THE DEVELOPMENT OF INTRAVENOUS DRIP DETECTOR BASED ON WIRELESS APPLICATION

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ABSTRACT

Development of Wireless Application Intravenous (IV) Drip Detector (WAivD) is a device in nursinghouses or hospitals used for delivering Sodium Chloride solutions for IV therapy. The development of this device may assist nurses to manage the IV infusion process by integrating hardware devices, which includes a load cell sensor and Android Studio software. The idea of this development is integrated from the problems encountered by nurses during the therapy. Nurses tend to spend extra time to monitor patients who receive IV therapy because nurses need to frequently walk around IV therapy patient to check the balance of IV drip. To overcome the problem, one of the objectives of WAivD is to design a wireless IV drip detector by using Android Studio software system with alarm notifications. Thus, it can help nurses in monitoring their patients. The method used in this project is a combination of hardware devices and software systems. A Nodemcu ESP 8266 based microcontroller is used as a platform to connect a bar load cell sensor. The bar load cell sensor transforms a tension, pulled by a drip-bag, to weak the electrical signal. The electrical signal is amplified and fed into a 16-bit A/D converter. Therefore, the weight data that has been converted will send data on application software through Wireless Fidelity (Wi-Fi). The flow rate will be displayed on users' electronic devices. As an output for this development, the hardware system will show an exact amount of IV drip left on OLED. Meanwhile, the application software will show date, name of the patient, starting time, remarks and also the amount of fluid so that nurses can easily read patient's IV infusion information and it will help to reduce nurse time which nurses take in monitoring the IV infusion.

Keywords: Intravenous Infusion, Monitoring System, ESP 8266-based Microcontroller, Load Cell Sensor, Android Studio

1. INTRODUCTION

application intravenous drip detector (WAivD) is the device and application to help monitoring and notifying user by using load cell sensor [1], wireless connection and Android Studio software [2]. This device is monitoring system that automatically monitors all patients IV therapy as long as a drip bag is hung on the scale module of the system. The scale module is used to measure the weight of a drip bag continuously[3] and the weight data will be shown on nurses' electronic device such as a tablet.

Information technology plays an important role in many fields including the healthcare field. A hospital needs doctors, nurses, nutritionists and other staff to work together for caring patients [4]. There should be information technologies or tools to help the nurses work easily, safely and comfortably. Intravenous (IV) fluid drips deliver saline solution through a small catheter and tubing directly into the bloodstream. In hospital, intravenous therapy is an important therapy for patients [5]. A nurse sets an IV infusion device up according to the doctor medical order. The IV infusion rate needs to be adjusted with a designated IV infusion rate and it needs to take follow up nursing work.

Most of the problems happen towards patient is when during the IV therapy, the user or nurse is not alert if the solution entering into patient is not enough. So, once the status of the solution is about to finish occurs, an alarm will be issued to the nurse in charge. The objectives of this project are to monitor the volume of IV drip bag during patient IV infusion by using load cell sensor [1][6]. Besides, this device can also display the accuracy of quantity IV drip bag left using Arduino system and design a wireless IV drip sensor by using Android Studio software with alarm notifications. This project is divided into two parts that are hardware and software. The method to develop this project is by using load cell sensor which is to identify the quantity of the solution left. Moreover, wireless connection will help to connect between the device and the software which is in users' mobile phone. Furthermore, Android Studio will develop application and will be installed in user mobile phone to monitor the IV drip bag from afar. Last but not least, as an output of this project it will show number of quantity left and alarm notification will be send through user mobile phone to notify. In other words, nurses just hang a drip bag onto the load cell and the system will run automatically.

Intravenous therapy (IV) is a therapy that delivers liquid substances directly into a vein [7]. The intravenous route of administration can be used for injections with a syringe at higher pressures or infusions typically using only the pressure supplied by gravity [8]. Intravenous infusions are commonly referred as a drips. The intravenous route is the fastest way to deliver medications and fluid replacement [5] throughout the body, because the circulation carries them. Intravenous therapy may be used for fluid replacement such as correcting dehydration, to correct electrolyte imbalances, to deliver medications, andfor blood transfusions[9]. Patient might need IV therapy to rehydrate after becoming dehydrated from illness or excessive activity. Moreover, it can also treat infection that is using antibiotics and for cancer treatment through chemotherapy drugs. IV therapy is important to humans, one of the reasons is IV can decrease time spent at clinics or hospitals. It allows patients to return to work or school with a decreased risk of infections. Besides that, IV therapy can prevent negative side effects that occur if the fluids were administered orally. It also can cure from hangovers. Hangovers can result in severe dehydration. If instant action is not taken, it can cause irreparable damage to the body. An IV therapy is the best cure for hangovers as it can quickly restore the fluid imbalance.

