Design and Development of a Low Cost, Smart Infusion Pump to Deliver Medications for Patients using Labview Interface With Arduino

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Abstract: ***An infusion pump is a medical device that delivers fluids such as nutrients into a patient's body in controlled amount. They are widely used in clinical settings such as hospitals, nursing homes etc. There are many types of infusion pumps including large volume, patient-controlled analgesia and insulin pumps. Some are designed mainly for stationary use at a patient's bedside, because infusion pumps are frequently used to administer critical fluids, including high-risk medications, pump failures and can have significant implications for patient's safety. From 2005 to 2009, FDA received approximately 56,000 reports of adverse events associated with the use of infusion pumps, including numerous injuries and deaths. Some of the problems include software problems, alarm errors, inadequate design, broken components, battery failures, spark, and shock. In order to overcome these problems, our team came up with an idea to rectify. Our project is very compact in size when compared to the ordinary syringe pump. It can be lifted with single hand since it is weightless and the components used in our project are reliable, cost efficient and user friendly.***

Keywords* : *Infusion pump, Cost efficient, LabVIEW.

I. INTRODUCTION

Infusion pump is an external medical device used to deliver fluids in controlled manner into the patient's body. For variety of environments and variety of purposes there are many different types of infusion pumps being used. Infusion pumps are capable of delivering drugs into human body in smaller or larger amounts while in some cases they are used to deliver nutrients and medications which include insulin, other hormones, antibiotics, chemotherapy drugs and pain relievers. There are two main types of infusion pumps which are stationary and portable. The stationary pumps are used at bedside and portable or wearable infusion pumps are used in ambulance.

Revised Manuscript Received on December 16, 2019.

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I. LITERATURE SURVEY

[1] Erin Quattromani *et.al,* made a study to determine whether the smart pump app will be effective and engaging education tool for junior nursing students when compared with the traditional methods. Students assessed the application based on their knowledge and performance for learning infusion pumps users. Since, there was no difference they rated the app as an education tool.

[2] C. Luca, D.Andritoi *et.al.*, have discussed about the techniques based on wireless to reduce the electromagnetic interference and conducted some tests to identify the source of equipment that disrupts the operation of diffusion pumps and concluded that changes gets disappear with the removal of source of equipment that causes disruption and promote awareness of EMI.

[3] Paul Pankhurst and Zahra McGuiness Abdollahi have developed a new portable micro-pump which solves the defects of current pumps. It is user-friendly and cost efficient. It has very high performance, accuracy and small erring size which can be used in wider medical applications. It provides controlled dosing and timing in drug delivery.

[4] XialiHei, Xiaojiang Du, Shan Lin *et.al,* have personalized a patient infusion pattern (PIP) for wireless insulin pumps. It detects the dosage amount, rate, and time of infusion, and prevents the lives of people from being given overdosed. It prevents from the attack. They concluded the performance was good and can also be generalized to other infusion systems.

[5] J. P. Silva, B. A. Rodrigues, J. C. S. Casado, and S. S. R. F. Rosa tried to obtain the output they have done the mathematical modeling process of Systolic and Diastolic Blood Pressures for controlling the blood pressure of the patient. Specifications of the infusion pump and the mathematical model did not diverge. Infusion pump can also be interface with devices like biosensors or applications.

[6] Pooja Rajendra Prasad *et.al,* have designed a secure software for infusion pump on considering the security. It is controlled by including security with the design of the Wireless infusion pump software. It gives the information when there is lack of security. But the network is not secured.

[7] Luiz E. G. Martins, Hanniere de Faria *et.al*, have planned to develop a low cost insulin infusion pump for the treatment of diabetes, since the existing pumps are not at a reasonable cost. It has some drawbacks as not accuracy, non-reliability and some parameters. It is useful for blood glucose and overcome the risk factors of diabetics.

[8] M.Deepalakshmi and Dr.R.Jayaparvathy have proposed small size and cost-efficient integrated infusion pump system which is not available at low cost so far in the Indian market. It keeps the blood glucose at the limited range and provides the correct dosage of insulin. They concluded that, continuous monitoring is essential which may be considered as a drawback of this system.

[9] HasnaaElKheshen, Ibrahim Deni *et.al*, discussed about an integrated system for monitoring the patient's condition along with recording of syringe pump are done simultaneously. They mainly focused on the safety of patients. The patient's condition is not totally monitored in critical situations in intensive care units.

[10] Isabella L. Grassetti, *et.al*, have discussed that infusion pumps exposed to radiation must be protected from the x-rays, so an alter method is essential for shielding which is safer and economical. So, a casing material is given with the composites to reduce the risk factor. For more effectiveness and medical applications, more development is essential.

