

# A Reliable and Smart E-Healthcare System for Monitoring Intravenous Fluid Level, Pulse, and Respiration Rate

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## ABSTRACT

The paper presents a reliable and quality maintenance of intravenous fluid level, pulse rate, and respiration rate measurement system in healthcare networks. Implementing information and communication technology becomes essential to monitor an elderly patient's health condition in the hospital environment. In this paper, a continuous monitoring system is developed to monitor the level of the intravenous fluid, pulse rate, and respiration rate during pandemic situations with an alarm indication. The integration of pressure sensor, strain gauge sensor, PPG sensor, and Piezo sensor with low-cost microcontroller provides a reliable and quality maintenance of an intravenous fluid level. Also, it gives an accurate measurement of pulse rate and respiration rate. Advanced signal processing tools have been used in this paper for processing and feature extraction. The hardware implementation of the proposed wireless monitoring system is done using a microcontroller programming environment that consumes meager power and provides reliable monitoring.

## KEYWORDS

Biosensors, GSM, Intravenous Fluid, Labview, Microcontroller, Pulse Rate, Respiration Rate

## INTRODUCTION

Generally, due to the population's growth, the importance of health care also increases. Nowadays, many advanced techniques are carried out in the medical field. According to Dudde et al. (2006), an intravenous infusion is an essential practice in clinical treatments. Intravenous fluid monitoring plays a significant role in many medical treatments. Nowadays, many devices are developed in a healthcare environment to ensure patients' safety. Moreover, there will be a huge demand for using IV drip to treat patient diseases during pandemic situations and increase patient health immunity. SARS-CoV (Severe Acute Respiratory Syndrome-Corona Virus) is a virus that originated from animals (Bats) in Gningdong province in China in 2002. According to the World Health Organization (WHO), this virus has spread around 26 countries, and more than 8000 cases were registered around the world.

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Human to human transmission is found to be the reason for the rapid spread. SARS-CoV symptoms include fever, headache, myalgia, diarrhea and shivering (Weiss et al. 2011). At the same time, the disease was declared an epidemic by the WHO. In 2012 MERS-CoV (Middle East Respiratory Syndrome- Corona Virus) broke out in Saudi Arabia (Erika et al. 2020). Until 2020 around 2519 people were infected by MERS. A genetic variation of SARS-CoV was active in 2019 and is coined as SARS-CoV2 by the International Committee on Taxonomy of Viruses (ICTV) (Chih Cheng Lai et al. 2020). It originated in the Wuhan province of China from Bats (Phelan et al. 2020). The disease caused by SARS-CoV2 was named the 2019 novel Corona Virus (2019- nCoV).

Later it was called COVID-19 (Corona Virus Disease 2019) when announced as a pandemic disease by WHO. The virus is known to affect the infected respiratory system (Shereen et al. 2020). It takes around a minimum of five days to show any symptoms of virus infection. In some instances, it has even taken around 24 days Symptoms include fever, sore throat, body ache and troubled breathing (Huang et al. 2020; Guan et al. 2020). The virus travels through our windpipe to reach the lungs. Air sacs will be developed inside the lungs, which causes trouble in breathing.

Around 14% of the affected people had this trouble. These critical patients were kept on a ventilator, and timely care was needed. It is also believed that the disease is fatal in persons above age 60 or anyone with prior life-threatening diseases like cardiovascular disease, diabetes, chronic respiratory disease, and cancer. Human to human transmission is significantly due to droplets from the mouth. A person is also prone to illness if the person comes to contact with any surface with an active virus.

The spread of the virus is growing very fast, and the number of infected patients is rapidly increasing. The research reported no vaccine for this disease. However, various manufacturers are researching to find a cure at the earliest. Due to increasing the number of infected patients, providing timely, reliable treatment for diseases by healthcare network's becomes challenging. It is also tough to monitor inpatient health status by a caretaker due to the spread of the virus.

As a result, it is necessary to bring other technologies to the treatment of infected patients in an instrumental healthcare network.

The purpose of this article is to provide an efficient and straightforward prospective implementation of GSM-based wireless monitoring of intravenous fluid level, pulse rate and respiration rate of the patients. The scientific environment's relevant information has been reviewed and proposed a reliable system in an e-healthcare network.

The paper proposes an alternative solution to use innovative engineering concepts and new technology to monitor the patient's conditions to overcome these issues. It provides the method of monitoring patient health status automatically without healthcare providers' support during an emergency. It also highlights the practical use of sensing technology in healthcare to measure the necessary vital parameters such as pulse rate and respiration rate and enable the control actions by communicating the information to the caretaker. Advanced signal processing tools have been used in this paper to extract the desired features from the biosignals.

## BACKGROUND

Cardiovascular diseases, nervous problems, and brain-related problems are one of the most critical sources of death. It is also essential to monitor older adults who need more care due to the growing effect of diseases. According to Haydar Ozkan et al. (2020), it was reported that 17.7 million peoples have affected and lost their life due to long term diseases. As a result, the home monitoring of vital patient parameters becomes essential in the biomedical engineering environment due to the ageing problem.

There is a considerable need for using engineering technology in the healthcare environment to solve human problems. The application of information and communication technologies drastically increases healthcare services to long-term diseased people and elderly patients. One of the main

requirements to deal with these patients lies in their continuous health monitoring. Due to the lack of services, workforce, and equipment, continuous health monitoring for elderly patients becomes crucial. Therefore, an alternative mechanism must be introduced to overcome the drawback of existing methodologies and provide an efficient monitoring platform in the healthcare network.

