A Novel Model of Patient's Health Monitoring System Using IoT Platform

Lakshminarayanan.V[1]
Dr. Mahalingam College of Engineering and Technology, Pollachi, Tamilnadu, India

Thirunavukkarasu. M[2]
Dr. Mahalingam College of Engineering and Technology, Pollachi, Tamilnadu, India

Suganya. A[3]
Dr. Mahalingam College of Engineering and Technology, Pollachi, Tamilnadu, India

ABSTRACT

The present era technology is everything to do all work devoid of any human error. Health care is most vast area requiring continuous monitoring, especially in intensive care unit patients, adulthood patients has additional care and they are needed to monitor periodically. Whether the patients suffer breathing, body temperature, pulse rate and failing to change the Intravenous fluid (IV) bottle may affect the patient's health, so the IoT automated system is used to protect the patients at exact timing and that report will be transferred to the patients handling doctors and nurses. Patient datum measured by using LM35, Node MCU ESP8266 controller it will be working the principles of temperature increases, the voltage across diode increases at known rate. Doctors can be obtaining the results in their mobile phone and immediately they can attend the patient for the further treatment if it's necessary, to ensure the wellness of the patient and to maintain good medic care.

Keywords— Wheatstone bridge, Node MCU ESP8266 controller, IoT-Internet of things, Thingspeak.

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I Introduction

India has vast technological development in the medical field; the caretaker and nurse find difficulties in monitoring the level of the drip bottle especially during night and busy schedule. It is a tedious process for a nurse to remember the time taken for Intravenous bottle to run out of fluid when it is necessary to monitor more than three patients. There is a possibility when the drip bottle becomes empty, it may cause backflow of blood and affects the patient's health severely. The pulse rate of a patient will not be the same all the time and nurse cannot monitor the temperature of the patient round the clock.

To avoid such situations and to reduce the work burden of a nurse, an IoT based patient's health monitoring system which is simple in design and low cost is required for monitoring and sending pop-up notification to the nurse. This project focuses on monitoring patient's health by identifying three important parameters which are IV fluid level, body temperature and pulse rate.To operate IoT based health monitoring system needs a Wi-Fi connection. [1]The low level of the intravenous fluid in drip bottle is measured by the weight of the bottle using load cell. The stages of bottle are given below:

- Normal – The fluid left is more than 25% of the Initial weight
- Warning – The fluid left is between (25 – 15) % of the Initial Weight
- Critical – The fluid left is less than 15 % of the Initial Weight.

The body temperature is measured using LM35 and pulse rate is measured using Pulse Sensor 9031. All the data from the sensors are processed by Node MCU ESP8266 and communicated to server. In case of IV fluid level the controller compares the obtained value with the pre-calculated value and sends an alert message to the smart phone of the nurse through IoT which avoids continuous monitoring of the patient and helps to change

the drip bottle at right time for that particular patient. [2]The temperature and pulse rate are also sent along with the IV fluid level data.The microcontroller (ESP8266) connects to the Wi-Fi module and continuously monitoring inputs from sensors and the datum were passed to the cloudat particular URL/IP address by using IoT apps and the information's can be viewed bythe doctor or family members.

II Literature Survey

1. Ram Kumar S proposed "Remote monitoring the glucose bottle level in the hospitals". [3] IR sensor is used to monitor the glucose bottle level. A comparator is used to compare the values got from the patients, where the fluid level was reached predefined threshold value means GSM module is used to communicate the respective nurse through the message at accurate time. This method is used to prevent the back flow of blood.

2. Priyadharshini.R proposed "Automatic Intravenous Fluid Level Indication System for Hospitals". [4] This method is used to control IV fluid level by using RF technology with affordable cost. RF transmitter continuously monitoring the level of bottle, whether the bottle reaches the empty level means the buzzer intimate the bottle level to doctors and nurses.