[11] Moret, E. *et.al*, has analyzed the situation of infusion pumps at the hospital for continuous monitoring of drug to reduce the medical errors. To improve accuracy, eliminate dangerous pumps, and also designing pump formation for staff. It overcame the medication errors and been very helpful and safer for the patients.

[12] Haneen Ali *et.al*, have identified the problems in oncology and identified the various problems and proposed new designs. Their problems include lack of information about patient's condition, very low efficiency and found difficulties in controlling the task. Their proposed system had solutions for those problems to overcome.

[13] Frank Doesburg *et.al*, have estimated the advantages of adding the bedside central that controls all the intravenous (IV) infusion pumps. The execution time is not more, usability is very good and the medication error is reduced. It is user-friendly to control and monitor the various multiple infusion pumps. But, they have not mentioned about the accuracy of the result.

[14] Jennifer Biltoft *et.al*, have discussed about implementing a smart electronic pump that health condition of the patient around the particular region. Safety, accuracy, time and efficiency are the factors considered in this paper. It is measurable and data-based improvements. Due to these improvements, revenue is being increased for the outpatients.

[15] Jeffrey M. Rothschild *et.al*, have performed a time-series trial and compared the rate of error and found that, the errors and the time delay can be solved by using smart pumps. And also serious drug events can be detected. Technical and nursing behavioural factors must be known for improving and achieving the medication safety. They identified serious errors before implementation of smart pumps.

[16] ThorunnOskarsdottir *et.al*, have discussed about the usage of intravenous infusions pediatric and neonatal units. Only weight-based traditional methods are being used in United Kingdom and so it is important of publishing the SCI, but also there is no real value of standardization. They concluded that, research must be conducted surely on harmonizing the SCI to improve adoption.

[17] Jennifer Lehr *et.al*, have introduced a new technology according to the medication and more efficient conversional process. This technology improved the nursing practice and provides the essential data. Hospital uses this project for nursing practices and improving quality of care for its renewal certification and for magnet status.

[18] Brian J. Anderson and James Houghton have discussed about the total intravenous anesthesia to implement along with the pumps. Total intravenous (IV) sedation and anesthesia are used in intensive care, but propofol is contraindicated for very longer use in sick or young children because of the risk of developing propofol infusion syndrome (PRIS).The arrival of pumps programmed with pharmacokinetic information which allow the pump to determine the infusion pump to maintain certain concentration.

[19] Linda J Murdouch, Victoria L Cameron have discussed about the serious risk factors being faced in the intensive care units. So, the smart infusion pump is used in prevention, drug calculation, and identifying and correction of the medication errors. This smart pump technology sets a minimum safety especially for the intensive care units. Implementation of this system is mainly used in reduction of medication errors.

[20] Karen K. Giuliano have discussed that before the introduction of the infusion pumps the rate of infusion were calculated manually, and now implementation of this smart IV pumps will overcome those medication errors easier. Proper dosage of drugs can also be injected through this smart pump. It is faster when compared to other methods.

[21] Karen Wilson & Mark Sullivan mainly focused in identifying the areas that causes harmful to the patients and prevent the medication errors. Software is provided to prevent the key-stroke errors and also implementation of infusion pump technology to prevent errors involving heparin and also prevention of patient.

[22] Pascale Carayon et.al, have discussed about implementation of smart intravenous infusion pump to reduce the medication administration errors. The data are collected through three different surveys including implementation, technical performance, usability and acceptance by the user.

[23] Koji Kashikara evaluated an adaptive controller on the basis of deep convolution neural networks (DCNN). Compared with the standard one, convolution one regulates arterial pressure response. This DCNN controller improves the development of automated drug infusion system providing simple extensibility.

[24] Mark H. Myers *et.al*, discussed about the automatic drug delivery method with a computer-aided control for propofol delivery in total intravenous anesthesia (TIVA). A dilution chamber is used to model the decay of the drug. The concentration is monitored and assessed. They demonstrated and confirmed the feasibility.

