Smart Infusion and Web Based Monitoring Infusion Fluids in Isolation Room Based on Fuzzy Logic

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Abstract. High-tech improvements with reference for health advance to develop numerous medical tools have been build to support doctors and nurses performances. This analysis research applied web-based system of infusion monitoring and microprosessor or microcontroller to grease performances of nurser and pharmaceutical helping in clinics or public health centers of the district. In this research, smart infusion web-based is builded for providing for the infusions by applying Node MCU and ESP 8266 Wi-Fi module. Smart Infusion aimed at helping nurser and medical helpers handling infusions of contagious complaint cases or Covid-19 cases to provide for infusion situation in isolation room or emergency room at hospital also public health centers at the district. Detecting the infusion weight, volume and percentage by applying a digital scale and the Load Cell sensors. This monitoring tools or devices is created to count the display from LCD and infusion weight the volumes and percentage of infusion with 3 colors alert display on the Website such as red color, yellow color, and green color depend on a web developed by php language, C programming with Arduino by C language embedded in microprocessor or microcontroller and based on fuzzy logic. Testing results have been achieved, monitoring device can work efficiently and completely when calculating weight, percentage, and volume. Scanning data of success accuracy of Load Cell sensors is 98.00%.

Keywords – Microprocessor or Micro-controller, Fuzzy Logic, Infusion.

1. Introduction

Previous studies, [2] and [6], showed that the design of a microcontroller-based infusion fluid monitoring system to assist inpatients in hospitals, which utilizes Wi-Fi module as an integration into the system can monitor the amount of patient’s infusion fluids. The analyzing procedure of the infusion fluid is still hand-operated for nurses making decision to visit the patient room for controlling of infusion at any moment. If there are several infected patients in a clinic or environmental health care with toxic disease or Covid-19 patients, authority nurses of the infusion must be in isolation room immediately in purpose for monitoring infusion condition of isolation room of hospital.
Another problem is that nurses lean to be negligent to control infusion fluids for each patient and as result there are critics for the provided services by reason of delays of infusion fluids replacement. Medical staff can cause mistakes for providing intravenous fluids and this is probability that may appear. The error of installation of the infusion can cause obstacle or running out of intravenous fluid with unconscious medical staff. Several cases that are not considered can quickly be fatal to patients. The patient blood pressure in infusion tube will not be balance and it can be blocked by reason of blood clots [6].

Mistakes cannot be underestimated because the latency in infusion fluids replacement can lead to negative risk toward the patient if that is not changed immediately. An monitoring system of intravenous fluid has been built with providing purpose of medical staff with information on the status of the IV fluid in tube. Micro-controller-based monitoring system of infusion fluids to serve patients in hospitals has also been designed. This research is designed for a residual fluid monitoring system based on the Wemos D1 R2 micro-controller. It is able to recommend way for overwhelming delays of replacing infusions fluids [8].

Failures of installation of the infusion fluids cause obstacle or running out of fluid volumes without notification by medical staff. If this is not detected immediately, it will be fatal to patient. Patient blood pressure in infusion tube will not be balanced and can be blocked by reason of blood clots [12].

The devices design uses Node MCU ESP 826612E micro-controller as main control and provides info over Wi-fi network and IR Obstacle Avoidance sensor module. Drip infusion detector can be designed by power supply with +12V and +5V DC output and then making voltage lower using DCDC LM 2596 Step Down Module as a voltage-lowering circuit from DC12V to DC3.3V [8].

The study refer to presentations of valid investigation of experts and users in valid category. Infusion fluid data can be sent by the sensor to web page with a error measurement of 2,46% from the manual measurement results. MySQL database store data and send data on each 24 seconds and auto-refresh web pages on each 5 seconds [11].

In this research, monitoring device of infusion fluid with module of ESP 8266 Wi-Fi will be created to check remotely infusions without urgency for nurses to visit to patient room and patients will mention nurses without need to get up from bed.