## Intravenous Fluid Monitoring

Medical avoidance during intravenous infusion can cause different kinds of severe medical accidents (Agarwal et al. 2009). Zhang et al. (2011) proposed the sensor network-enabled intravenous infusion monitoring. This paper illustrates a family of intravenous infusion monitoring systems based on a fork-type light barrier incorporated with the zig-bee protocol. The system's reliability is analyzed and proved massive experimental statistical results to show that the monitoring system can provide the networkable system's required functions. The system also offers low cost, low power consumption, small size, good scalability and flexible use.

Swain et al. (2015) proposed an intelligent saline level indicator with a controller. The paper described a system that aims to troubleshoot problems caused by the backflow of blood effectively. Priyadharshini et al. (2015) proposed an automatic intravenous fluid level indication system for hospitals. In this paper, a low-cost radio frequency-based automatic alerting indicates when the device might use an infra-red sensor as a level sensor. It is based on the principle the sensor output voltage level changes when the intravenous fluid level is below a specific limit. A comparator is used to compare the sensor output with a predefined threshold. When the transceiver output is negative, the controller identifies the fluid level. It alerts the caretaker by a buzzer, and an LCD at the control room indicates the patient's room number for quick recovery. Bhavasaar et al. (2016) proposed an automated intravenous fluid monitoring and alerting system through load cell and heartbeat sensors. Intravenous therapy is a typical treatment method that may modify electrolyte imbalances in the body, deliver medications, and transfer blood or fluid injection. The advantage of the proposed method lowers the chance of heart problems by monitoring the patient's status. Periodic therapy, especially in the case of chemotherapy, can be effectively carried out. The necessity to monitor IV administration is profound, and this paper presents a solution to the above problem. Chidgopkar et al. (2015) proposed an automatic and low-cost saline level monitoring system using a wireless Bluetooth module and the CC2500 Transceiver. The paper proposed a system that can automatically monitor the saline flow rate by using a microcontroller. It is beneficial for nurses and doctors at rural hospitals to monitor saline level at long distance.

Tiwari et al. (2016) proposed a system that consists of a color sensor, ATmega 328P microcontroller, transmitter and receiver. This system overcomes the complications faced during IV therapy. It detects the emptying of an IV bag with the help of a level indicator. The indicator is based on a color detecting principle. The alarm will ring at the set point level and alert the staff to replace the IV bag. Bustamante et al. (2010) proposed a wireless sensor for intravenous dripping detection. They proposed a system that can detect when an intravenous liquid provided to patients in hospitals runs out and detect obstructions in the catheter. That way, sanitary centres' attention is more efficient and immediate, as the container's observation does not need human supervision.

Also, a novel algorithm has been simulated to improve the network with its mobility. The device size and sensor dimensions are considerably smaller, which reduces power consumption. Harsh Dave et al.(2016) & Jegan et al. (2018) proposed the Zigbee based wireless health monitoring system. The paper proposed a system that uses low power ZigBee wireless technology along with an ARM-based microcontroller. Vital health signs like heart rate, temperature and blood sugar level can be monitored in real-time using this system. Chi-Fang Huang et al. (2011) proposed a warning system based on the RFID technology for running out of the injection fluid. They demonstrated the results of a warning system of running out of intravenous drip in hospitals. RFID technology was adopted as a means of triggering the device of the whole system. Hidekuni et al. (2010) proposed a system that detects the

fall of each drip of fluid. Table 1 gives a detailed list of sensors, hardware/software approaches and wireless devices used by various researchers in the process of intravenous fluid level measurement

## PPG Sensor and Pulse Rate Measurement

Shobhitha et al.(2013) describe that the human heart functions by a series of electrical activities from a specific region within the cardiac muscle. These activities spread through the cardiac areas and stimulate contractions to pump deoxygenated blood. The deoxygenated blood is passed to the lungs for purification and allowed into the vascular system. The heart's electrical activity produces a change in mV range (millivolts), measured by two electrodes. The regular heartbeat starts with the Sino Atrial node and is triggered into the right atrium, which causes depolarization of the cardiac muscle. The PPG signal has waveforms that indicate the variation of blood volume with each cycle. Physiological sensors play a significant role in the field of acquiring physiological signals and their processing. The atrial and ventricular activity of the heart plays a vital role in generating a PPG signal. The PPG signal is achieved by a sensor that measures changes in light absorption. The PPG sensor is widely used to sense the blood flow rate controlled by the heart's pumping action.

Elgendi et al. (2012) and Jegan et al. (2015 & 2018) used a sensor placed on the fingertip for PPG signal acquisition. Ya-Li Zheng et al. (2014), Bolanos et al. (2006) and Melvin et al. (2017) proposed a device for the measurement of blood pressure and heart rate variability. Yousefi et al. (2014),

**Table 1 List of Sensors, Hardware, Software and Wireless Modules Used for IV fluid level Monitoring**

Reference	Sensor Used	Software Used	Hardware Used	Wireless Device Used
F.Chen et al. 2015	RFID/NFC tag reader	Embedded C	UDP protocol, ADC Microcontroller	RFID
S.Joseph et al. 2019	Level sensor	Embedded C	ATmega microcontroller	Bluetooth
Reza C. Jianwen et al. 2011	IR Sensor, Laser	Embedded C	Amplifier, Microcontroller, Stepper motor	CC1101 RF module
V. Caya et al. 2019	Drip level sensor	Embedded C	Raspberry Pi Processor, Servo motor	Webserver
K. R. Rani et al. 2017	Pressure Sensor	Embedded C	Amplifier, Microcontroller	nrf24L01
Raghavendra et al. 2016	Light detector	Embedded C	Microcontroller	NA
Yang Zhang et al. 2010	IR Sensor	Embedded C	Atmega 128 controller	CC2420 Zigbee
S. Yadav et al. 2016	IR Sensor	Embedded C	ARM Cortex M3, Servo motor	Wi-Fi
A. Cataldo et al. 2011	Strip electrodes	NA	Time-domain reflectometry	NA
A. Cataldo et al. 2012	Strip probe	MATLAB	Microwave reflectometry	NA
Ray et al. 2019	Ultrasonic, IR sensor and Load cell	Embedded C	Atmega 328 controller	ESP8266 module
Rashid et al. 2017	Flow Sensor	Embedded C	Atmega 2560 controller	Bluetooth

Zhilin Zhang (2015) and Byung & Sun (2006) proposed the method of the systematic acquisition of PPG signal with noise cancellation algorithms to remove motion artefact noises, while Asada et al. (2003) proposed the use of wearable biosensors for the acquisition of the PPG signal. Table 2 gives the existing techniques and focusing areas for PPG signal feature extraction and monitoring.