3. Hiromichi Maki proposed "A new drip infusion solution monitoring system with a free-flow detection function". [5] Electrodes are used to measure the fluid level. Electrodes were placed inside of the bottle and it gets drift forces from glucose molecules. [6]Transducers are used to measure the capacitive coupled signals getting from all electrodes and intimate to the respective nurses as well as doctors.

III Methodology

Even though we have extensive development in medical technologies, still, patients are affected due to minor mistakes made by doctors and nurse. One such problem is monitoring the level of the IV fluid in drip bottle. [7]This system has proposed to assure the patient's health. The low level of IV fluid in the bottle is identified by measuring its weight using load cell. [8]The weight of the bottle is continuously compared with the pre-calculated value by the controller. The different data from separate IV monitoring systems are collected and transferred using IoT. A pop-up notification is sent to the smartphone of the nurse using IoT. This helps the reduction in work tension for a nurse and also avoids the situation of back flow of patient's blood and it also pave way for a nurse to handle the number of patients thus reducing the work force.

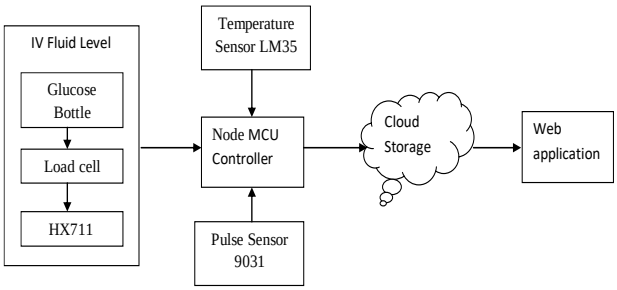


Fig: 3.1 Block Diagram

IV Hardware Requirement

Calibration of Load cell:

Calibration is a comparison between knew standard value and measured value by using instrument. The tests will be used to conduct by the instrument. The device reaches linearity means that process is going to be end otherwise this process is to be repeated when that device reaches accuracy. [9]The standard calibration accuracy is ten times equal to device accuracy may be its working in ascending or descending order. The report is based on error measurement with the measuring device before and after the calibration. Load cells are frequently monitored by its weight and give highly measured accurate data on each steps finally provides 0.03% accurate data.

Calibration of the load cell in loading and unloading condition is performed and the results are tabulated as follows

Table.4.1 Calibration of Load cell

S. No	Actual weight(mg)	Loading weight(mg)	Unloading weight (mg)
01	0	0	0.001
02	100	100	101
03	200	200	200
04	300	301	300
05	400	400	402
06	500	500	500
07	600	603	602

08	700	701	700
09	800	801	802
10	900	903	906
11	1000	1002	1001

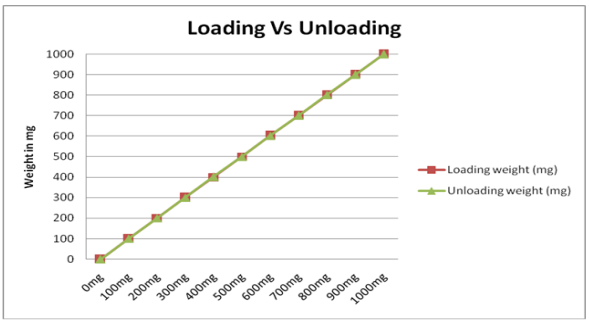


Fig:.4.1 Calibration Graph

Intravenous fluid measurement:

After necessary calibration, weight measurement is done.The weight is monitored continuously through the Arduino program. When the IV fluid bottle is hang in IV fluid monitoring system the strain gauge experience strain. Due to this, the output is obtained from the load cell in terms of mV. This analog output is amplified and converted into digital output using 24bit ADC which is HX711. The HX711 is interfaced with NODE MCU to obtain weight of IV fluid in terms of digital data.

