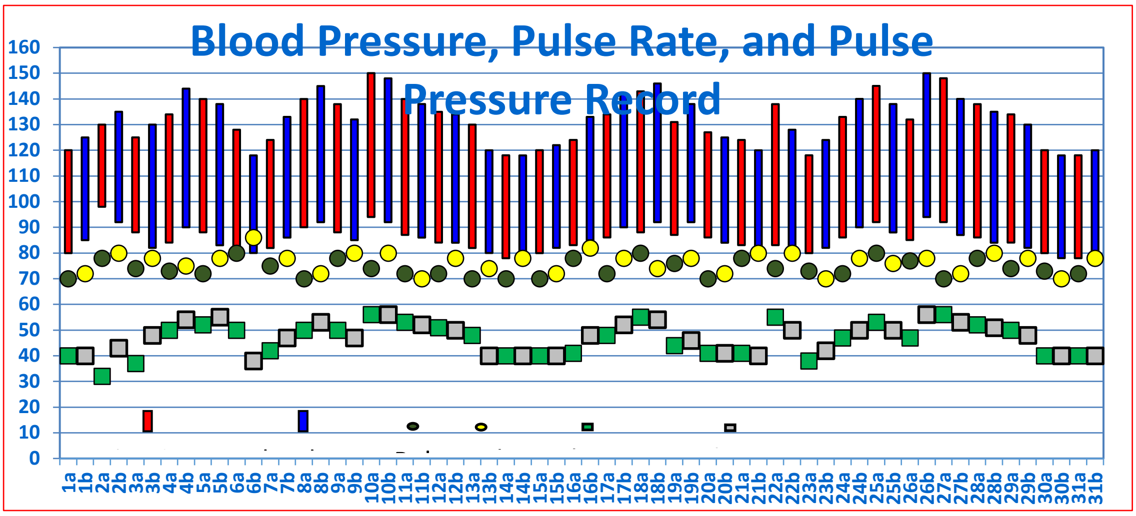

Figure 13. Graph between Blood pressure, pulse rate and pulse pressure for 31 days

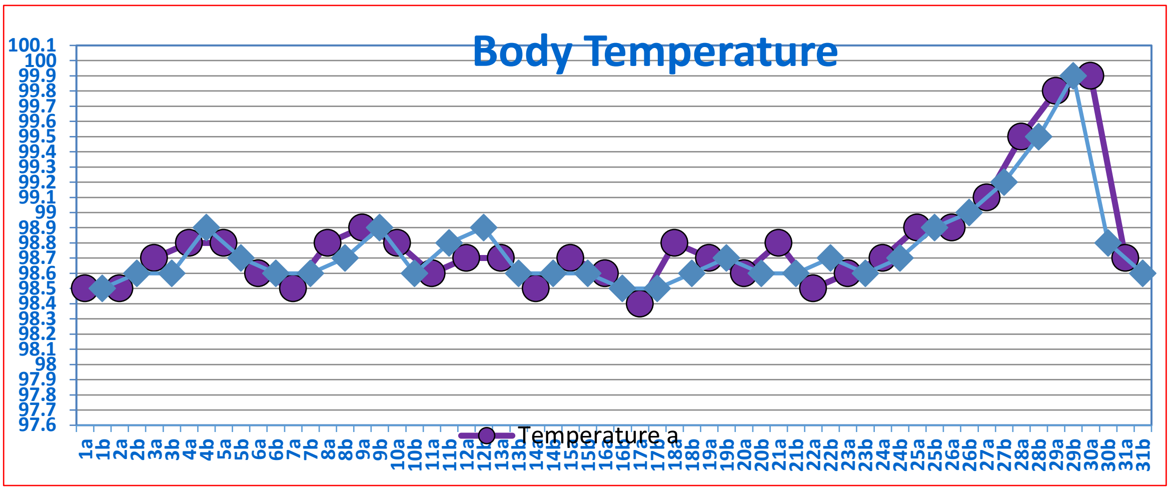

Figure 14. Real time graph of Body temperature variation using Thermal image for 31 days

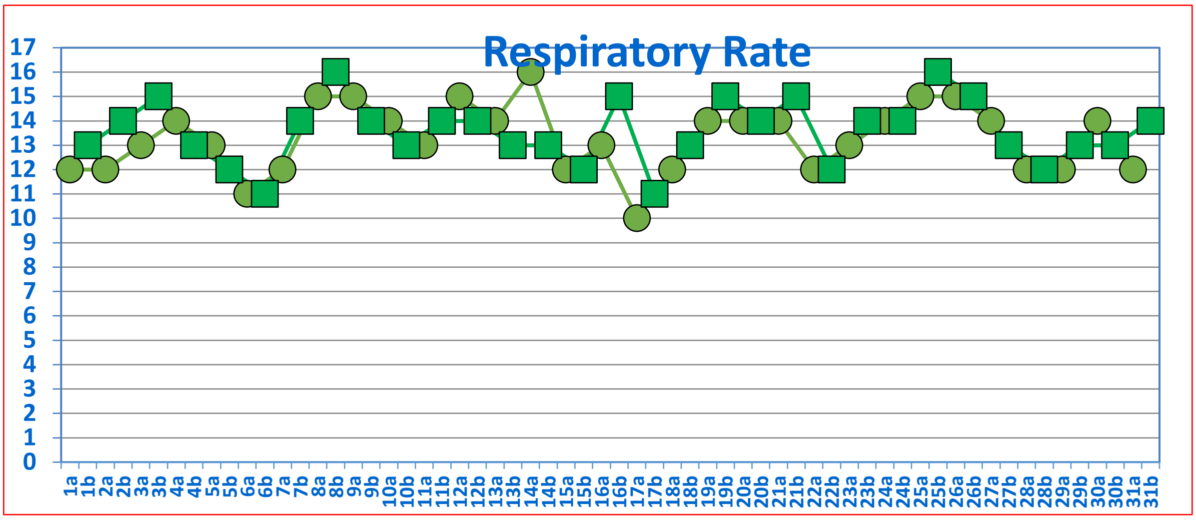

Figure 15. Real time graph of Respiratory rate using Thermal image for 31 days