Along with the technology nowadays, one of the companies has made new invention on IV drips. The company has created a monitor device called DripAssist Infusion Rate Monitor[10]. This device was created to measure flow rate, drop per minute and total volume. DripAssit was a good invention but unfortunately the price is expensive and not everyone can afford and willing to buy. Based on paper entitled Intravenous Infusion Monitoring System Based on Wireless Sensor Network, IV monitor device is designed. They used ZigBee-based RF communication as microcontroller. Wireless sensor network (WSN) [11] technology which is based on novel sensor and RF communication technology provides a low-cost, easy to deploy and flexible method for reality perception and data acquisition as well as transmission. The paper shows the progress and velocity of droplet through droplet monitoring. Establishing an IV line has become routine in pre hospital intervention for seriously ill or injured patients. Many studies have been done of local and systemic complications resulting from IV therapy begun in the hospital [4]. Complications were classified as either local or systemic. The nursing staff was notified if complications developed in any patient. Fluid overload is frequently found in acute kidney injury patients in critical care units. In critically ill patients, fluid overload is related to increased mortality and also lead to several complications like pulmonary edema, cardiac failure, delayed wound healing, tissue breakdown, and impaired bowel function. In other way to prevent the liquid overload, invention of Wireless application intravenous drip detector (WAivD) will help user by monitoring the liquid left and notifying user through software application.

2. METHODOLOGY

Method that was used to deliver this device using hardware and software methods for assisting nurses on monitoring the progress and status of intravenous therapy of all patients. The delivering method can be described as WAivD is composed of two components which are an IV infusion data collector hardware and an IV infusion monitoring application software. The IV infusion monitor application is executed on a handle electronic device for nurses to be use [12]. Nurses can directly check and monitor the IV infusion status of patient on the table or mobile phone[13]. An IV infusion status is designed as a numerical form for quickly checking the IV infusion status. This can help nurses to easily check the IV infusion status at a glance. Before using the application, user need to register few of information about patient such as name of the patient, date, starting time and remarks as a notes about patient. All the IV infusion status and information are gathered in mobile phone application software.

NodeMCU ESP 8266-based microcontroller as the single chip microcontroller[14]. This components will act as microcontroller board. Pairing with Wireless Fidelity (Wi- Fi) as a platform to connect with monitor such mobile phone from far with certain distance. NodeMCU is an open source development board and firmware based in the widely used ESP8266 -12E WiFi module. It allows to program the ESP8266 WiFi module with the simple and powerful LUA programming language or Arduino IDE. Arduino provides C/C++ programming language and a PC-based development environment. It provides an input and output interface with analogue and digital simultaneously. Also there are many extensions, function shields, in the market. In the system, Arduino functions as an integrator of different data and bag weight. Arduino send the integrated data via the wireless communication module to mobile phone. With its USB-TTL, the nodeMCU Dev board supports directly flashing from USB port. It combines the features of WIFI access point and station + microcontroller. These features make the NodeMCU extremely powerful tool for Wi-Fi networking. It can be used as an access point and/or station, host a webserver or to be connected to the internet to fetch or upload data.