## Respiration Rate Monitoring

A necessary vital parameter to analyze patient health is the respiration rate. In various studies, the respiration rate measurement plays a crucial role in analyzing the respiratory problem. Different authors have developed a system for measuring the respiration rate from the patient signals by involving various sensors (Jegan et al. (2017, 2020). Marek Krehel et al. (2013) proposed a wearable sensing system with optical fibers for respiration rate measurement. Navajas D. (2016) developed the system, which consists of pneumotachographs for sleep-related breathing issues. V. Kulkarni (2013) introduced the system, which consists of polyvinylidene fluoride sensors for respiration monitoring. Many biomedical devices have been developed in the healthcare network to measure vital patient

**Table 2. Related methods Used for Pulse rate monitoring**

Reference	Sensor Used	Hardware and Software Used	Purpose
K. Watanabe et al. 2019	PPG sensor	STM32L432 Microcontroller, ADC, Current to voltage circuit	Heartbeat
S. Vadrevu et al. 2019	PPG sensor	Filters, Matlab	Peak detection
L. Zhu et al. 2019	PPG sensor	Moving average filter, neural network	Heart rate
H. Lee et al. 2019	PPG sensor	Gyroscope, Accelerometer	Heart rate
Besleaga T et al. 2019	PPG Sensor	Filtering and BP measurement	Mechanical Alternans
A. Thomas et al. 2019	PPG sensor	Sparsity Based Signal Extraction	Heart rate
C. Yang et al. 2019	PPG sensor	MSP 430 controller, wavelet transform	Atrial Fibrillation Screening
S. Vadrevu et al. 2019	PPG datasets	ARM Controller, Matlab	Signal quality assessment
J. Lee et al. 2019	PPG sensor	Multi-mode particle filtering	Heart rate
W. He et al. 2020	PPG sensor	Short time Fourier transform, Dictionary learning	Heart rate
Eerikainen et al. 2020	PPG sensor	Random Forest (RF) model	Detecting Atrial Fibrillation and Atrial Flutter
K. R. Arunkumar et al. 2020	PPG sensor	Recursive Least Squares, Normalized Least Mean Squares adaptive filters, Fast Fourier transform	Heart rate
M. Panwar et al. 2020	PPG sensor	Deep Learning Framework	Heart rate
L. G. Rocha et al., 2020	PPG sensor	Convolution neural networks (CNN) and two-layer extended short-term network	Heart rate
Chowdhury et al. 2018	PPG sensor	Multiple reference adaptive filter	Heart rate
G. Ryu et al. 2018	Flexible PPG sensor	Amplifier, filter	Drowsiness detection
D. Biswas et al. 2019	PPG sensor	Deep learning Framework	Heart rate

parameters. However, these devices are extensive and consume much power. Hence, there is a necessity to develop a better monitoring unit that can be used in e-health applications. Continuous monitoring is essential for some patients in the long run. In addition, the constant monitoring of patients using an intelligent healthcare system requires complex circuitry. The monitoring system designed utilizing the acquisition unit occupies a large area and consumes more power. Table 3 presents the detailed components involved in measuring the respiration rate from biomedical sensors.

Various researchers from different science domains have become increasingly interested in PPG signal processing and respiration rate measurement because of its advantages as a non-invasive, inexpensive, and convenient diagnostic tool for physiological parameter measurement (Jegan et al., 2013, 2015, and 2018).

## SYSTEM ARCHITECTURE

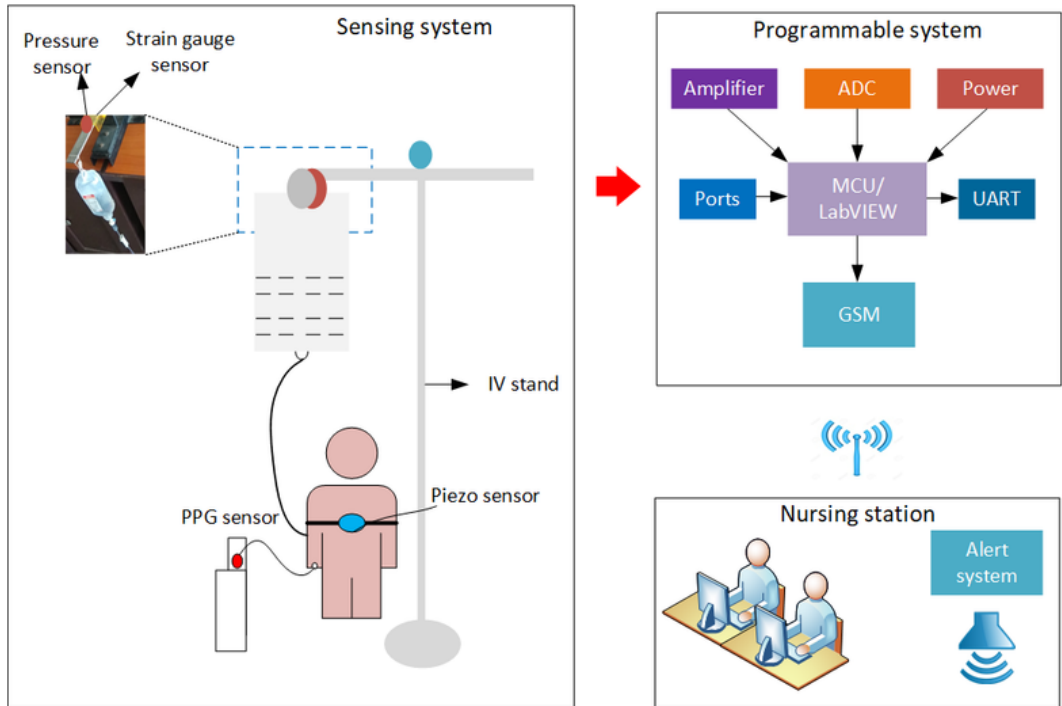
The paper targets the development of a reliable smart system consisting of a PPG sensor and a respiration sensor for easy acquisition of a real-time signal to measure physiological parameters. It also provides continuous monitoring of the intravenous fluid level by pressure sensors and strain gauge sensors. The proposed system consists of a GSM wireless module for constant monitoring. Here, a sensor-based physiological system has been developed to acquire PPG and respiration signals, and filtering techniques have been implemented to remove various noises and improve the signal's quality.