Monitoring system apply Load Cell sensors where Load Cell sensors is a identifying tool for weight. Weight information can be showed at web. Based on web information, staff will take first movement in form of infusion fluid replacement. Based on mention background of problem, author intend to conduct a final project entitled “Smart Infusion and Web-Based Monitoring Infusion fluids in Isolation Room Based on Fuzzy Logic”.

2. Method
2.1. Infusion
The requirement of various functional and painless to use medical equipment are very needed in the same way the sophisticated development of technology nowadays, with the development of medical technological instrumentation to help demands of medical devices for serving patients. Infusion fluids for patients is one of them. Infusion is a medical equipment operated under certain conditions providing periodically fluids into patient body. Infusion contain fluids, drugs or nutrients infused intravenously by direct infusion over vein network.

Infusion is chemical liquid infused through bloodstream via intravenous route in certain period. Intravenous fluid is commonly delivered to patient who has fluids reduction of body that requires liquid medicines as treatment. Infusion is applicable antibiotic due to effortlessly consumed by the human body cells by reason of liquid form. The infusion occasionally is used as a backup for patient feeding [10].

Infusion therapy mostly perform method for patients who undergo in hospitalization as a treatment of intravenous IV therapy, blood sampling or blood product, drugs, and fluids.
2.2. Load Cell Sensors

The Load Cell is a Transducer and it is a force that acts found on the foundation of a material transformation by reason of mechanical voltage, reorganize mechanical force in electrical signal. Automatic voltage is based on the inventions of “Robert Hooke” and then he invents link between mechanical voltage and results of deformation named strain. Strain occurs in top layer of material so that it is possible assessed by strain sensor or Strain Gauge [9]. Load Cell is fundamental unit of weighing digital system. It is sensor which develops electrical signal where the magnitude of the signal is evaluated proportionally. Furthermore, developing an output proportionally for the applied loads and forces that can supply detailed measurements of loads and forces, it is converted the strain to the metals to resistance [9] [11].

| Maximum load | Range of Output voltage | Impedance the Input | Impedance the Output | Input Voltage maximum | Range of Operating temperature | Size of Material Aluminum Alloy |
|--------------|-------------------------|---------------------|----------------------|-----------------------|-------------------------------|--------------------------------|
| 5000 grams   | a. 0,1mV ~1,00mV/V.     | 1066 Ω ± 20,0%      | 1000 Ω ± 10,0%       | 10 Volt DC            | -20 °C ↔ 65,00 °C             | 60x12,8x12,8 mm, and weight 23gram |

2.3. HX711 module

HX711 module is integrated devices unit of a 24bit Avia Semiconductor for converting analog to digital. ADC is developed for weigh digital sensors and industrial control applications connecting to Wheatstone bridge sensors. HX711 module is a weighing module with working principle such as [3]:

- To convert measured changes in resistance changes.
- Then change them to voltages capacity over existing circuit.

The Specifications of HX711 module, such as:

a. There are two ADC channels can be operated for two loading cells with synchronized TTL output serial, SCK and DI.
b. 5Volt DC of voltage operating.
c. Various voltage input ±40mV at full scales 24bit of data accuracy or 24bit ADC.
d. Scanning of frequency and refresh rate 80Hz for consumption less than 10mA.
e. Capacity 38x21mm with a weight of 20grams.

2.4. Node MCU ESP 8266

Node MCU ESP 8266 module is electronic devices board on the ESP 8266 chip with capability of activate micro-controller operations and the connection of Internet by Wi-Fi. There are a few input-output pins in case they can be build up for IOT projects of monitoring and controlling applications. Node MCU ESP 8266 can be set up with Arduino compiler by Arduino IDE. The environmental form of Node MCU ESP 8266. There is mini-USB port in caset making to code programming easily. Node MCU ESP 8266 is a development derivative module of Internet of things platform of ESP 8266 type ESP 12 [7].

