Project Title: Development and Implementation of an Automated Locking System to Mitigate Retrograde Blood Flow in Intravenous Infusion Tube Configurations

BME 3200: Biomedical Systems Design Project

A project submitted to the Department of Biomedical Engineering in Third Year Second Semester

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DEDICATED TO MY MOTHER

ABSTRACT

Intravenous (IV) therapy is a common treatment practice in hospitals and clinics.However, one drawback of the intravenous infusion approach is the blood flowing backwards into the IV tube. The pressure difference between the drip and venous chambers causes the reverse flow. To mitigate the aforementioned issue, hospitals use a blood pressure cuff that is tied on the arm where the infusion is given. Backflow causes the cuff to expand. However, this approach requires constant surveillance, which becomes difficult when multiple patients need to be attended over simultaneously. Air embolism, or air bubbles entering the IV tubing, is another major issue. When the number of air bubbles exceeds the threshold, it must count and cut off the IV fluid flow.Although many automated systems have been developed to help physicians and patients monitor intravenous infusions, no system has been developed specifically for this use. Because of its affordability and ease of use, this locking system with an a solenoid valve and LED-LDR for air bubble detection and is accessible even in areas with limited resources.

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Chapter 1

Introduction

1.1 Introduction

Intravenous therapy (IV), also known as intravenous therapy, is a medical procedure where a patient has nutrition, drugs, and fluids injected straight into their vein. Using a syringe or catheter to provide medication or fluids is known as an infusion treatment. It is a method of administering medications that must be administered gradually or cannot be taken orally. Backflow, also known as regurgitation, happens when a valve only partially shuts. Instead of passing through the heart or into an artery, this causes blood to flow back into the chambers. The amount of blood that can move forward to your body's organs is limited by a significant blood backflow. Eventually, your heart will become larger despite its best efforts to compensate by pumping more blood through it.

An air or gas embolism is a bubble that becomes stuck in a blood vessel and blocks it. This can lead to a range of symptoms, depending on the location of the obstruction. It is among the main reasons why divers die. A blood artery obstruction brought on by one or more bubbles of air or another gas in the circulatory system is called an air embolism, sometimes referred to as a gas embolism. A venous air embolism can occur when an air bubble gets within a vein. An arterial air embolism occurs when a bubble of air enters an artery.Heart attacks, strokes, and respiratory failure can be brought on by these air bubbles getting into your heart, brain, or lungs. Air intake. Air embolism can be caused by a number of factors – most commonly diving – but certain medical procedures can also cause gas bubbles in the blood. The exact prevalence of air embolisms is not known; more minor cases may go untreated and can be without symptoms.

A method has been discovered to stop blood and air embolism from traveling backward.The load cell, amplifier module, solenoid valve, LCD display, Arduino microcontroller, LED, and LDR are the system's primary parts. The load cell continuously measures the bottle's weight, but the electric signal it produces is a little too faint for the microcontroller to read, so it needs to be amplified. This is done with a Hx711 module amplifier. The microprocessor then reads the increased signal. The bubble in the IV tube is located using LED and LDR.

1.2 Literature Review

Numerous investigations have been carried out and methods devised to facilitate the administration of intravenous infusions. The following is a list of the many techniques that have been employed in the studies:Alarm-based and RFID-based systems, respectivelyc) Detection by optical means d) Flow sensorse) Wireless sensors f) One-way valves.

a) Alarm-based systems: Research has suggested that an alarm-based system be used to monitor intravenous infusions [1, 2]. Jianwen et al. used photoelectric sensor technology in conjunction with a signal processing system to track and display the fluid's velocity and to sound an alarm in the event of an infusion process blockage or completion. SCM processing unit, data display module, sound and light alarm module, the locking module and wireless communication modules [3], [4]. In a study conducted by Shelishya et al., the system consists of slotted interrupter modules which are IR sensors used to monitor the flow of fluid in an IV tube. The sensor output is then given to an analog to digital convertor. This ADC output is then fetched by a microcontroller which is programmed to activate a voice module to alert the nurse on the end or blockage of an infusion process [5], [6]. Bhavasaar et al. emphasize intravenous liquid monitoring and alarm system using load cell as well as heart beat sensors. This method lowers the chance of

heart attacks and reduces the complications in IV therapy by monitoring the level of the liquid in the IV bag when the level drops below the set point and by sensing air bubbles formed in the catheter [1], [7]. Raghavendra et al. designed a system for detecting variations in light transmission between a LED and a photodiode placed around the drip chamber. This device displays the drip flow rate and also has an alarm system which indicates the deviation from the pre-set value [2], [8].

b) RFID based systems :RFID system uses tracker tag system, these tags consist of electronically stored information and the passive tag collects information from the nearby available RFID reader. In this technique the major components are load cell of s-type, drip bag weight scale, RFID/NFC tag reader, 6502microcontroller system. The load cell transforms the tension pulled by a drip bag, to weak electrical signal. Then the electrical signal is amplified and is filled into a 16-bit A/Dconverter. Finally, the tension is converted into 2-byte digital weight data. The two-byte data and five-byte RFIF data are packed as a data packet which is transmitted via UDP protocol to a data collector module of IV infusion monitoring system [9]. The RFID tag is designed and attached on the bag of intravenous drip. The tag is disabled when the bag is not empty because liquid contained [9]. Sometimes LAN (Local Area Network) has been used in the process of data transmission. Active tags have local power source and it may operate hundreds of meters away from the RFID reader [12].

c) Detecting optically : An appropriate electromagnetic signal, usually a step-like voltage pulse, is used to excite the system to be monitored in this case. The signal is propagated through a probe, and any fluctuation in impedance will produce a partial reflection of the signal as it passes through the probe. The propagating signal will partially reflect with any variation in impedance. The dielectric properties of the material being tested can be obtained by analyzing the reflection coefficient in the time domain, or ρ. as well as of its numerical properties, like the liquid material level in some cases [10], [11].When a liquid sample reaches a particular level, the difference in dielectric permittivity causes an impedance chance to arise at the air-to-liquid interface. As a result, there is a noticeable fluctuation in the observed reflection coefficient that can be utilized to identify the air-liquid boundary. Here, the non-invasive probe consists of two strip electrodes that are fastened to the outside of a container holding the medicinal liquid. Two adhesive copper strips measuring 3 mm in width and 3 mm apart were used to create the ad-hoc probe arrangement [11],[4].

d) Flow sensors: A piezoresistive flow rate sensor has been constructed and assembled. It was inspired by the hair cell sensor present in the fish lateral line system. The sensor has been fitted onto an intravenous tubing and glued to a 3D manufactured fixture. It is noted how the sensor reacts to flow rates ranging from 100 ml/h to 500 mL/h. An experimental setup was used to examine the flow rate, which is managed by a peristalstic pump. The sensor exhibits stable phase responses in addition to transient phase responses [11], [12].

e) Valved one way

Many medical devices use one-way valves, often known as non-return valves (NRVs).as a way to stop intravenous infusion backflowas well as a way to stop the pollution of the fluids that patients receive by infusion [14], [15]. These valve are specifically made to permit only a certain direction of flow (DDF) [15] and is typically resilient high reverse pressure levels prior to failure [14]. But two research projects [14], [15] that looked at these valves have demonstrated that they are not reliable as a way to stop backflow or as an infection command.Ellger et al.'s study [15] looked at five several NRV models and examined them for rising pressure levels against DDF .

1.3 Our Approach

Following a thorough assessment of all relevant variables, such as cost-effectiveness and key performance indicators (KPIs), a solenoidal valve and LED-LDR solution were chosen as the means of accomplishing flow control and bubble detection.

Chapter 2
Background Study

2.1 Introduction

Intravenous therapy is the process of directly injecting medication, intravenous solutions, blood, or blood products into a vein.A backflow occurs when blood flows through the heart or blood vessels in the incorrect direction.An air embolism occurs when one or more air bubbles block an artery or vein. It is sometimes referred to as a gas embolism1.

2.2 Purpose

The nurse must keep an eye on the patient after inserting the IV to ensure that the recommended dosage is being administered. Additionally, whether or not the patient's blood volume is at the proper level to avoid blood backflow determines how well the patient will fare, which can be challenging in areas with few resources. The most crucial thing to keep in mind is that air or bubbles should never go inside an artery or vein.All of these characteristics can be guaranteed by an automated system, protecting the patient from the dangers of air embolism and blood backflow. There are occasions when our elderly relatives require constant observation while receiving IV therapy. Our idea offers an excellent way to keep an eye on the IV bag's condition as well.

2.3 Motivation

The technology is quite intuitive and easy to use.A therapist can set an IV without experiencing any stress by employing this approach.Before anything bad happens, this device will notify the nurse. Chemotherapy can be administered efficiently with periodic therapy in particular.The system will notify the caregiver by buzzer. The IV fluid supply can also be stopped remotely and also the limit of saline can be determined remotely.

Chapter 3
Methodology

The main purpose of this project is to prevent air embolism and stop the backflow of blood.