Figure 1 shows the proposed system architecture of intravenous fluid level, pulse and respiration rate measurement. The system architecture consists of three modules. The sensing module comprises

**Table 3. Related work on Respiration rate monitoring**

Reference	Sensor Used	Components Used	Purpose
Pimentel et al. 2017	PPG sensor	Multiple autoregressive models	Respiration rate
V. Soleimani et al. 2018	RGB-D sensors	depth-based photoplethysmography	Remote Pulmonary Function Testing
M. A. Motin et al. 2019	PPG sensor	Empirical mode decomposition, Principle component analysis	Breathing rate
D. Jarchi et al. 2019	PPG sensor	Accelerometer, auto-regressive method, Hulbert transform	Respiration rate
J. Jorge et al. 2019	ECG, PPG Sensor	Autoregressive, Fast Fourier transform	Respiration rate
C. Park et al. 2019	PPG sensor	Compressive covariance sensing	Respiration rate
R. Katiyar et al. 2019	PPG sensor	Fourier–Bessel series expansion-based empirical wavelet transform	Respiration rate
K. V. Madhav et al. 2013	PPG Sensor	Modified multiscale principal component analysis	Respiration rate
M. R. Ram et al. 2013	PPG sensor	ICA-based improved dual-tree complex wavelet transform	Respiratory information
M. A. Motin et al. 2018	PPG sensor	Ensemble empirical mode decomposition with principal component analysis	Respiration rate
H. Chang et al. 2018	PPG sensor	Holo-Hilbert spectrum	Respiration rate
D. Kim et al. 2020	PPG Sensor	Filtering, ADC	Respiration rate
H. Sharma, 2020	PPG sensor	Ensemble empirical mode decomposition with Kalman filter	Respiratory rate

Figure 1. System architecture for IV fluid level, pulse rate and respiration rate measurement system



a strain gauge sensor, pressure sensor, PPG sensor, and Piezo sensor for sensing the required physiological signal quantity. The pressure values differ regarding the volumes of liquid contained in the intravenous container. The pressure is measured using the strain gauge sensor and pressure sensor.

Moreover, the patient's pulse rate is calculated using a PPG sensor, which works on the principle of light-based technology. It consists of a LED and photodetector for sensing the pulse signal of the patient. The patient's respiration is measured by a piezo sensor placed on the patient chest to feel the patient respiration. The programmable system module consists of a low power microcontroller for processing input physiological signals' parameters and measuring required parameters. The low power amplifier is used to achieve the input quantity of the input signal, which the microcontroller and LabVIEW environment can process.

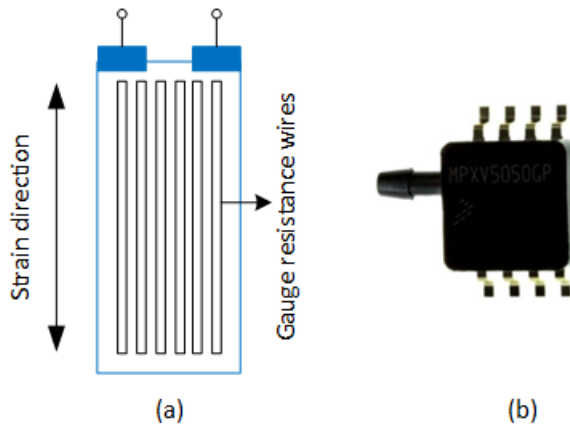
## INTRAVENOUS FLUID LEVEL MEASUREMENT

### Strain Gauge Sensor and Pressure Sensor

The paper proposes a pressure sensor and strain gauge sensor to measure the container's intravenous fluid level. Thus, when the volume of the liquid in the container is reduced, there is a drop in the container's pressure. The pressure sensor provides the sensing of the pressure in the container and produces the output as an analog voltage. However, the pressure sensor's voltage is very low since the pressure change in the container is also low. Hence, this voltage drop needs to be amplified to produce a considerable output that other processing devices such as a microcontroller can process.

A precision amplifier has been considered and interfaced between the sensing system and processing unit. A strain gauge is a sensor used to measure the strain on the object. The indicator is connected to the medium and deformed to change its electrical resistance, measured with the Wheatstone bridge configurations. Figure 2 provides the schematic representation of the used strain

Figure 2. Sensor used for IV fluid level measurement (a) Strain gauge sensor (b) Pressure sensor - MPxx5004



gauge and a pressure sensor for detecting and sensing the pressure of the saline bottle and identifying the container's level.