ESP 8266 Functions is additional device of Wi-Fi module for microprocessor or micro-controllers such as Arduino so that it can join directly to Wi-Fi to build up TCP/IP connections. This modules require about 3,3volt of power and have three Wi-Fi modes and access point. This modules equipped processor, memory and GPIO where pin numbers depend on ESP 8266 type. The module can stand-alone without any microprocessor or micro-controller because it is already having equipment like the microprocessor or micro-controller, but it can also operate an another microprocessor or micro-controller in this case the Arduino controller [7].
Table 2. The following features of the ESP 8266 Wi-Fi module.

| Feature                                      | ESP 8266 Wi-Fi Module Features |
|----------------------------------------------|---------------------------------|
| a. Software-AP                               | a. LNA, Integrated TR switch, power amplifier, balloon. |
| b. Wi-fi Direct or point to point.           | b. Regulator, DCXO, and Integrated PLL, power management unit. |
| c. 802.11 b/g/n                              | c. 802.11 b/g/n.               |
| d. 32 bit CPU, 1 MB Flash Memory.            | d. 32 bit CPU, 1 MB Flash Memory. |
|                                              | a. SPI, UART, SDIO 1, 1 / 2.0. |
|                                              | b. 1 × 1 MIMO, 2 × 1 MIMO, STBC |
|                                              | c. Integrated TCP / IP stack protocol |
|                                              | a. A-MSDU aggregation and 0.4 ms of guard interval and A-MPDU. |
|                                              | a. Standby power consumption < 1.0 mW or DTIM3. |
|                                              | b. 19.5dBm output power in 802.11b mode. |

2.5. C Language

By using are Microsoft and Linux/Unix OS or perhaps like Cygwin on Windows OS that has preinstalled compilers which are applicable for the C Programming language. C language on various platforms has a lot of compilers for this, serving as [1]:

| GCC | CC on Linux/Unix (Turbo C and Miracle C) | Microsoft Visual C++ on Linux/Unix |
|-----|-----------------------------------------|------------------------------------|
|     |                                          |                                    |

There are many compilers that can be operated like GCC and it uses a text editor, such as:

| Notepad | Emacs | Pico | Vim | Kwort | Nano | Vi | Gedit |
|---------|-------|------|-----|-------|------|----|-------|
|         |       |      |     |       |      |    |       |

The C language structure can be viewed as compilation of various functions, such us: The first operation that must exist in C language is main(). The functions of C language established with a pair curly brace ({}) and (}). C language statements can be written between the curly braces [1].

Figure 1. Structure of C Language

2.6. Arduino IDE

Arduino IDE devices is developed by java programming language and is needed with languages of C/C++ library commonly called wiring having function to input-output operations also specifically for programming with Arduino Arduino is developed from processing software remodeling into Arduino IDE. There are three parts of The IDE software, consists of [5]:

1. The function of program editor tool is editing and writing program code in processing languages system. Sketches is the program listing of code on Arduino.
2. The function of compiler tool is a module having duties to replacement the program code in processing languages system into binary and bit code because it is the only system of programming language understood by Arduino IDE at the microprocessor or microcontroller.
3. Upload tool is a module having operations to add bit and binary codes to the memory of the microprocessor or microcontroller.

There are two parts of command structure on Arduino basically, consists of:
- Void setup is contains commands that will be executed only once since Arduino is turned on.
- and Void loop is containing commands that will be executed repeatedly if Arduino is powered on.
2.7. General system for infusion monitoring flowchart

![Flowchart](image)

**Figure 2.** The Infusion monitoring flowchart

3. Results And Discussion

3.1. Fuzzy Logic

The fuzzy logic-based infusion monitoring system has input from the expert system, the expert system as fuzzy Logic Control materials after that make the system as PWM input. Before becoming output, the sensors adjust the opening degrees in advance as feedback from the system. This feedback required as a correction factor for the degree of aperture [4].