3.1 System Design Architecture

The system operates in two ways-

- First it detects the weight of the bottle by load cell and
- Then detect the air flowing through the tube by LED-LDR
- If the weight drops down to a minimal value then the OLED display will show it .if the value is below 50g then it will show warning in app, otherwise will show ok.
- And if the air pass through the tube which is detected by the LED-LDR system and we get a Serial Value in A0 pin of the Arduino.
- .If both output satisfies the condition then the channel relay will show green light .But previously it will always show red light.
- There is also a system for Wirelessly controlled the valve using APP interface built in MIT App Inventor

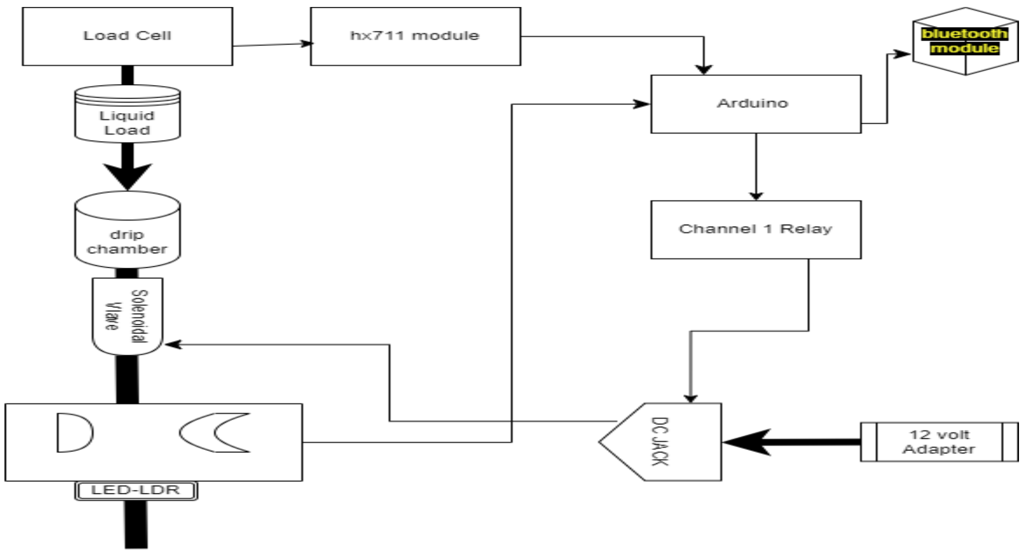

Fig. 3.1.1: Architecture diagram of the system.

3.2 Algorithm and Flowchart

The software platform used is the Arduino UNO. A LCD display will show the results.

3.2.1 Algorithm

- STEP 1: Start IV transfusion.
- STEP 2: If the bottle weight is lower than threshold level and the value of IR greater than threshold ,then will stop the flow.

3.2.2 The Flowchart

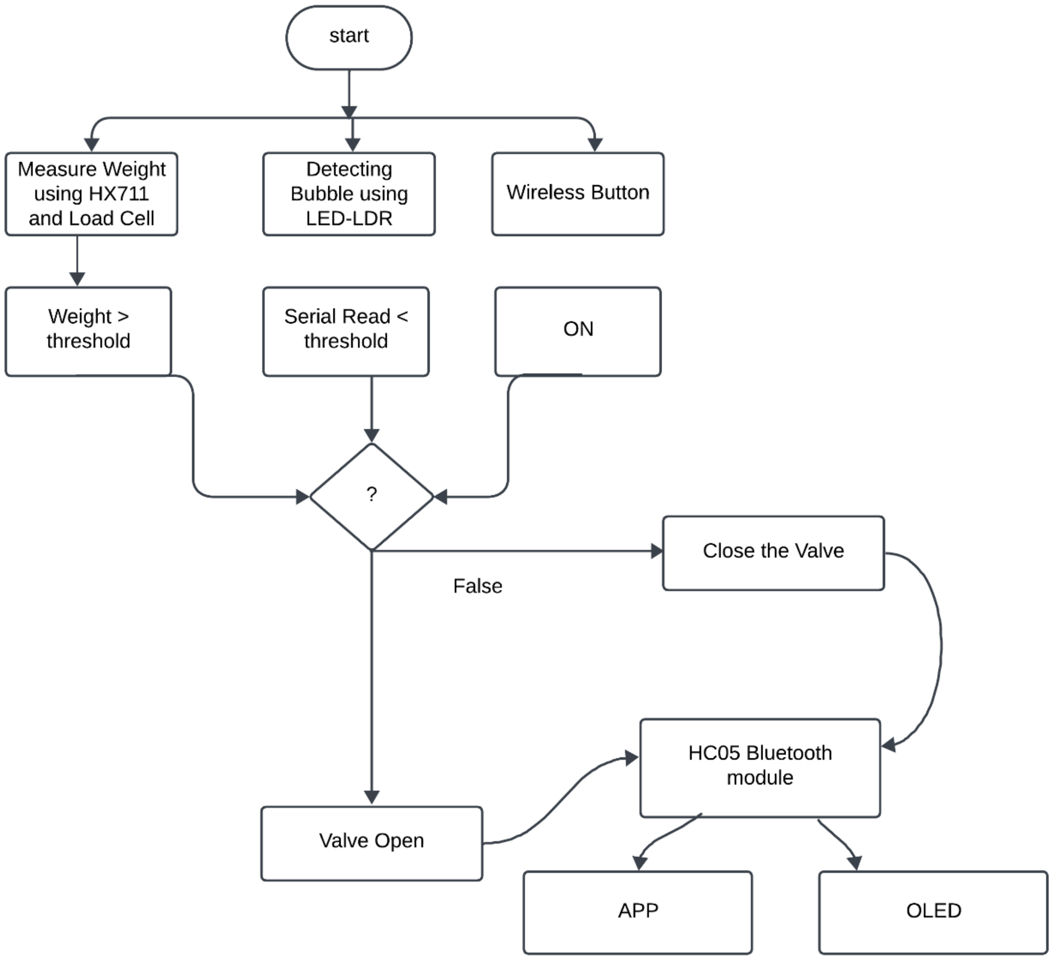

Fig. 3.2.2.1: Flow chart of the control program

Chapter 4
Experimental set-up

Blood embolism and backflow of blood block unit. It prevents blood and air from returning to the vein.

4.1 Components

- Arduino UNO
- Solenoid Valve
- Load Cell
- Hx711 amplifier module
- Channel relay
- Dc jack
- LED
- LDR
- 12 Volt Adapter
- OLED display
- Bluetooth Module
- Male to female jumper wire

4.1.1Arduino UNO:

The microprocessor serves as both the valve's controlling element and the hub for all hardware components. As seen in Figures 6 and 7, the solenoid valve and sensors in this configuration are interfaced with an Arduino microcontroller. A microcontroller board based on the ATmega328P datasheet is called the Arduino Uno. It contains six analog inputs, an ICSP header, a 16 MHz quartz crystal, a power jack, a USB port, nearly 14 digital input/output pins (six of which can be used as PWM outputs), and a reset button [8]. The Arduino has the functionality required to support the microcontroller; to get it going, just plug it in using a USB cable to a computer, or power it using a battery or an AC-to-DC adapter. In comparison to other controllers, it is affordable, has a wide range of sensor interfaces, and is simple to use. It maximizes power consumption because it also has a comparatively low operating voltage. The signal from the amplifier module, which is equal to the IV bag's weight, is read by the microcontroller. The solenoid valve is activated and the IV tube is locked by the microcontroller if the value falls below a predetermined threshold.

Fig. 4.1.1: Arduino UNO

4.1.2 Solenoid valve

In this configuration, the solenoid valve, an electromechanical device, is employed to lock the tube when the right circumstance occurs. This valve features a ferromagnetic plunger and an electric coil known as a solenoid. A magnetic field is produced when the valve is turned on by the electric current flowing through the coil. The coil opens when the plunger is drawn in the direction of its center. To keep the solenoid valve in the pull-in state while it is closed, a reduced current must be provided to it. This lowers the calorific value and energy consumption while simultaneously improving the turn-off responsiveness and turning down the turn-off time [15]. Solenoid valves are available in operating voltages of 5, 12, and 24, 110, and 220 volts. For thiN system, a 12-volt valve has been used. The solenoid valve was chosen not only due to its' wide variety of applications in the medical device industry such as in oxygen concentrators, drug-delivery systems, and dialysis machines to control blood flow but also due to a list of other benefits including energy efficiency lightweight and compact nature, cost-effectiveness and reliability.

Fig. 4.1.2: Solenoid valve

4.1.3 Load cell

A load cell was utilized to determine the IV bottle's weight. Here, it has been converted to analog data via the load cell module and sent to the microcontroller [13].A load cell is a type of sensor that produces an electric signal in response to the tension an object suspended from it applies to it [14]. Load cells range in capacity from 400g to 40 kilogram. The IV bottle in this setup is suspended above the load cell. The calibration factor of the load cell is a parameter that must be set appropriately to determine the stability and accuracy of the recorded values.