### Processing Unit

The saline bottle is set to hang on the medium where the strain gauge sensor and pressure sensor are placed. Before hanging the IV bag on the medium, the strain gauge sensor must be calibrated or set to a null position. The strain gauge sensor and pressure sensor are fitted on the medium on which the IV bag is hanged with one end connected to the sensor and the other end to the patient. According to the speed, the fluid level is getting reduced step by step, which is adjusted by the tube's roller clamp, as shown in Figure 1. The voltage produced by these sensors needs to amplify. The processing unit is used to strengthen the voltage from the strain gauge sensor made up of the OP07CP precision operational amplifier. The output voltage is taken from the sensing medium, and it is given to the amplifier, as shown in Figure 3.

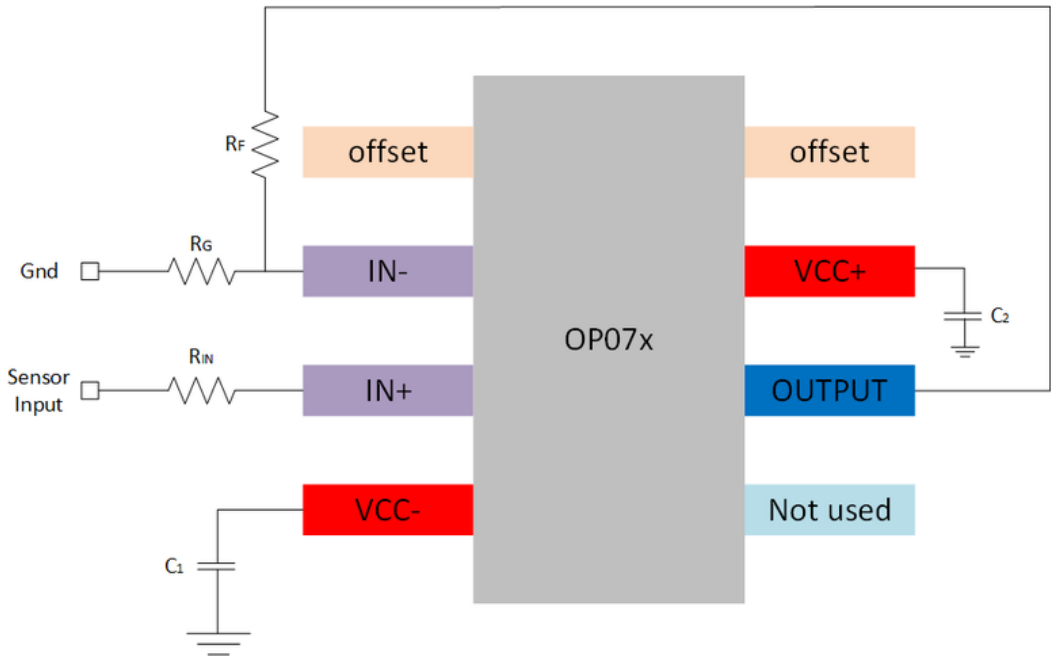
### IV Fluid Level Measurement

A strain gauge is operated on the principle of measuring a change in the resistance of a wire. In this paper, the input terminal of the system is developed by a strain gauge used and calibrated to measure strain. The indicator is attached to the object by a suitable adhesive arrangement. The resistance change is calculated using a Wheatstone bridge related to strain by the quantity known as gauge factor. Strain gauges are used as sensors in IV fluid monitoring systems to measure the change in pressure. The experiment deals with measuring the strain in a cantilever beam by using four resistance strain gauges. A static load in the form of IV fluid is incremented at different locations along the beam to produce measurable strains. In many applications, a Wheatstone bridge in the form of strain gauges, which consists of four resistors in an electrical circuit, is used to measure resistance change. Any one of these resistors may be replaced with strain gauges, and the resulting circuit can be used to measure deflections. The pressure in the intravenous container is calculated using these strain gauges as a sensor. The pressure values differ for various volumes of liquid contained in the intravenous container. Thus, when the volume of the liquid in the container reduces, there is a drop in the container's pressure. That change in pressure has to be measured.

In the second approach, the pressure sensor (MPXV5004GP) measures the IV fluid level. It generates a signal which is a function of the pressure. These piezoresistive pressure sensors provide a very accurate and linear analog voltage equal to the input pressure applied. The pressure sensor MPXV5004GP and IV chamber are placed at the same elevation. One end of the IV tubing is connected



Figure 3. Amplifier circuit configuration to amplify sensors output



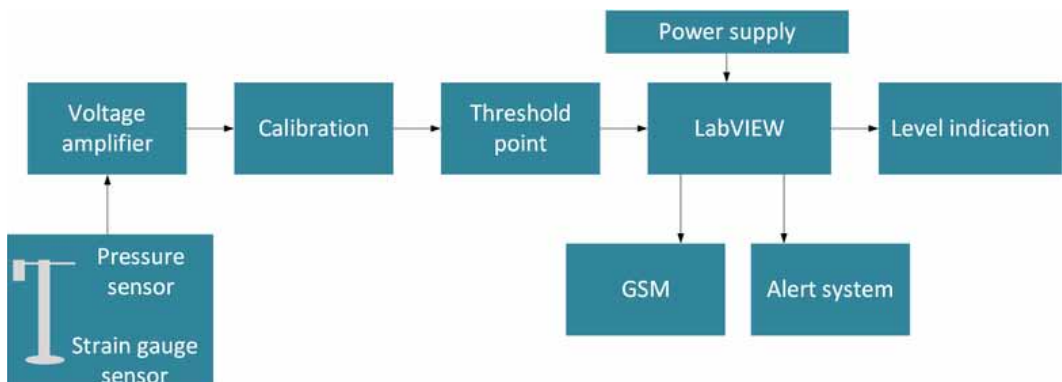
to the pressure sensor, and the other end is maintained as a drain. The pressure sensor produces analog output voltage based on the intravenous fluid level reduction. Figure 4 provides the necessary steps involved in the process of IV fluid level measurement and monitoring.