3.2. Fuzzy Logic Control Design and Mamdani Method

Fuzzified parameters are inputs in the form of drops and weight. Drop values and body weight are divided into four linguistic forms, namely Slow, Medium1, Medium2, Fast and L, M1, M2, H. While the defuzzification result parameter, in the form of output, is the degree (deg) to rotate the hose clamp infusion. The output parameter has the same linguistic form as the input value. Inference process using Mamdani method [4].

![Fuzzy Logic Schematic](image)

**Figure 3.** Fuzzy Logic diagram

**Figure 4.** Fuzzy Logic Schematic for infusion using Mamdani method
#include <ESP8266WiFi.h>  // WiFiClient.h
#include <ESP8266WebServer.h>  // WiFiServer
#include <ESP8266HTTPClient.h>  // HTTP/1.1
HX711 scale(D6, D7);
const int buttonPin = D8;
float calibration_factor = -380; float units;
float ounces;
const char* ssid = "SSID"; const char* password = "PASSWORD";
const char* host = "192.168.4.2";
WiFiServer server(80);
void loop() {
  String beratValueSend, postData; units = scale.get_units(), 10;
  if (units < 0)
    units = 0.00;
  ounces = units * 0.035274; Serial.print(units);
  beratValueSend = String(units);
  postData = "berat=" + beratValueSend;
  http.begin("http://192.168.4.3/salman_test/InsertDB.php");
  http.addHeader("Content-Type", "application/x-www-form-urlencoded");
  int httpCode = http.POST(postData);    // Send the request
  String payload = http.getString();     // Get the response payload
  Serial.println(httpCode);              // Print HTTP return code
  Serial.println(("bb" + beratValueSend + " " g"); http.end();  // Close connection
  if (buttonState == HIGH) {
    // turn LED on: digitalWrite(16, LOW);
    Serial.println("NYALA");
  } else {
    // turn LED off: digitalWrite(16, HIGH);
    Serial.println("MATI");
    delay(100);}
  digitalWrite(16, HIGH);
  Serial.println("MATI"); delay(100);}

3.3. Smart Infusion Implementation and Application
In this research, smart infusion implementation the function of the tools or devices main by part will be explained in the Figure 5, as follows.

Figure 5. The Device Display and Position of Node MCU
The Load Cell sensors is placed at the top because testing start scanning data from Load Cell sensors like as a weight tool of total infusion fluids weight.

HX 711 module is loacted at toolbox. HX 71 has working principle of converting and filtering measured changes receives weight data from Load Cell sensors. Node MCU is placed at toolbox beside other units. Node MCU has functions as data processor and sends data to database.

3.4. Smart Infusion of Software

The software used by the Node MCU program is Arduino IDE using C language, while for developing website use html programming and php programming language, as follows:

The table name of database is db_infus and databases save data. In status table, there are ID of volume number and weight of fluids infusion. There are three ID's stores. Total weight of fluid infusion is 570,00grams.

![Figure 6. The initial views on the Website](image)

Figure 6. Basic views of web, displaying data of detected patient data at isolation room at clinic or community health center. Fluid infusion condition is full.

![Figure 7. One of alert displays on Website](image)

Figure 7 displays id INF-001 of 25.00%, id INF-002 of 50.00%, and the id INF-003 of 100%. So, id of INF-001 of 25.00% will be ringing alarm and will stop alarm when volume and percent of fluids infusion is 23.00%.

![Image](image1)

**Figure 8.** Two alert displays on the Website

Figure 8 displays id INF-001 of 25.00%, id INF-002 of 15.00% and id INF-003 of 40.00%. So, id INF-001 and id INF-002 will be simultaneously ringing an alarm with a different tone.