Fig. 4.1.3: Load cell

4.1.4 Hx711 amplifier module

The load cell and the Hx711 amplifier module are utilized in tandem, and the microcontroller is directly integrated.Because of the load cell's weak signal, a microcontroller cannot directly read it. As a result, it needs to be amplified, which is where the Hx711 module is useful. In addition, it converts the analog signal that is received from the two-weight sensors into a digital signal that is supplied to the microcontroller, acting as an analog-digital converter [15]. The microprocessor receives the boosted signal from the amplifier module and processes it further.

Fig. 4.1.4: Hx711 amplifier module

4.1.5 Channel relay

A probability model of communication between a sender and a recipient with the assistance of one or more intermediary relay nodes is called a relay channel. An electronic device is an eight-channel relay module. Actually, these come with switching and isolating parts in addition to eight 5V relays. In addition, it has eight terminal blocks, each of which shares two relays.

Fig. 4.1.5: Channel relay

4.1.6 Dc jack

A DC jack exists for the purpose of supplying direct current to a device from an external source, as opposed to the batteries inside the device.

Fig. 4.1.6: Dc jack

4.1.7 LED (GREEN)

When an electric current flows through a green LED (Light Emitting Diode) bulb, it emits light in the green spectrum, which is typically between 520 and 570 nanometers. LEDs that produce green light are semiconductor devices that use the motion of electrons in the semiconductor material to produce light. Compared to conventional lighting sources, they are more energy-efficient, need less electricity, and last longer. Green LEDs are used in many different applications, such as decorative lighting, electronic displays, and indicator lights. The lighting sector is seeing an increase in their use because of its adaptability to different design and functional requirements, minimal heat output, and capacity to generate particular green light wavelengths. In addition, there are environmental advantages including lower energy use and longer lifespans.

Fig. 4.1.7: Green LED

4.1.8 LDR

A unique kind of resistor known as an LDR (Light Dependent Resistor) operates on the basis of the photoconductivity principle, which asserts that resistance varies with light intensity. When the intensity of the light increases, so does its resistance.

It is frequently utilized in situations where light sensitivity is required as a light sensor, light meter, automatic street light, and other applications. A light sensor is another name for an LDR. LDR typically come in dimensions of 5 mm, 8 mm, 12 mm, and 25 mm.The light-dependent resistors, which are arranged in a Zig-Zag pattern as seen in the picture below, are built of photosensitive semiconductor materials such as cadmium sulphides (CdS), lead sulphide, lead selenide, indium antimonide, or cadmium selenide.

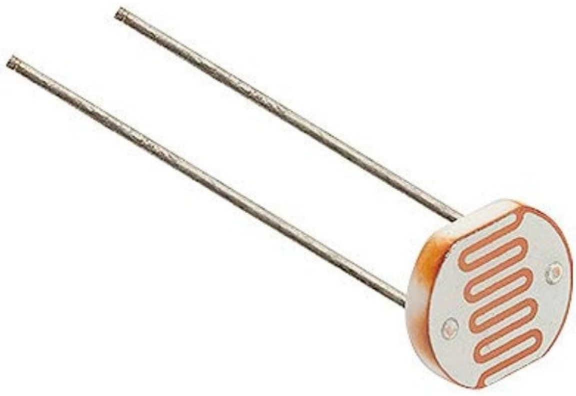

Fig. 4.1.8: LDR

4.1.9 12 Volt Adapter

One of the most widely used power sources in use today is the 12V power supply, also known as the 12VDC power supply. Generally, a mixture of transformers, diodes, and transistors is used to convert a 120VAC or 240VAC input into a 12VDC output. There are two kinds of 12 volt power supplies: regulated power supplies and unregulated power supplies.There are three types of 12V regulated power supplies: Linear regulated AC to DC, Switching regulated DC to DC, and Switching regulated AC to **DC.**

Fig. 4.1.9: Adapter

4.1.10 OLED Display

The Organic Light-Emitting Diode, or simply OLED, is the technology used for the screen in the Arduino Sensor Kit. The OLED uses an organic, carbon based material for emitting light. When electricity is applied to this material, it emits light. The Grove OLED display 0.96" module's behavior can be controlled by using the **Arduino_SensorKit** library.

Fig. 4.1.10: OLED Display

4.1.11 Bluetooth Module

Numerous consumer applications, including wireless headsets, game controllers, mice, keyboards, and many more, make use of it. Depending on the transmitter and receiver, atmosphere, geographic location, and urban settings, its range can reach less than 100 meters. The established IEEE 802.15.1 protocol is what allows one to create a wireless Personal Area Network (PAN). It transmits data over the air using frequency-hopping spread spectrum (FHSS) radio technology.For device communication, it employs serial communication. It uses the serial port (USART) to connect with the microcontroller.

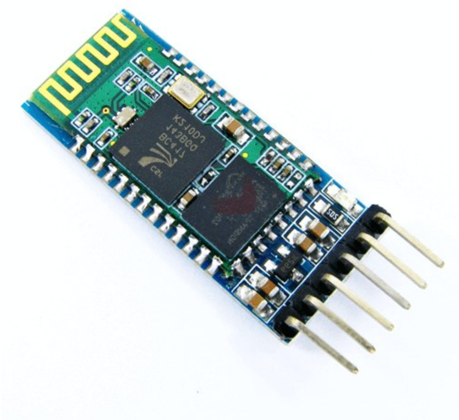

Fig. 4.1.11: Bluetooth Module HC05

4.1.12 Buzzer

The piezo, sometimes referred to as the buzzer, is a part that produces sound. When the output is HIGH, this digital component—which can be coupled to digital outputs—emits a tone.

Alternatively, it can produce a variety of tones and effects by connecting to an analog pulse-width modulation output. The Grove Buzzer has an 85 dB sound output and runs at both 3.3V and 5V. This module can be used to give your application audio feedback that sounds like a digital watch button clicking**.**

Fig. 4.1.11: Buzzer

Chapter 5

Implementation

5.1 Load Cell Attachment

For implementing the load cell following steps are considered.

1. Connect the +5v pin of Arduino UNO to breadboard.
2. Connect the VCC pin of Hx711 amplifier to +5v pin from the breadboard.
3. GND pin of Hx711 amplifier to Arduino UNO GND pin.
4. Connect the Hx711 module's Data (DT) pin to Arduino digital input pin 2.
5. Connect the Hx711 module's Clock (SCK) pin to Arduino digital input pin 3.
6. The load cell's red wire connects to the E+ of Hx711 module.
7. The load cell's black wire connects to the E- of Hx711 module.
8. The load cell's white wire connects to the A- of Hx711 module.
9. The load cell's green wire connects to the A+ of Hx711 module.

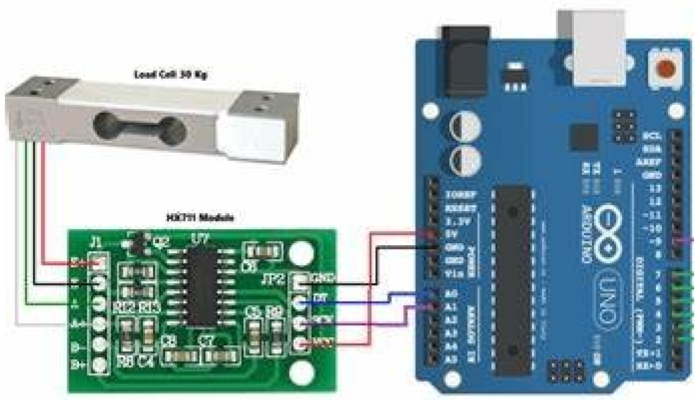

Fig. 5.1: Interfacing load cell and Hx711 amplifier module with Arduino UNO

5.2 channel relay Attachment

For implementing the Servo motor the following steps are required.

1. Connect the 1 channel relay GND pin to Arduino GND pin.

2. Connect the 1 channel relay VCC pin to +5v pin of breadboard.

3. Connect the 1 channel relay INPUT pin to digital pin 9.

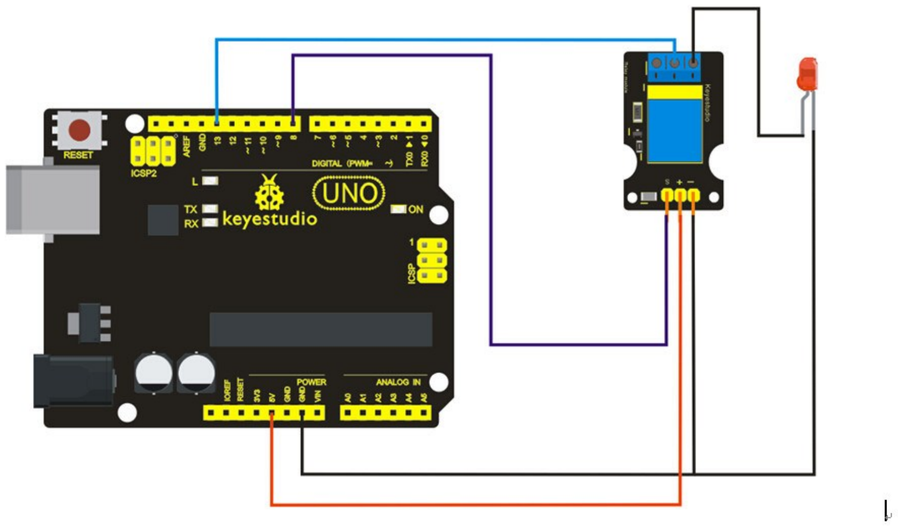

Fig 5.2: channel relay Attachment with aurduino UNO

5.3 I2C Embedded OLED Display Attachment

For implementing the Servo motor the following steps are required:

1. GND is connected to Arduino GND.

2. VCC is connected to the 5V output of the Arduino.

3. SDA is a Serial Data Pin, and is connected A4 pin of Arduino UNO.

4. SCL is a Serial Clock pin and connected to A5 pin of Arduino UNO.

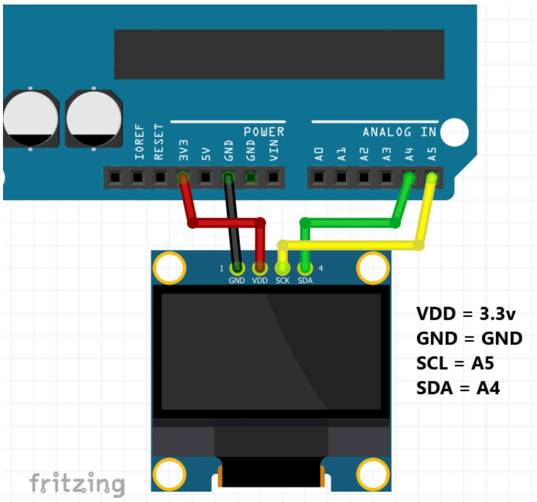

Fig 5.3 : I2C Embedded OLED Display Attachment with Arduino UNO

5.4 Solenoid valve

For implementing the Servo motor the following steps are required:

1. GND is connected to 1 channel relay GND.

2. VCC is connected to the 12V output 1 channel relay.

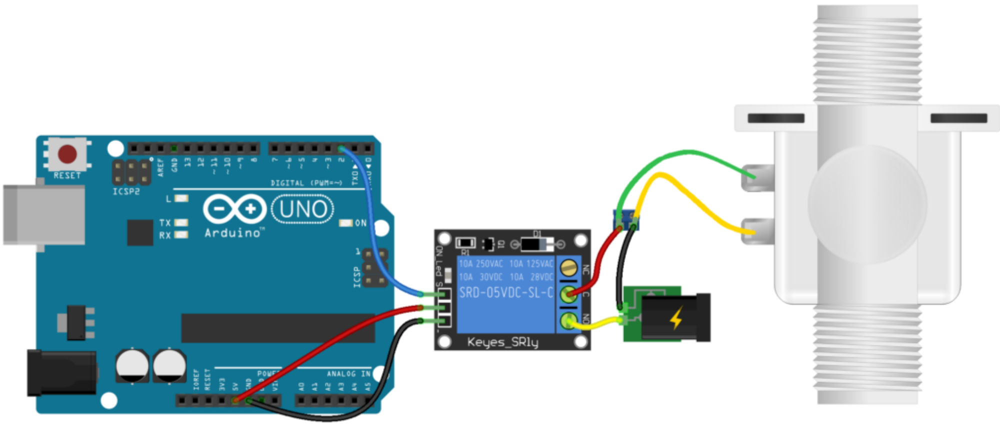

Fig 5.4 :Solenoid valve with relay and Arduino UNO

5.5 LED-LDR

For implementing the Servo motor the following steps are required

1.LED anode is connected with VCC across the resistor 100 ohm

2.LDR is connected with another 10k ohm resistor.