Load cell designs can be distinguished according to the type of output signal generated from pneumatic, hydraulic and electric or according to the way they detect weight like bending, shear, compression and tension, etc[15]. Load cell is a type of transducer which performs the functionality of converting force into an electric output that can be measured. This type of transducer is highly accurate[3] when is properly designed an

used. Load cells are used in a variety of industrial weighing system[16]. There is a constant need for knowing the exact weight of many items such as for, ingredients for production, pharmacology, chemistry, technology, etc. Load cells are applied in several different fields, usually for weighing measurements. The load cell converts pulling stress to tiny electrical current, the more stress the more electrical current[17]. S-type load cell is used to measure the weight of the hanged drip bag. This straight bar load cell (sometimes called a strain gauge) can translate up to 3 kg of pressure (force) into an electrical signal[18]. Each load cell is able to measure the electrical resistance that changes in response to, and proportional of, the strain (e.g. pressure or force) applied to the bar. It has four lead wires which can be connected to HX711 A/D Pressure Sensor[19].It is easy to use with driving voltage 5-10V and produce the output voltage as per the force changes over it. An electronic weighing machine uses a load cell to measure the load or pressure produced by the load, here most load cells follow the method of the strain gauge, which converts the pressure (force) into an electrical signal, this load cells have four strain gauges that are hooked up in a Wheatstone bridge formation. When apply to load the strain gauge resistance will change and hence the output voltage from the load cell get changes by the way so it can measure the load value.

Android Studio is the official integrated development environment (IDE) for Google's Android operating system [2], built on JetBrains' IntelliJ IDEA software and designed specifically for Android development. It is available for download on Windows, macOS and Linux based operating systems. It is a replacement for the Eclipse Android Development Tools (ADT) as the primary IDE for native Android application development. Android Studio was announced on May 16, 2013 at the Google I/O conference. It was in early access preview stage starting from version 0.1 in May 2013, then entered beta stage starting from version 0.8 which was released in June 2014. The first stable build was released in December 2014, starting from version 1.0. The current stable version is 3.3, which was released in January 2019. Android Studio supports all the same programming languages of IntelliJ (and CLion) e.g. Java, C++, and more with extensions.

Figure 1: Modulated Diagram of project for every layer

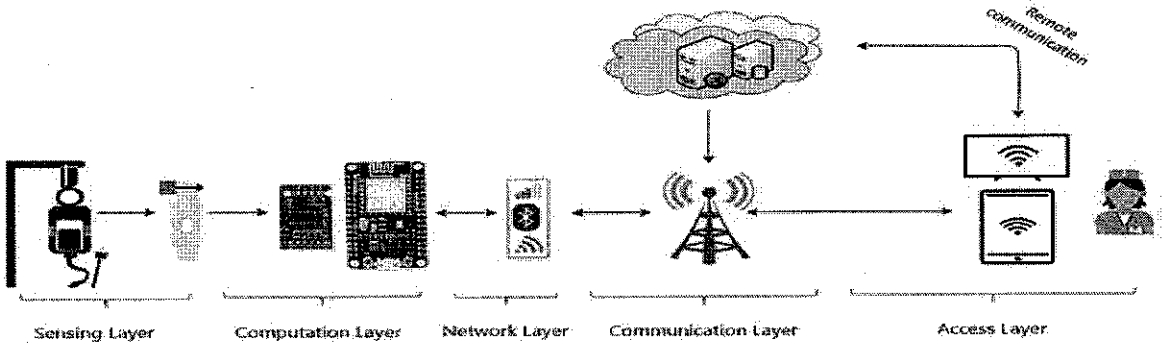

Figure 1 shows modulated diagram of the device. It will started with the sensing layer where the sensor will sense the weight of the solution bag. Secondly, it continues to computation layer where the Nodemcu ESU 8266 will act as microcontroller board to computed and process the data of the weight of the solution bag from analogue data to digital data. Thirdly, in network layer will take action. For this device, the use of WiFi is chosen compared to Bluetooth. Then, in communication layer WiFi will take the data and passed it to user through local communication and last but not least in access layer the user will use the application in their mobile phone to collect the data from the sensing layer.

Modulated layer for the project will begin with patient drip bag weight and it will show status indication and status notification at monitor of application. The function of modulated layer can be explained. Firstly, at sensing layer patient drip bag weight is to collects all drip-bag weight from patients. Second, at computation layer, patient drip bag weight data dispatching is to process the data that collects all drip-bag weight from patients. Later, at network layer data that has computed will be sent through WiFi connection at communication layer. Lastly, at access layer IV infusion status indication is a software application that deliver to the electronic device that shows all patients dripping status in graphic and text. Patient IV Infusion Monitor is a background thread that checks the status of all IV infusion. Access layer or available status notification is called as alarm, handles events between the system core and the mobile app. It orders nurses handle all events and log actions and results.