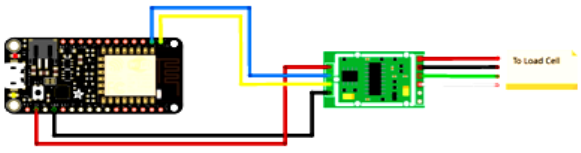


Fig.4.2.NODE MCU connection with HX711

Detection of Low Level:

The initial weight when the device is ON is set by pressing SPST switch. The weight during the switch button press is considered as 100% weight. This weight includes the weight of bottle and IV tube. Now from this weight, a threshold weight is set which is 25% of initial weight and critical weight is set which is 15% of total weight. Then the continuous measurement is checked with the threshold measurement and critical measurement to detect the low level of the fluid.

One liter IV bags of physiologic saline contained an average volume of 1051 ml (range 1033-1069 ml).The weight of the IV bottle or bag is approximately 1kg.From the initial weight the threshold weight is calculated. In a similar way, 500ml bottle weighs 500g approximately.

Threshold weight=25% of initial weight

Therefore, threshold weight =125g.

When the threshold weight is reached, a signal is generated that alarms the nurse to reach the patient.

Inspection on Drip Flow Level:

When the device is calibrated the initial time and value of weight in that instance is noted as elapse-time and elapse-weight. A pre-defined time to determine whether the drips has been flowing into Patient's IV tube or it has been abruptly stopped due to some reason has been set. This also depends on the speed of the IV flow which varies from patient to patient and with disease. Then the elapsed-time is incremented. Once the elapsed-time reaches the pre-determined time, the instance weight and elapsed-weight is compared. If both equals it is indicated as the flow is blocked at point. Otherwise it is a sign that patient experience pleasant IV flow.

Preparation and Read Pulse Sensor:

Pulse sensor is used to sense the pulses from patients routinely and provide the monitored report into the respective in charges. The sensor is needed to be placed in patient fingers after that it continuously gives signals to the monitor. Sensor is made up of thin film of vinyl and capacitor is added to decrease the noise. [10]The output voltage is analog and it's dependent on input voltage. The sensor voltage range is 3-5 volt and Node MCU range is 3.3 volt. The sensor output voltage maximum range is 0-1 volt, so it cannot affect the voltage divider.

	Age	Min	Normal	Max
	1 to 12 months	75 / 50	90 / 60	100 / 75
	1 to 5 years	80 / 55	95 / 65	110 / 79
	6 to 13 years	90 / 60	105 / 70	115 / 80
	14 to 19 years	105 / 73	117 / 77	120 / 81
	20 to 24 years	108 / 75	120 / 79	132 / 83
	25 to 29 years	109 / 76	121 / 80	133 / 84
	30 to 34 years	110 / 77	122 / 81	134 / 85
	35 to 39 years	111 / 78	123 / 82	135 / 86
	40 to 44 years	112 / 79	125 / 83	137 / 87
	45 to 49 years	115 / 80	127 / 84	139 / 88
	50 to 54 years	116 / 81	129 / 85	142 / 89
	55 to 59 years	118 / 82	131 / 86	144 / 90
	60 to 64 years	121 / 83	134 / 87	147 / 91

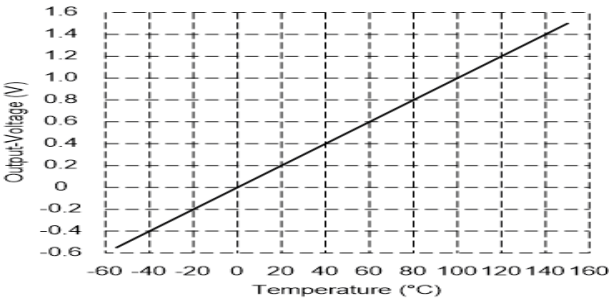
Table.4.2.Blood Pressure range by age

Read temperature Sensor:

LM35 does not require external calibration or amplifying device. If LM35 is held in armpit it will give accurate reading than in Finger tip. In Finger tip it reads skin temperature whereas in arm-pit it reads body temperature. [11]It has analog output and it is proportional to the temperature.