3.LED cathode is connected to GND

4.One end of LDR is connected to VCC

5.Last end of 10k ohm resistor is connected with GND

6.The Value is captured in between the LDR and 10 k Ohm

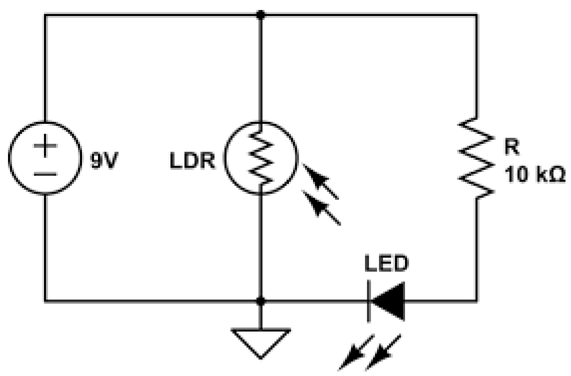

Fig 5.5 :LED and LDR connection

5.6 Implemented Device

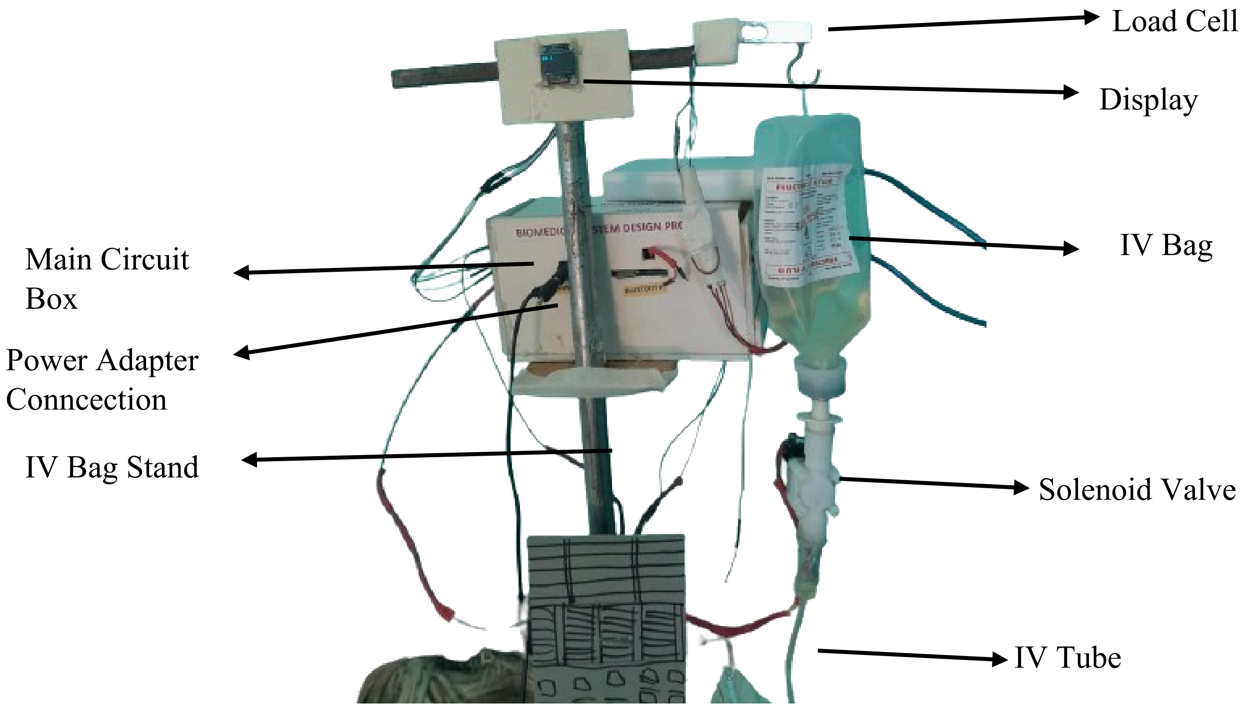

Fig 5.6.1 :Complete Setup

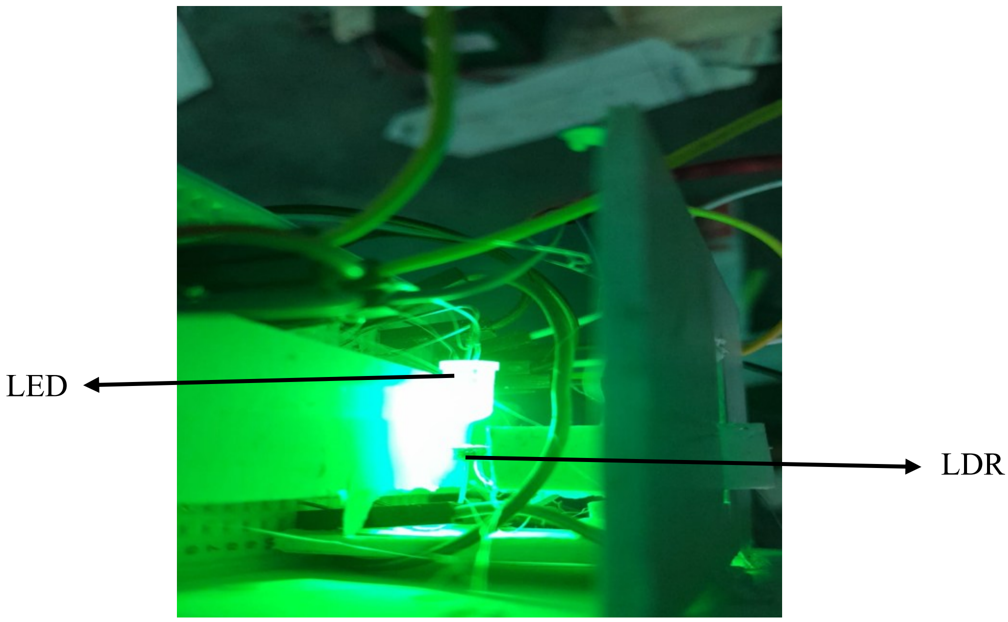

Fig 5.6.2 :LED-LDR Setup

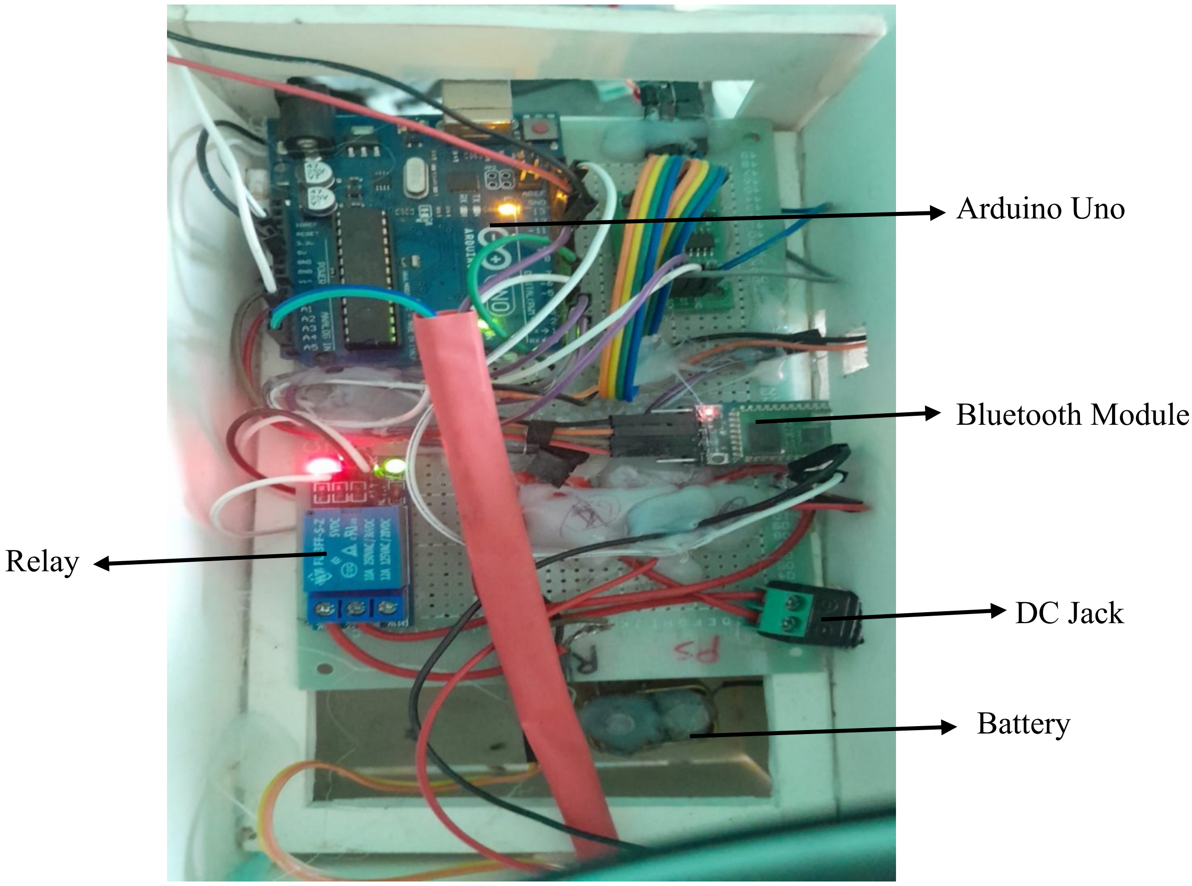

Fig 5.6.3 :Main Circuit Board

5.7 App

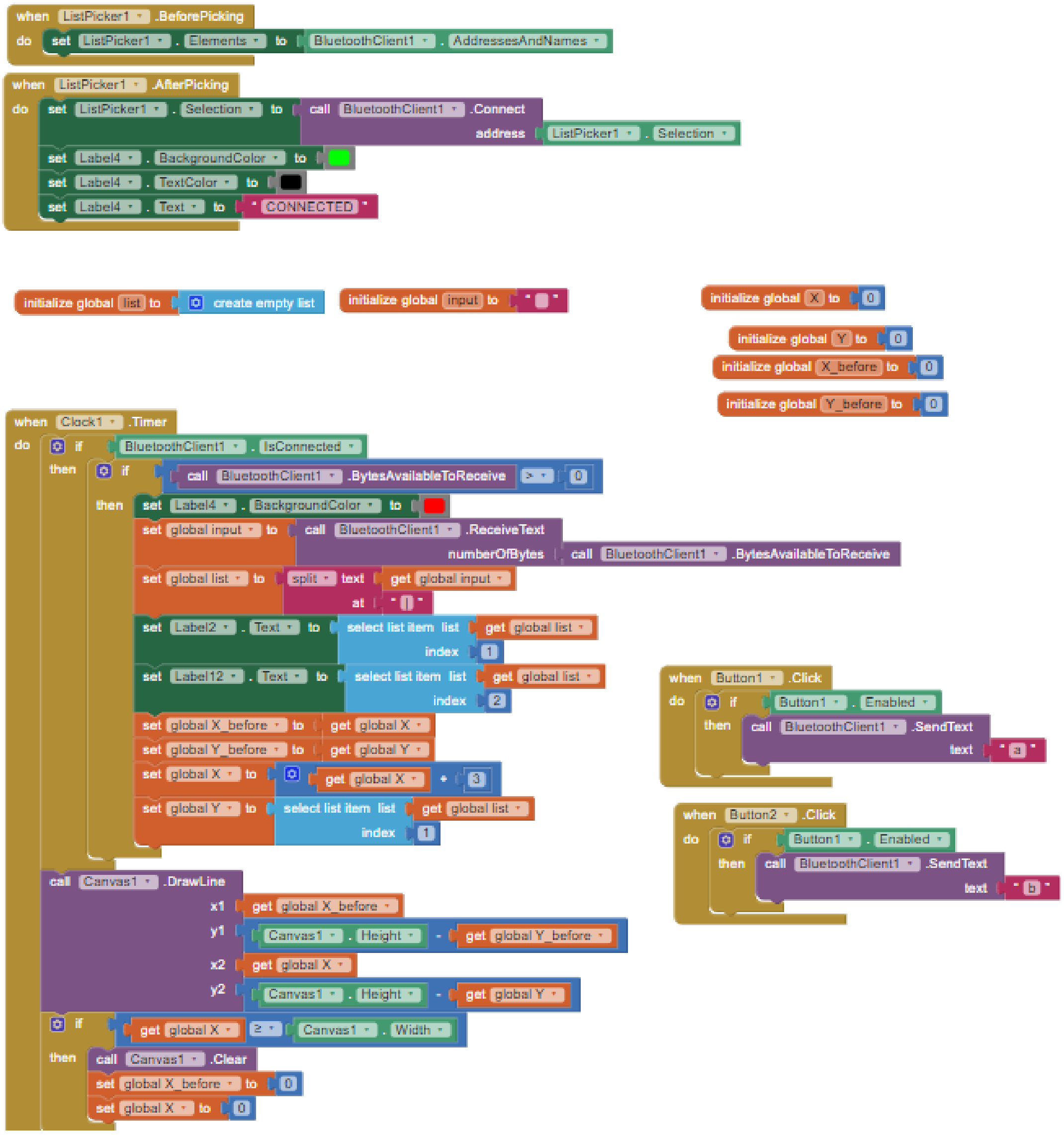

Fig 5.7 :Logic blocks for App

Chapter 6

Results and Discussions

6.1 Results

For the analysis here two different condition is set.