## PULSE RATE MEASUREMENT

### PPG Based System Design and Pulse Rate Measurement

The PPG signal recording by the PPG sensor has been an integral part of medical engineering for measuring a patient's vital parameters. The real-time PPG signal is acquired and analyzed using data acquisition (DAQ) hardware. The literature review seems to incorporate PPG sensors to receive a pulse

Figure 4. Steps involved for IV fluid level measurement



signal. A PPG is a method of obtaining a plethysmogram signal. A real-time PPG signal is acquired through the PPG sensor, which illuminates the skin and estimates variation in the light absorption.

In this work, the PPG measurement can be done at the finger. The PPG signal contains waves that reflect the change in blood volume with each cardiac cycle. The photodetector detects this volume change. Figure 5 shows the typical sensor and its output signal representation. PPG signals may contain the baseline drift. That is mainly due to the noises that occurred during the acquisition. It is removed by applying a bandpass filter to the signal. Then, the number of peaks is detected to calculate the pulse rate.

## RESPIRATION RATE MEASUREMENT

### Piezo Sensor and Respiration Rate Measurement

The wide use of the piezo sensor in biomedical engineering plays a central role in measuring vital parameters. The working methodology of the piezo sensor mainly depends on the principle of the piezoresistive effect. In this paper, a patient respiration signal is acquired and recorded with a piezo sensor. Figure 7 shows the type of piezo sensor used in this paper for the respiration rate measurement. The experimental set up consists of a piezo sensor with a belt arrangement attached to the patient chest. The set up provides effective measures of the respiration signals whenever the person breathes. That could be further amplified using an amplifier. The graphical programming environment is used to process the acquired signal. The signal is taken for 15 seconds, and the remaining data is interpolated for a minute.

Figure 8 shows the process flow diagram for the proposed system. In a medical environment, modern technology plays a significant role to reduce work. In this paper, the GSM-based monitoring system monitors the intravenous fluid level, pulse rate, and respiration rate. Whenever the IV fluid's desired level, pulse rate, and respiration rate reaches the required limit, an alert message is sent to the nurse station through the GSM. The system is designed using the LabVIEW environment and is also implemented in the ATmega128 low power microcontroller. The Atmel based microcontroller board is chosen for the embedded implementation of the monitoring system. To reduce the calculation inaccuracies due to finite word length, a 16-bit processor is used. The physiological sensor is used to acquire the human body's signals and is represented in samples. The bio sensor's analogue voltage is amplified and fed to the 10-bit A/D converter of the microcontroller. The digitized data is filtered and used for measuring physiological parameters. A threshold voltage is set to send an alert message to the nurse station through GSM. The sensor's analogue output voltage is amplified and given into the ATmega128 microcontroller using the ADC technique in the hardware part. A GSM module has to be interfaced with the microcontroller to alert the nurse station. A threshold voltage needs to be programmed in the microcontroller. When the desired parameters come at the threshold, the GSM will send an alert message to the nurse station.

Figure 5. Schematic representation of Pulse sensor: (a) PPG sensor (b) PPG signal

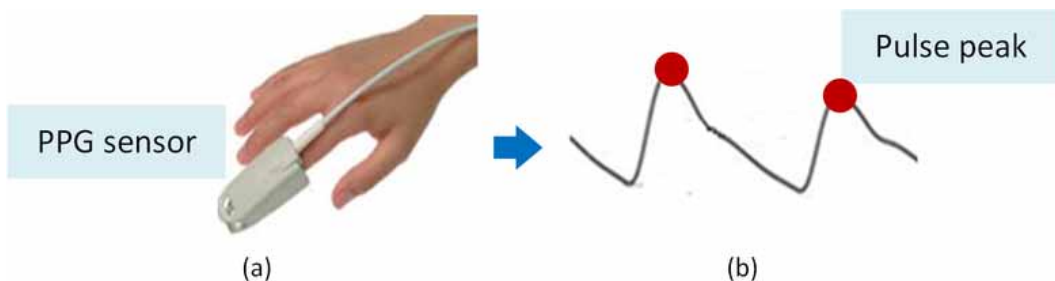
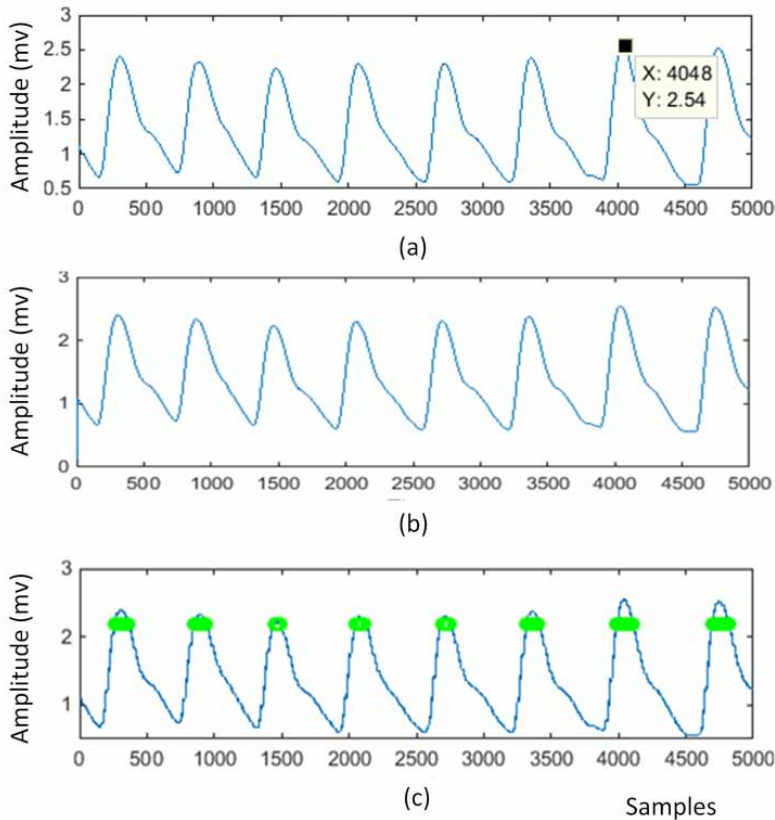