Real Tmp	LM35 Tmp	A/D	Device Output	LM35 Output
21.5 °C	21.5 °C	50	0.061035 V	0.214600 V
22.3 °C	22.3 °C	109	0.133057 V	0.222500 V
22.4 °C	22.3 °C	116	0.141602 V	0.223400 V
22.6 °C	22.6 °C	132	0.161133 V	0.225500 V
22.9 °C	22.8 °C	151	0.184326 V	0.228100 V
23.0 °C	23.0 °C	162	0.197754 V	0.229500 V
23.2 °C	23.2 °C	179	0.218506 V	0.231800 V
23.5 °C	23.5 °C	204	0.249023 V	0.235200 V
23.7 °C	23.7 °C	215	0.262451 V	0.236600 V
23.9 °C	23.8 °C	226	0.275879 V	0.238100 V
23.9 °C	23.9 °C	233	0.284424 V	0.239000 V
24.3 °C	24.4 °C	270	0.329590 V	0.244000 V
25.0 °C	25.1 °C	320	0.390625 V	0.250700 V
25.3 °C	25.3 °C	340	0.415039 V	0.253300 V
25.5 °C	25.5 °C	350	0.427246 V	0.254700 V
26.8 °C	26.9 °C	456	0.556641 V	0.268800 V
28.0 °C	28.2 °C	556	0.678711 V	0.282200 V
28.7 °C	29.0 °C	612	0.747070 V	0.289700 V
29.5 °C	29.7 °C	670	0.817871 V	0.297400 V
31.7 °C	31.5 °C	799	0.975342 V	0.314700 V
32.2 °C	32.2 °C	855	1.043701 V	0.322100 V
32.9 °C	32.9 °C	908	1.108398 V	0.329200 V
33.6 °C	33.5 °C	949	1.158447 V	0.334700 V
34.1 °C	34.1 °C	993	1.212158 V	0.340600 V
34.6 °C	34.6 °C	1032	1.259766 V	0.345800 V
35.3 °C	35.2 °C	1078	1.315918 V	0.351900 V

Table.4.3.Output of Temperature Sensor



3 Graph of output of temperature sensor

Sample Database Creation:

To store the necessary data, a database is created and named as "IV monitor". This database is linked to the Android application.