Table 6.1.1: Records of IV bag weight and Bubble detection using LED-LDR

Threshold set : >30 lbs & >10 LED-LDR Serial Read(1= ON ,0=OFF)

no	**Recorded in IV bag**	LED_LDR value	Result
1	33.1	11	1
2	33.0	11	1
3	32.9	11	1
4	32.5	12	1
5	31.5	12	1
6	31.0	10	0
7	30	9	0
8	29.8	12	1

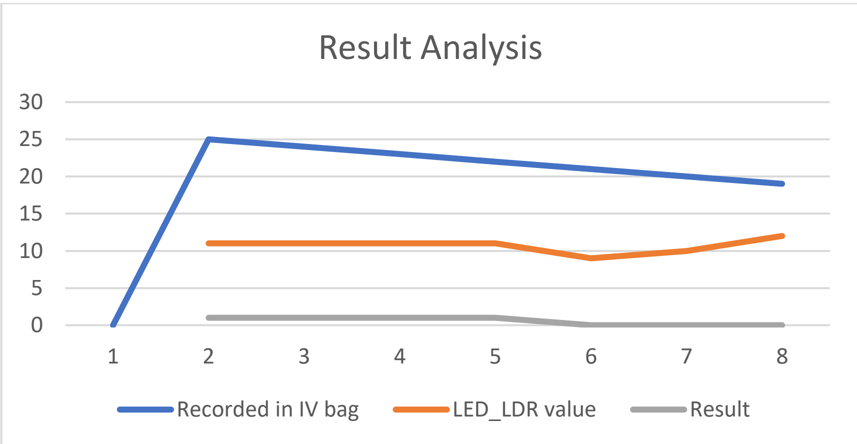

Fig 6.1.1 :Result Analysis for First Conditional Approach (X axis= Observation ; Y axis= value)

Table 6.1.2: Records of IV bag weight and Bubble detection using LED-LDR

Threshold set : >20 lbs & >9 LED-LDR Serial Read(1= ON ,0=OFF)

no	**Recorded in IV bag**	LED_LDR value	Result
1	25.0	11	1
2	24.0	11	1
3	23.0	11	1
4	22.0	11	1
5	21.0	9	0
6	20.0	10	0
7	19.0	12	0

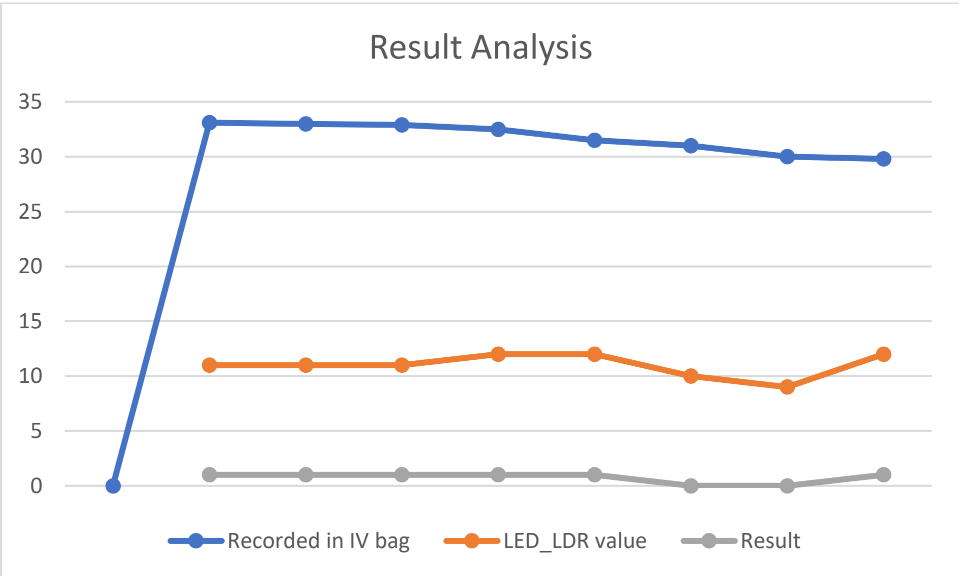

Fig 6.1.2 :Result Analysis for Second Conditional Approach(X axis= Observation ; Y axis= value)

Table 6.1.3: Thresholding of LED -LDR Setup

no	Manual Observation	LED_LDR Threshold	Detection
1	1	12	0
2	1	11	0
3	1	10	0
4	1	9	1
5	1	8	1
6	0	7	0
7	0	6	0

(1=Bubble Detected ; 0=Not detected)

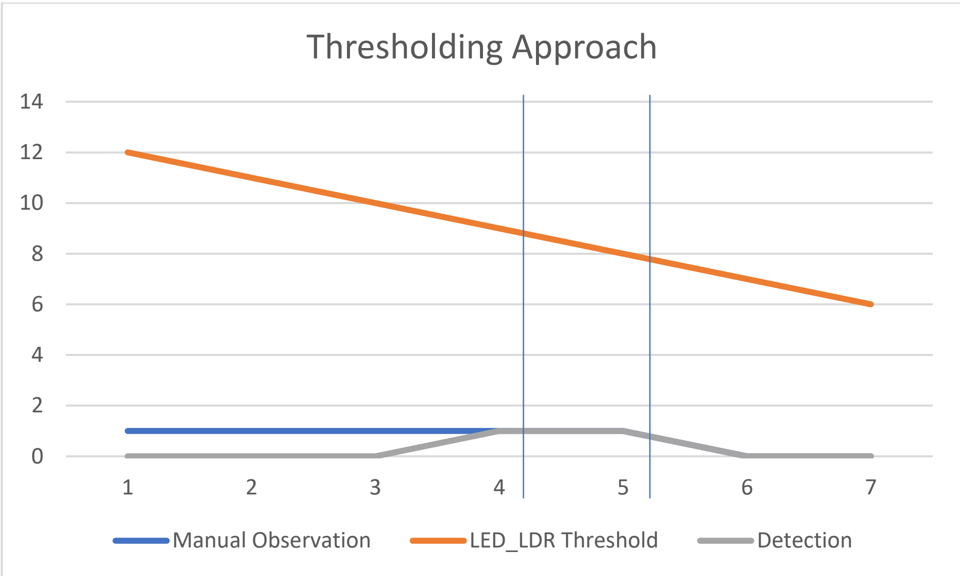

Fig 6.1.3 :Threshold Selection for LED-LDR Bubble Detection (X axis= Observation ; Y axis= value)

So the Perfect threshold for Detecting bubble will be **<9.** This is actually the value of analog serial read of Arduino.

Table 6.1.4: Performance Checking of LED -LDR Setup

(1=Bubble Detected ; 0=Not detected)

no	Manual Observation	Detection
1	1	1
2	1	1
3	0	1
4	0	1
5	0	1
6	1	1
7	1	1
8	1	1
9	1	1
10	1	1
11	0	1
12	0	1
13	0	0
14	1	0
15	1	0
16	1	1
17	1	0
18	0	0
19	0	0
20	0	0

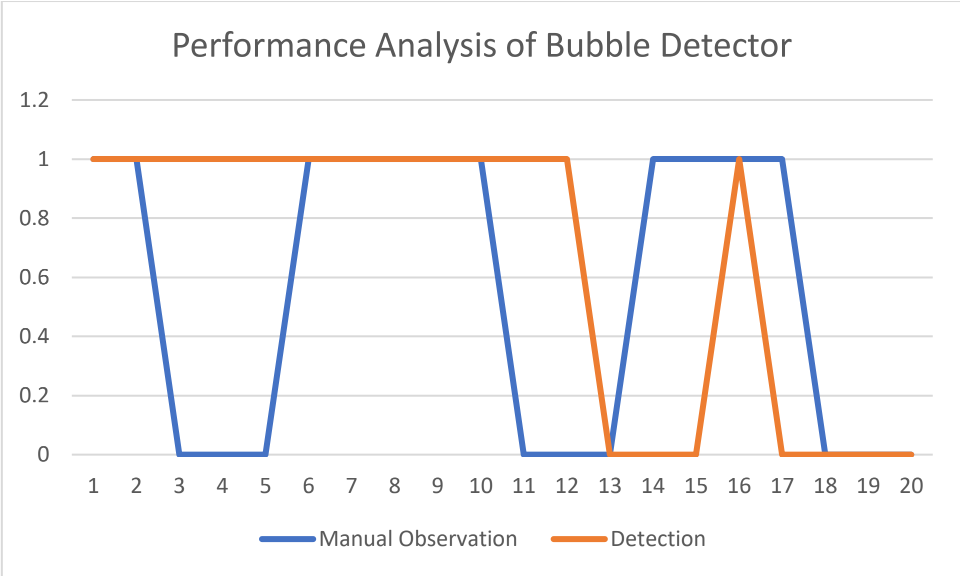

Fig 6.1.4 :Performance Curve of LDR Bubble Detection (X axis= Observation ; Y axis= value)

The accuracy $= \frac{\sum Matched\ value}{Total\ Value} * 100\ \% = \frac{13}{20} * 100\% = 65\%$

(Here the human observation error is ignored for simplicity **)

Table 6.1.5: Performance Checking of Load Cell

no	Manual Observation(g)	Acquired Result (g)	Error
1	100	100.150000000000	0.150000000000006
2	99	99.1300000000000	0.129999999999995
3	98	98.1500000000000	0.150000000000006
4	97	97.1700000000000	0.170000000000002
5	96	96.2100000000000	0.209999999999994
6	95	95.2100000000000	0.209999999999994
7	94	94.3200000000000	0.319999999999993
8	93	93.2200000000000	0.219999999999999
9	92	92.2200000000000	0.219999999999999
10	91	91.1000000000000	0.0999999999999943