![Image](image2)

**Figure 9.** Three alert displays on the Website

Figure 9 displays id INF-001 of 25.00%, id INF-002 of 15.00% and id INF-003 of 5.00%. Then Id INF-001, id INF-002 and INF-003 will simultaneously ringing as an alarm with a various tone. Generally, the display basic web presents three ids such as id INF-001, id INF-002 and INF-003. When an id is selected, a full screen of that id is going to present. Thi situations display the infusion id such as INF-001 and the total weight of the infusion fluid is 530grams, with volume and 100% percentage, pointing out the infusion fluid is still full. This condition displays total weight of fluids infusion, which is 265grams, with a volume and 50.00% percentage, pointing out that the fluids infusion is in fifty-fifty full condition. When total weight of fluids infusion is 212grams, with volume and 40.00% percentage, in this condition the web display shows a yellow color. When the total weight of fluids infusion is 132.5grams, with a volume and 25.00% percentage. In this condition, web display shows a red color which is sign of warning zone and alarm will be automatically ringing until 23.00% of volume left.

When the condition of total weight of fluids infusion is 79.5grams, with volume and percentage of 15.00%. Alarm will ring until volume and percentage of 13.00% fluid infusion. This condition reveal that infusion of standby state is running out soon. The weight on the Load Cell sensors is 570grams and weight of an empty infusion fluid bottle is 40grams. Conclusion of net weight of infusion is 530grams.

Condition of display of the infusion weight is 0grams. Volume and percentage of fluids infusion is 0%. It indicates that infusion has been run out.

| No | Volume Percentage (%) | Weight of Load Cell (grams) | Weight of Empty Infusion Bottle (grams) | Infusion Net Weight (grams) |
|----|------------------------|------------------------------|------------------------------------------|-----------------------------|
| 1.  | 100                    | 570                          | 40                                       | 530                         |
| 2.  | 0                      | 40                           | 40                                       | 40                          |
Table 3 the weight on the Load Cell sensors is 570 grams and empty weight volume of an infusion bottle size is 40 grams. The conclusion of the net weight of the infusion volume view is 530 grams.

Table 4. Load Cell Sensors Testing and Notifications on Website

| No | Volume Percentage | Warning Colors | Warning on Website |
|----|-------------------|----------------|--------------------|
| 1  | 100%-40%          | Green          | visible warning    |
|    | 40%-25%           | Yellow         | visible warning    |
|    | 25%-15%           | Red            | visible warning    |
|    | 15%-5%            | Red            | visible warning    |
|    | 5%-0%             | Red            | visible warning    |
| 2  | 100%-40%          | Green          | visible warning    |
|    | 40%-25%           | Yellow         | visible warning    |
|    | 25%-15%           | Red            | visible warning    |
|    | 15%-5%            | Red            | visible warning    |
|    | 5%-0%             | Red            | visible warning    |
| 3  | 100%-40%          | Green          | visible warning    |
|    | 40%-25%           | Yellow         | visible warning    |
|    | 25%-15%           | Red            | visible warning    |
|    | 15%-5%            | Red            | visible warning    |
|    | 5%-0%             | Red            | visible warning    |
| 4  | 100%-40%          | Green          | visible warning    |
|    | 40%-25%           | Yellow         | visible warning    |
|    | 25%-15%           | Red            | visible warning    |
|    | 15%-5%            | Red            | visible warning    |
|    | 5%-0%             | Red            | visible warning    |
| 5  | 100%-40%          | Green          | visible warning    |
|    | 40%-25%           | Yellow         | visible warning    |
|    | 25%-15%           | Red            | visible warning    |
|    | 15%-5%            | Red            | visible warning    |
|    | 5%-0%             | Red            | visible warning    |

4. Conclusion
Some conclusions can be drawn this research as follows:
1. Node MCU devices, Wi-Fi Module for Web Based ESP 8266 devices and Microcontroller base on Fuzzy Logic can monitoring also calculating the infusion fluids weight, percentage, and volume reading the data of the infusion with three colors indicators, namely colors are red, yellow, and green, with the volume and percentage of infusion fluids 100.00% - 40.00% is green color, fluids infusion volume 40.00% - 25.00% is yellow color, and 25.00% - 0% is red color.
2. The Load Cell sensors devices are successful to calculate sizes of infusion fluids weight. Scanning data from the percent and detailed volume of the Load Cell sensors is 98.00% successfully by weight infusion fluids volume and percentage.
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