Figure 6. Acquired PPG signal by the PPG sensor attached to the patient's finger: (a) Raw PPG signal (b) Baseline drift removed PPG signal (c) Peak detection



## DISCUSSION AND FUTURE DIRECTIONS

To analyze the proposed method's performance, real-time PPG and respiration signals from the actual subject are used. The recordings are digitized at a sampling rate of 1KHz. The PPG sensor and piezo sensor are appropriately placed at the correct location of the human body. The respective signals are acquired for different patients, as shown in Figures 6 and 7. The Processed PPG signal retains the original PPG signal's main characteristics, as shown in Figure 6. The respiratory rate measurement technique is based on the stretch applied by the ribcage movements during inhaling and expiration. The belt consists of a piezo sensor to collect a respiration signal. The inhaling value is lower than the expiration value because, during inhaling, the chest volume increases and the pressure is increased. To perform the measurement, the piezoresistive sensor is used. That way, the pressure changes with the resistance due to the recorded chest volume, increasing or decreasing during the respiratory activity. The signal from the sensor is given to the controller for each breath it counts. Finally, the respiration and pulse peak counting algorithm consists of a soft threshold detector for counting the peak. The measured IV fluid level, pulse rate and respiration rate are then given to the controller. The program is executed, and the data is transmitted to the smartphone through the GSM module if the parameters exceed the threshold limit. Table 4 shows the comparative analysis done for the IV fluid level, pulse and respiration measurement. The results are compared and tabulated. From the processed PPG and respiratory signal, the total numbers of peaks for 60 seconds have been calculated.

Figure 7. Piezo sensor and wearable belt-based sensor set up for respiration rate measurement: (a) the sensor set up (b) acquired respiration signal

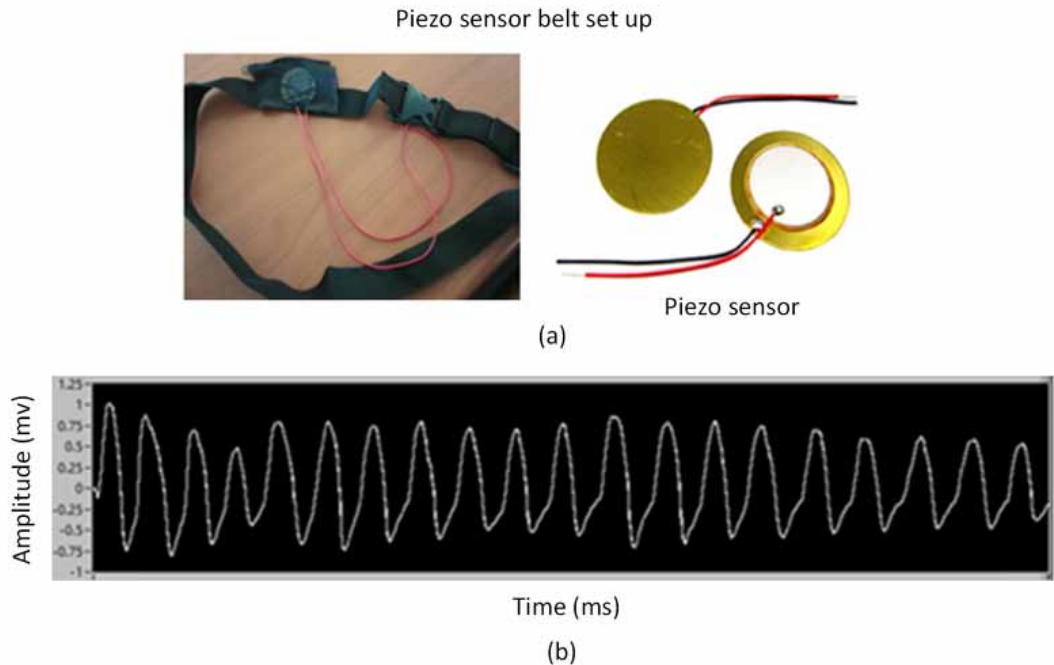
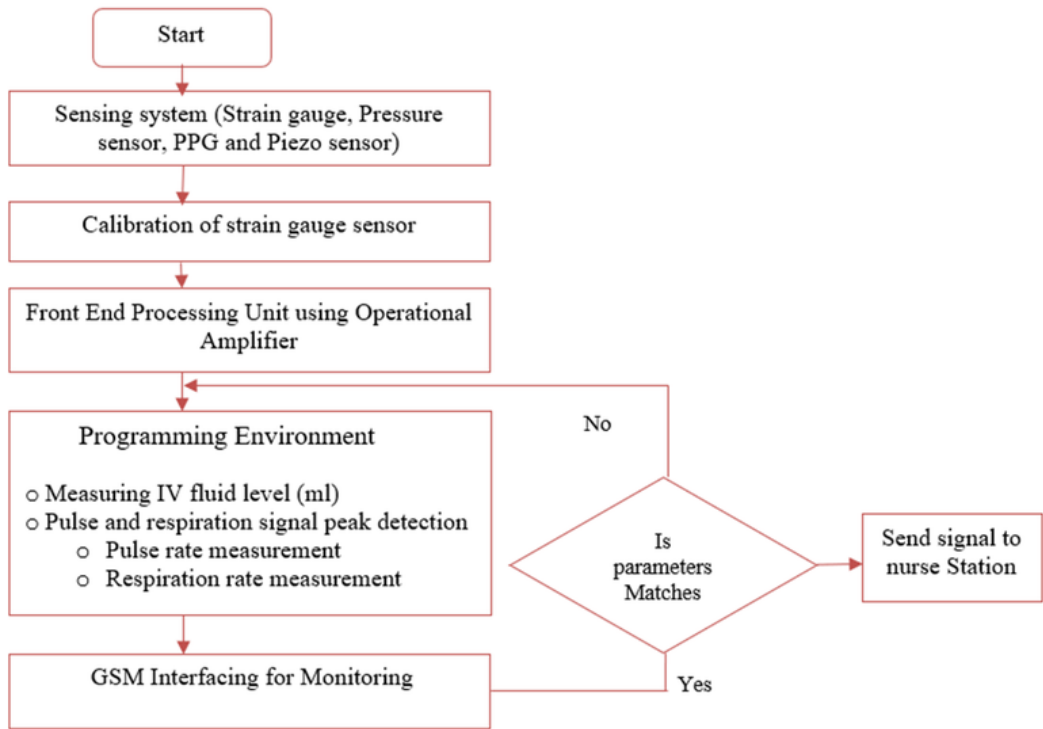