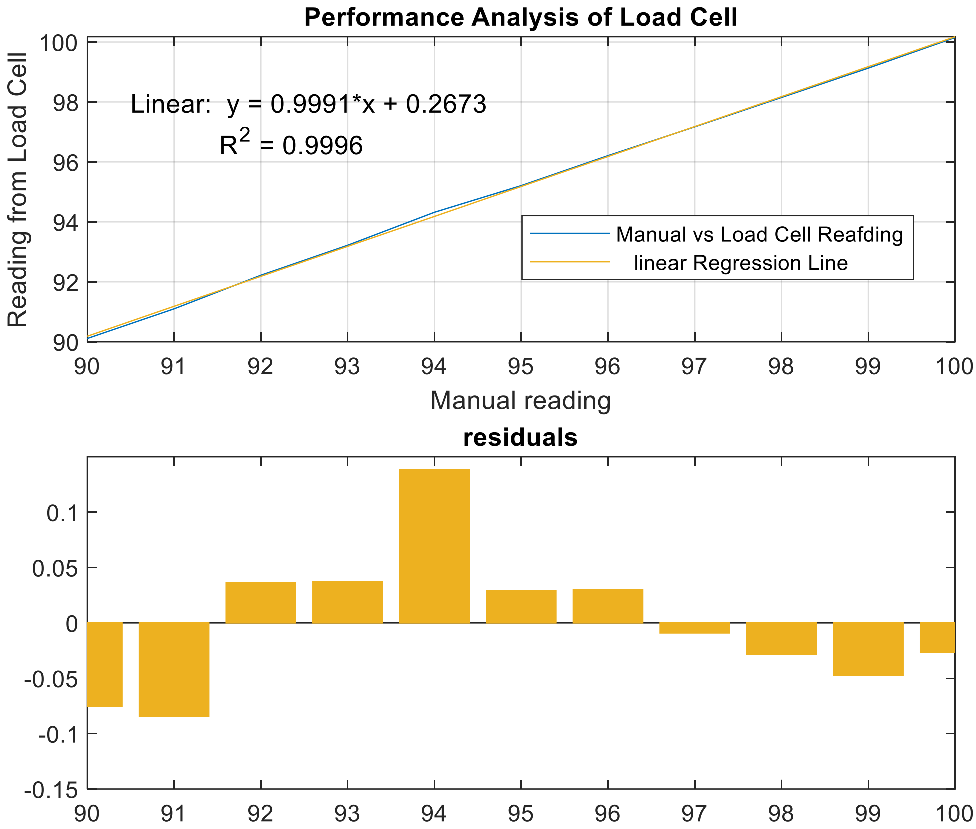

Fig 6.1.5 :Performance Analysis of Load cell using Regression Model Between Load Cell Reading Vs Manual Reading

The accuracy $=1-\frac{\sum error}{10}*100\ \% =1-\frac{1.99}{10}*100\% = 80.1\%$

So the Overall accuracy of the designed system can be calculated by the law of probability.

P(accurate result for an attempt)=1-(1-P(load Cell))(1-P(Bubble Detector))

P(accurate result for an attempt)=**0.9305**

So the Accuracy of the system is =**93.05%**

Table 6.1.6: Response Time for Relay Channel

(charted by keeping on/off time using stop watch manually)

no	Time(ms)
1	4.45
2	4.5
3	4.5
4	4.7
5	5.3
6	5.2
7	4.7
8	4.5
9	4.6
10	4.8

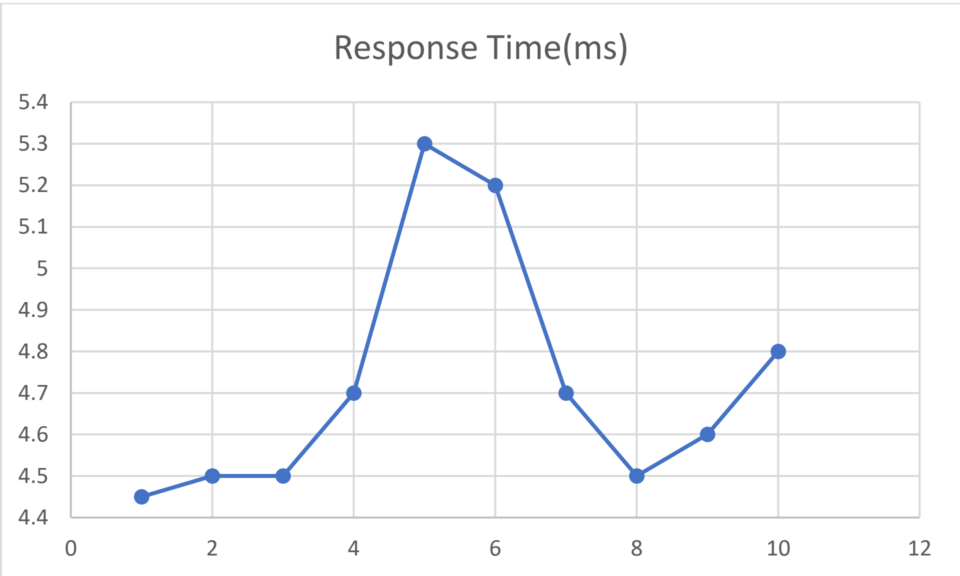

Fig 6.1.6 :Response Time of Relay Switching for Pump (X axis= Observation ; Y axis= value)

Table 6.1.7: Power Consumption Rating

Component	Power needed(Watt)
Arduino Uno	0.29
Bluetooth Module	0.20
Relay	0.35
Solenoid Valve	16
Load Cell	0.008
Hx711 Amplifier	0.008
Green LED	0.1
LDR	0.1
Total	17.146
Unit	0.411 per day

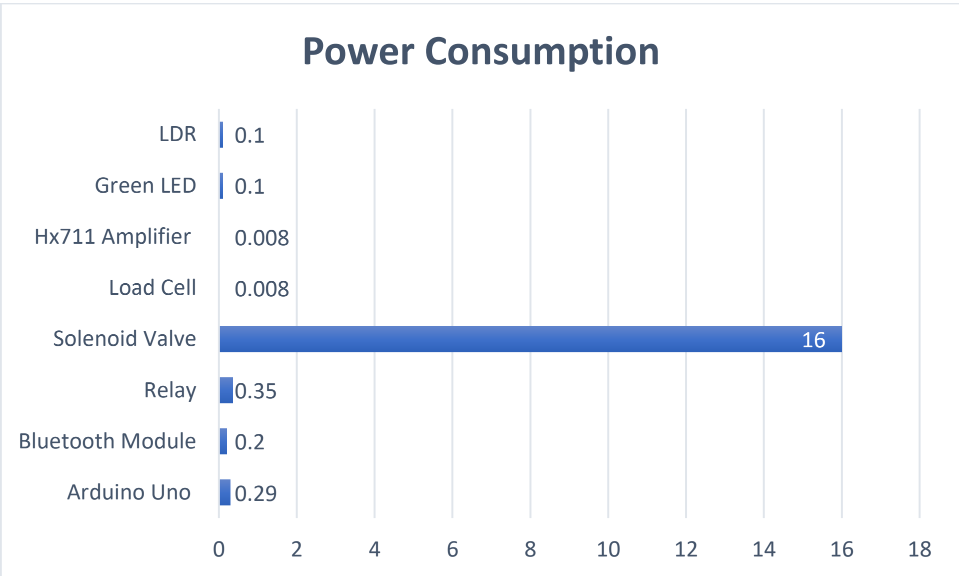

Fig 6.1.7 :Component wise Power Consumption of the System (X axis= watt ; Y axis= component name)

Discussions

When the criterion is not met, the solenoidal valve can be stopped by the system thanks to its design.Two distinct thresholding systems are applied here. One measures the IV fluid weight, while the other measures the LED and LDR value serial read threshold. While the bubble detector provides **65%** accuracy in detecting bubbles via the tube, the load cell provides **80.1%** accuracy in detecting the ideal load of the saline bag.Combining all of the probabilities to obtain an accurate result on a single try yields an overall accuracy of **93.33%** for the system.The avergae response time less than **5** milli second which is bound in the expectation.

Load cell shows some fluctuating result due to the higher sensitivity of the noise .The bubble detector provide a very low accuracy compare to the medical grade device.The reason of this fall in accuracy is that the interfering noise of ambient light of the room. Another problem is that the part of the system is not compact or closed perfectly.Another reason is that the tube is not perfectly attached in between the LED-LDR.Again,the serial read is done with **100**ms cycle.So the period of the reading also shows inaccuracy due to the time constant of the circuit.The pre-setting of threshold should be more precise.

The implemented system has another drawbacks in wire management.A proper and good wiring also be better for providing better result and accuracy of the system.A fine part of the system is that it has a good portability.More flexible portability will make a good way of handling in medical staffs or household caregivers.

The circuit size can be reduced using smaller microcontroller ,PCB board and proper wire wrapping .

The power consumption total is **0.411 unit per day**. So if any hospital has 250 bed and 25% of the bed has the continuously using this system the total power consumed for 1 year will be cost additionally 63.321 K taka. If the total patient helped by the system (assumed10 patient/per bed/per day) is 630 then the cost per patient will be 100 taka additionally.But in return the patient and caregivers will be free-from the mental tension of blood back flow through the tube.

Chapter 7

Conclusion and Future Work

7.1 Conclusion

The system can be implemented in hospitals as well as homes .The system proposed in the project is very simple and easy to use and implement.And it is also a budget friendly System.By using this system,the nurse or the caregiver can easily complete their other works without stress.so,it can be said a effective system.