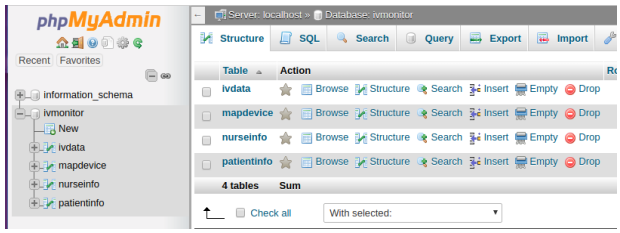


Fig.4.4 Displays the table in IV monitor database

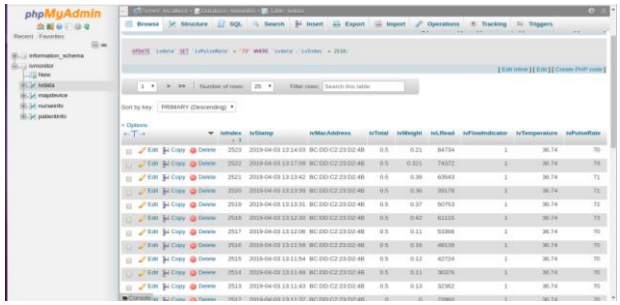


Fig.4.5.Displays the sample values stored in IV data table

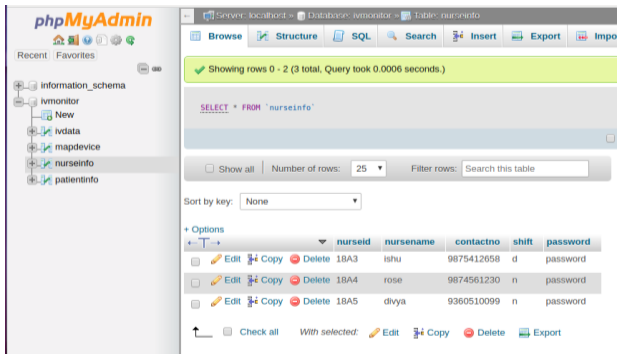


Fig.4.6. Displays the sample values stored in nurse info table

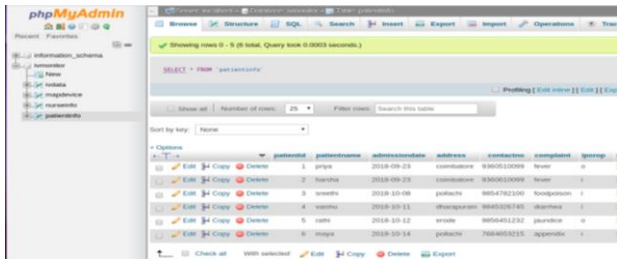
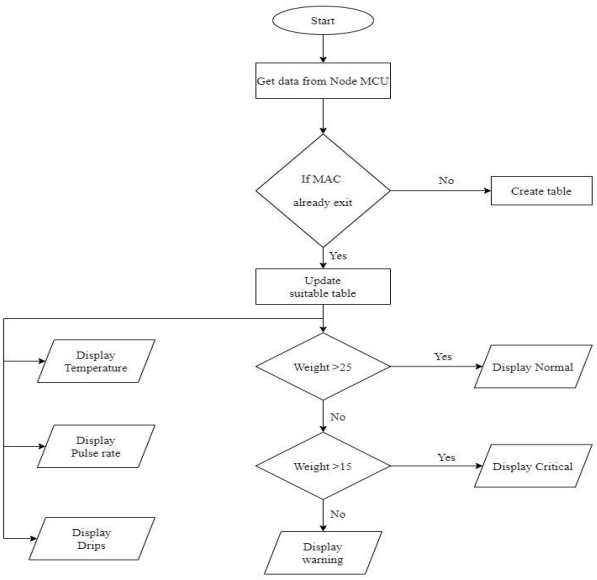


Fig.4.7.Displays the sample values stored in patient info table

Flow chart for server hosting in web

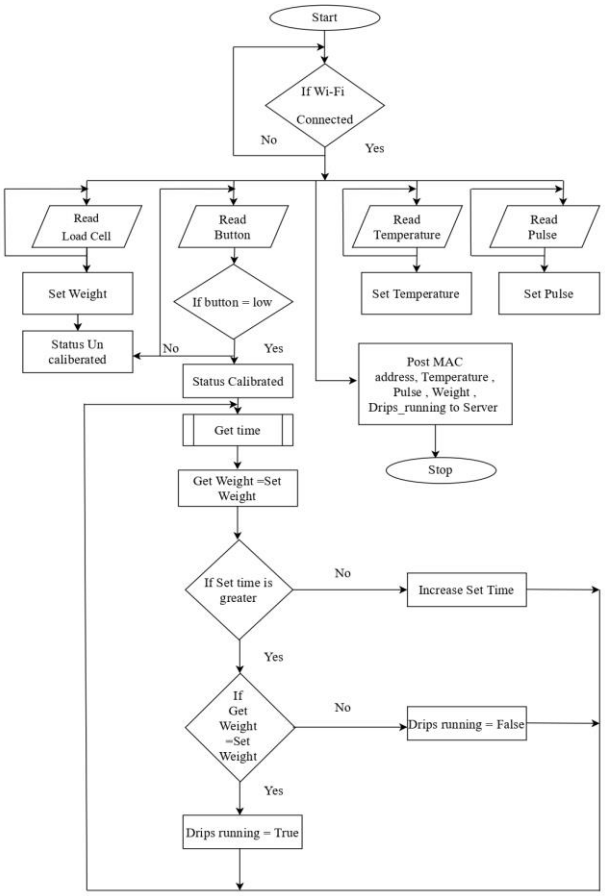


V Working of the Project using IoT:

It senses and collects data from all connected devices and then share date across internet so that it is easy for monitoring and analysing the data. In technological world, there are many devices and system that makes the work accurate,easy and comfortable with lesser time than the work done manually. [12]Even-though there are sensors which senses real time dates it is necessary for continuous monitoring of output from the system and hence it is difficult and how ever requires a man power.To sort out such difficulties IoT can be used. The n number of devices can be connected to internet so that data can be accessed from various parts of the world. As the data can be notified through internet in any place uncertain situations can be determined earlier disasters can be prevented or reduced.

The system measures the level of the IV fluid in the drip bottle, patient's body temperature and pressure. It may be automated as generating alarm signals or during critical situation and hence it cause disturbance to the patients. [13-14]But the IoT based system can senses real time date such as heart rate, body temperature and pressure of various patients and shares the status of various patients to the nurse or doctor through internet.[15-16]Hence monitoring the health an n number of patients in single webpage can not only reduce the work burden but also to ensure complete care and protection of the patient.

Flow chart for Node MCU



VI Results and Discussions

IoT Based Health Monitoring System is powered up and IV fluid bottle/bag is hanged into the setup. The button is pressed to set the Initial Weight. This initial weight is taken as 100% and then the fluid is allowed to flow into the IV tube. The weight of the fluid is continuously monitored.

When the weight reaches below 25% of the initial weight, an alarm signal is generated displaying status as the Warning. When the weight reaches below 15% of the initial weight, an alarm signal is generated displaying status as the Critical. Otherwise the status is Normal.

The usage of two-alarm signal is beneficial and it provides sufficient time for a caretaker to reach to the patient. Thus avoiding the problems caused due to the complete drain of IV fluid in the bottle. The problems may include the

backflow of blood and formation of air bubbles in the vein of the patient.

The drips running condition is inspected. When there is no flow of fluid for per-determined time, it is indicated as Drips stopped. Else it is displayed as Drips running. [17]This is again added advantage that in any scenario if there exist a block in IV tube and cannot be able to penetrate into IV vein of the Patient, care-taker can adopt further procedure to remove the block.

In addition to this patient's Temperature and Pulse Rate is displayed using the reading from the mounted sensor in IV monitoring system.

The temperature of the patient is measured using LM35 sensor and Pulse rate is measured using Pulse sensor 9031.[18]

Even-though the system is made using IoT, continuous monitoring of patient's health status becomes difficult. The system is made to generate pre-programmed colour in the electronic gadgets when the sensor reads a value greater than the pre-determined value. The future extension of the project is to notify the nurse when the body temperature and pressure of patient increases beyond the pre-calculated value. This system further reduces the work of the nurse or caretaker.

VIIConclusion

Our idea is successfully tested with the kit we proposed for different sizes of IV bags where each output is analyzed for different weights. If system detects any abrupt changes in IV fluid level, the system automatically alerts the nurse about the patient's status over IOT and also shows details of heartbeat and temperature of patient live over the internet. [19][20]The continuous monitoring of the level of IV fluid eliminates the consequences faced by the patient when there is no fluid to infuse in the bottle. The trace of temperature and pulse rate also eliminated the need to be manually noted and the data can be fetched for further reference. Thus IoT based patient health tracking system effectively uses internet to monitor patient health status and save lives on time.

In future, the data from various patients are collected and the body temperature is analyzed to give an alert when it reaches an unsafe level. The indication is set based on the analyzed value. In similar fashion, pulse rate of patients is also analyzed during both low blood pressure and high blood pressure scenario, analyzed and alert signal is given when abrupt changes occur. These alert signals give an immediate call to the doctor so that physicians arrive at correct time and the patient life is saved. In addition to this, the blood pressure of the patients is also monitored to save patient's lives.

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