Figure 8. Process flow diagram for proposed Intravenous fluid system



It has been calculated as if the number of PPG peaks below 70 and exceeds over 100 is considered abnormalities, and for respiration signal, rises above 25 are considered exceptions. The fluid level with a corresponding voltage of 1.25 V is fixed as a threshold.

Using the proposed method, the pulse and respiration count and IV fluid level can be easily monitored. The parameters such as the pulse rate and respiration rate, and IV fluid level are transmitted to the caretaker using a GSM wireless module. Using this method, the patient feels more comfortable as the system can avoid repeated checking of the patient's health during pandemic situations. The applications might also be used regarding the PPG and respiration monitoring in ambulatory care.

Nowadays, caretakers need to constantly monitor the level of the saline bottle, pulse rate, and respiration of the patients. Due to the negligence of a nurse or staff, the saline bottle might not be monitored correctly, and blood will flow outward into the saline bottle due to the pressure difference between the patient's blood flow and the empty saline bottle. Improper physical monitoring will induce many health-related problems, including blood loss, backflow of blood from a vein, improper breathing, and reduced hemoglobin level and death.

From the results given in Tables 4 and 5, it was observed that the proposed implementation provides a solution in developing a smart wireless monitoring system that creates a communication link between the patients and the caretaker. With the biomedical sensors and wireless modules, the patient medical data can be easily acquired and communicated to the caretaker wirelessly. This arrangement can also be strengthened to visualize the real-time patient signal through cloud technology. In addition, the proposed concept can be integrated with a programmable controller to perform control actions.

However, the limitation of this study relates to the processing speed and size. Moreover, the calibration of the sensor needs to be repeatedly done for every patient. That can be avoided by designing a digital electronics circuit with a PCB design.

Recently, body channel communications play a leading role in healthcare networks for providing flexible communication. They create a communication link in the form of a wireless body area network.

## CONCLUSION

Physiological signal processing and feature extraction are used to determine the regular rhythmic activity of the human condition in the healthcare environment. This activity is recorded on monitors by the electrodes. The proposed method for monitoring the saline level is a low cost, low power, highly

**Table 4. Parameters measured from the Proposed System**

SNo	Pressure Sensor		Strain Gauge Sensor		PPG sensor	Piezo sensor
	Level(ml)	Volt (V)	Level(ml)	Volt (V)	Pulse rate	Respiration Rate
1	500	3.12	500	2.97	77	19
2	450	3.02	450	2.65	74	20
3	400	2.88	400	2.43	72	18
4	350	2.56	350	2.13	76	18
5	300	2.32	300	2.01	73	19
6	250	2.02	250	1.91	76	21
7	200	1.88	200	1.84	77	20
8	150	1.58	150	1.57	75	18
9	100	1.24	100	1.34	76	18
10	50	1.02	50	1.21	77	19

**Table 5. Comparison analysis of proposed monitoring system**

Ref	Sensor	Software	Hardware	Wireless module
S.Joseph et al. 2019	Level sensor	Embedded C	ATmega microcontroller	Bluetooth
V. Caya et al. 2019	Drip level sensor	Embedded C	Raspberry Pi Processor, Servo motor	Webserver
K. R. Rani et al. 2017	Pressure Sensor	Embedded C	Amplifier, Microcontroller	nrf24L01
S. Yadav et al. 2016	IR Sensor	Embedded C	ARM Cortex M3, Servo motor	Wi-Fi
Ray et al., 2019	Ultrasonic, IR sensor and Load cell	Embedded C	Atmega 328 controller	ESP8266 module
Rashid et al. 2017	Flow Sensor	Embedded C	Atmega 2560 controller	Bluetooth
Proposed method	Strain gauge, Pressure, PPG and Piezo sensors	LabVIEW / Embedded C	Atmega 128 controller	GSM

accurate and highly efficient system that can be used for the patient's safety at hospitals. It is fully automated and almost needs no external supervision, reducing the burden of the nurses and staff in hospitals, and minimizing errors, providing a reliable and highly efficient mechanism for medical use.

In conclusion, the proposed system could be used in a hospital environment to monitor the patient condition due to its accurate measurement of vital parameters. The results indicated that the system produced an average error percentage of 3.2% of the pulse rate and 4.3% of the respiration rate.

Finally, the proposed wireless monitoring system also facilitates the communication between the hospital and the patient's room through the GSM. This context can be used with the standard bedside patient monitor and healthcare centers in rural areas for continuously monitoring the physiological parameters.

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