7.2 Future Work

- In future,the system will be use at clinics and homes for patients by the clinician or caregiver with necessary accuracy of the system.
- Bubble detection sensor will be upgraded to the level of medical grade.
- App UI/UX will be updated for patient/not-tech people friendly.
- A sensor which can detect desired percentage of the medicine constituents of the solution to ensure quality of medication.
- The UI can be developed to track any bubble or complexity regarding pressure difference, thus let the clinician know every single detail of the therapy procedure.
- Some other detectors can detect the blood and air.

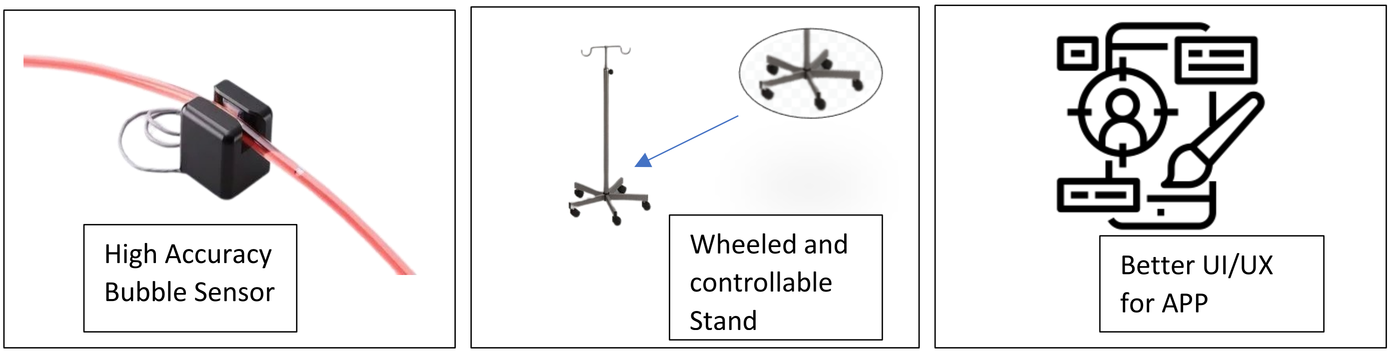

Fig 7.2. : Some Future Upgradation

References

[1] Kalaiselvi, T., Bhavasaar, M., Nithya, M., Praveena, R., and Bhuvaneswari, N. (2016).automated system for monitoring and alerting intravenous fluids. 2016 IEEE Technology Innovations in ICT for Rural and Agricultural Development (TIAR) Conference.

[2] Raghavendra, B., Vijayalakshmi, K., &Arora, M.(2016). Intravenous drip meter & controller.2016 8thInternational Conference on Communication Systems and Networks, COMSNETS 2016, 1–5.

[3] Shishya, R., Suma, S., & Jacob, R. M. R. (2015).A system to prevent blood backflow in intravenous infusions. ICIIECS 2015 - 2015 IEEE International Conference on Innovations in Information Embedded and Communication Systems, 3–6.

[4] Ambesh, P., & Ambesh, S. P. (2015). A simple technique to prevent reverse flow of blood from intravenous line in ipsilateral arm with noninvasive blood pressure cuff. Journal of Clinical and Diagnostic Research, 9(9), UL01.

[5] Chen, K. Y., Tu, S. C., Chen, F. G., Wang, J. Y., and Chen, S. (2015). An injectable infusion monitoring system that is ready to use. ACIT-CSI 2015, 278–281, Proceedings of the Third International Conference on Applied Computing and Information Technology and the Second International Conference on Computational Science and Intelligence.

[6] Jianwen, C., & Han, Z. (2011). Design of intravenous infusion monitoring and alarm system based on wireless communication technology. 2011 IEEE International Conference on Mechatronics and Automation, ICMA 2011, 130–134.

[7] Keerthana, K., Shree Vidhya, S., Janaki, M.,&Kanimozhi, J., (2019). A Survey of Systems used in the Monitoring and Control of Intravenous Infusion. International Journal of Engineering and Technology, 11(1), 114-119.

[8] C. F. Huang and J. H. Lin (2011). an RFID-based warning system for injection fluid depletion. The IEEE Engineering in Medicine and Biology Society's Annual International Conference Proceedings, EMBS, 2212–2215.

[9] Trotta, A., Giaquinto, N., Cannazza, G., Cataldo, A., and Andria, G. (2011). creation of a remote system for instantaneous intravenous drip control,2011 IEEE International Symposium on infusions Applications and Measurements in Medicine.

[10] Nandy et al. (2017); Young et al. (2017); Haugen et al. (2017); Katzenmeyer-Pleuss et al. (2017); Gordon et al. (2017); Retta et al. (2017). Assessment of one-way valves in medical equipment to avoid cross-contamination. 45(7), 793–798 in the American Journal of Infection Control.

[11] Friedrich, A. W. (2011); Ellger, B.; Kiski, D.; Diem, E.; van den Heuvel, I.; Freise, H.; Van Aken, Backflow and bacterial contamination of intravenous infusions are not prevented by non-return valves. Hospital Infection Journal, 78(1), 31–35.

[12] Asadnia, M., Miao, J., Shen, Z., Kottapalli, A., Subramaniam, V., and Triantafyllou, M. (2016). Biomimetic flow sensors are utilized in intravenous tubes for biomedical flow monitoring. IEEE SENSORS, 2016.

[13] Macker, A. (2018). Arduino based LPG gas Monitoring & Automatic Cylinder booking with Alert System. 2018 2nd International Conference on Trends in Electronics and Informatics (ICOEI), 1209–1212.

[14] Chattoraj, S., & Roy, P. (2015). Design and Implementation of Low-Cost Electronic Toll Collection System in India. 2017 Second International Conference on Electrical, Computer and Communication Technologies (ICECCT), (ND).

[15] Sheng-nian, C., Yu, J., Cheng-tao, X., Yu, L., & Ran, Q. (2012). Energy-saving Driver Circuit of High-speed Solenoid Valve Based on Soft-switch Technology. 2012 Second International Conference on Instrumentation, Measurement, Computer,Communication and Control (ICIMCCC), (ND).

Appendix A

```
#include <Wire.h>

#include <Adafruit_GFX.h>

#include <Adafruit_SSD1306.h>
#include "HX711.h"

#define calibration_factor -7050.0 //This value is obtained using the
SparkFun_HX711_Calibration sketch

#define LOADCELL_DOUT_PIN  3
#define LOADCELL_SCK_PIN  2

HX711 scale;

#define SCREEN_WIDTH 128 // OLED display width, in pixels
#define SCREEN_HEIGHT 64 // OLED display height, in pixels

int bubble_count=0;

// Declaration for an SSD1306 display connected to I2C (SDA, SCL pins)
Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, &Wire, -1);

void setup() {
  Serial.begin(9600);
  pinMode(9,OUTPUT);
  pinMode(5,OUTPUT);
  pinMode(A2,OUTPUT);
  pinMode(10,OUTPUT);
  pinMode(11,OUTPUT);
  digitalWrite(9,HIGH);
  digitalWrite(10,HIGH);
  if(!display.begin(SSD1306_SWITCHCAPVCC, 0x3C)) { // Address 0x3D for 128x64
    Serial.println(F("SSD1306 allocation failed"));
    for(;;);
  }
  delay(2000);
  display.clearDisplay();

  display.setTextSize(1);
  display.setTextColor(WHITE);
  display.setCursor(0, 10);
  // Display static text
  display.println("Hello, Biomed!");
  display.display();
  scale.begin(LOADCELL_DOUT_PIN, LOADCELL_SCK_PIN);
```

```
  scale.set_scale(calibration_factor); //This value is obtained by using the
SparkFun_HX711_Calibration sketch
  scale.tare(); //Assuming there is no weight on the scale at start up, reset the scale to 0
  delay(2000);
}

void loop() {
  digitalWrite(9,HIGH);
  digitalWrite(10,HIGH);
  display.clearDisplay();
  display.setTextSize(2);
  display.setTextColor(WHITE);
  float a=scale.get_units();
  float b=a;

  if(analogRead(A2)<=0)
  {
   bubble_count++;
   digitalWrite(11,HIGH);
  }

  Serial.print(b);
  Serial.print("|");
  Serial.print(bubble_count);
  Serial.println();

  char data=Serial.read();

  if((b>10 && bubble_count <0)&&data=="b")
  {
   digitalWrite(5,LOW);
  }
  else if ((b<=10 && bubble_count>=10)&& data=="a"){
   digitalWrite(5,HIGH);
}

  // Display static text
  display.setCursor(2, 5);
  display.print(b, 1);
  display.display();
  delay(100);

}
```

Appendix B

Table A.B.1: Cost Analysis

Component	Price
Solenoidal Valve	500 tk
IV bag	100 tk
Load Cell	250 tk
LED_LDR	20 tk
OLED	350tk
Adapter	300 tk
Arduino	1100 tk
other	300 tk
Total	=3000 tk (appx)

Cost benefit Ratio

Blood backflow can hamper internal physiological phenomena like clotting etc.Which costs = 25000 tk treatmentbill accordingly in Bangladesh !!

So the Cost Benefit Ratio =**25000/3000 = 8.33**