3. RESULTS AND DISCUSSIONS

This section discusses about the expected result. Every minute per drop were depends on type of drop sets. There divided into four types of drop sets which are 10 gtt/ml, 15 gtt/ml, 20 gtt/ml and 60 gtt/ml. For 60 gtt/ml is using different type of drip set which is used mini drip or called as micro-drops set while the rest is using macro-drops. For this device, it was used 20gtt/ml type.

Figure 2: Example of calculation has made based on formula

$$\frac{Volume \text{ x } Drip\ Factor}{Time\ in\ minutes} = \frac{gtt}{min}$$

$$\frac{500ml \text{ x } 20gtt}{60min} = 166.67\,\frac{gtt}{min}$$

❖ 15gtt = 1ml

$$= \frac{166.67}{15}$$

$$= 11.11\,\frac{ml}{min}$$

Based on the figure 2 calculation, the quantity of IV drip bag used is 500 ml. For drop factor (gtt/ml) type of drop used is 20 gtt/ml while time selected is an hour or 60 minutes. To get the drop per minute, the volume will multiply with drop factor and divide with times selected. So 500ml is time with 20gtt/ml and divide with 60. It will get 166.67 gtt/ml. Based on information given in figure 6 below, known that 15 drops (gtt) is equal to 1 milliliter (ml). From 166.67 gtt/ml need to divide with 15 to get how many milliliters for 166.67 drop per minute, as from figure above about 11ml to 12ml per minute.

Figure 3: Conversion reference between gtt and ml from journal A. Health and M. Supplement, "Appendix A — Conversion Units Appendix B — Conversion Units Worksheet," no. cc, pp. 78–80.

Volume

1 liter (L)	=	1,000 milliliters (mL)	=	1,000 cubic centimeters (cc)
1 milliliter (mL)	=	1 cubic centimeter (cc)	=	15 or 16 drops (gtt)
1 quart (qt)	=	2 pints (pt)		
1 pint (pt)	=	2 cups	=	16 ounces (oz)
1 glass or cup	=	8 ounces (oz)		
1 ounce (oz)	=	2 tablespoons (T)	=	8 drams (dr)
1 tablespoon (T)	=	3 teaspoons (t)		
1 teaspoon (t)	=	1 dram (dr)	=	60 drops (gtt)

Based on figure 3 shows, it is a reference of conversion between drops(gtt) and milliliter(ml) [20]. From the table, it can be understood that 1 ml is equal to 15 to 16 drops (gtt)

Table 1: Theoretical data that have calculate using formula

Time	IV Level
4.00pm	500ml
4.01pm	488.89ml
4.02pm	477.78ml
4.03pm	466.67ml
4.04pm	455.56ml
4.05pm	444.45ml
4.06pm	433.34ml

Table 2: Experimental data that have collected during testing

Time	IV Level
4.00pm	500ml
4.01pm	485.83ml
4.02pm	476.95ml
4.03pm	467.12ml
4.04pm	453.63ml
4.05pm	443.84ml
4.06pm	436.65ml

From the result table 1 and 2, both are not the same value. For table 1, it is theoretical result that followed the formula in figure 5 and has been calculated. While for table 2, the data is collected during testing. In table 2 result, most of the results are slightly different from table 1 about ± 3 ml tolerance.

4. CONCLUSIONS

This device was designed to implement the IV infusion monitoring system to help nurses monitor patient drip status. The core component is a hardware composed of NodeMCU ESP 8266 based microcontroller, and a load cell sensor. A nurse hangs a drip bag onto the WAivD and the system periodically reads the weight. The bar load cell sensor transforms a tension, pulled by a drip-bag, to weak electrical signal. The electrical signal is amplified and fed into a 16-bit A/D converter. Therefore, the weight data that has been converted will sent on application software through Wireless Fidelity (Wi-Fi) and displayed on user electronic devices. As an output for this development, the hardware system will show exact amount left of the IV drip on OLED, while for application software will show date, name of patient, starting time, remarks and also amount so that Nurses can easily read patient IV infusion information.

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