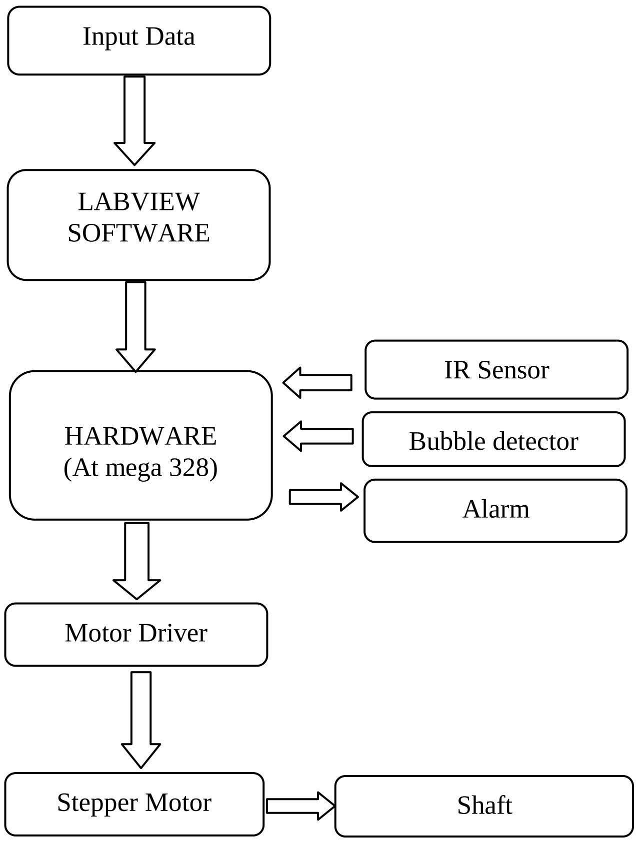
[25] Andrei Drumea and AlexandruVasile discussed about the hydro-electrolytic

trimming method for safety healing of medical diseases and also for electronic monitoring of perfusors for safety without risks of lack of surveillance or any other hazardous efforts. It controls the pump with emphasis of chip device that represents the heart of electronic system.

II. COMPONENTS DESCRIPTION

Stepper motor is controlled by electromagnetic coils in which the shaft containing a series of magnets is mounted onto it. Current is given alternately for the coils surrounding the shaft by creating magnetic field which repels or attracts the magnets on the shaft, thereby causing the motor to rotate. It is used to convert pulse to angular displacement.

Fig.1. 28-BYJ48 Stepper Motor



Flow chart.1 Methodology of the project

ULN2003 is a relay driver IC which can handle 7 different arrays at a time. It can be interfaced with a stepper motor as it can handle very high loads. Since the motor requires high ratings, any other interfacing devices cannot produce such high rating. It operates between 500mA – 600mA and voltage of about 50V. It can be connected to the drive loads up to (7*500mA). It is used as touch sensors in Arduino.

Fig.2 ULN2003A Motor Drive

III. PROPOSED SOLUTION

In our project we have utilized two sensors, one is infrared sensor and other is the bubble detector. We used IR sensor to detect the presence of the tube and its position, whether the tube is in right position or moving away during the pumping process. While the other one is the bubble detector. As the name indicates it is used to detect, whether there is any formation of bubble inside the tube during pumping. Because, there is any bubble formed inside the tube, the solution or fluid does not pass into the human body, but the bubble enters the human body which leads to formation of clotting. So, we use these sensors for monitoring the position of the tube and detecting bubble formation.

As next step our team has used the microcontroller Arduino interfaced with LabVIEW software. Mostly LabVIEW software is used with the combination of hardware DAQ and RIO. Here, we used arduino mainly to reduce the cost of the pump and also arduino is one of the easily interface able hardware with LabVIEW software. Here we used case structures, state mechanism etc., All the components are first interfaced with arduino and Lab view. The input is given through Lab View. Once the sensors and all other components are interfaced, the LabVIEW will ask for input, which has to be entered in the format as enter the data for parameters like enter total volume, total time.

Once we entered the input data, it starts progressing like whether the inputs given are in correct format and checks the parameters of both the sensors. Once the parameters are monitored and verified it will make the stepper motor to start. For the given input data, it produces the relevant and desired output for 1ml/min after processing the input. The obtained output in 1ml/min is given as input for the stepper motor in rpm, which starts rotating. It is connected to the shaft, we designed the shaft in the way that it will produce output as 1ml for one rotation. So, based on the rotation of the shaft, the output will be generated.

All these process are done accordingly in sequential manner and the fluid is pumped into the human body. For pumping, the parameter like pressure will be given correctly during measurement itself. In the existing methods, while pumping action takes place due to fast progression the tube placed in the pump may get damaged.

Here, in our proposed method we can avoid damages of tubes and can give exact quantity of drugs at appropriate and correct time.

In our project we have used State machine Architecture (SMA) with the following states.

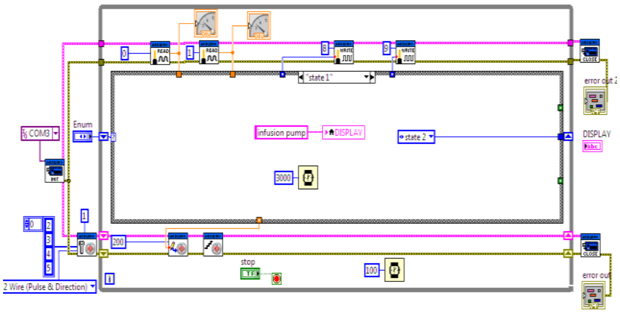


Fig.3 SMA of State 1

STATE 1: Displays the name of the pump and scrutinize the interface of Arduino with Lab VIEW.

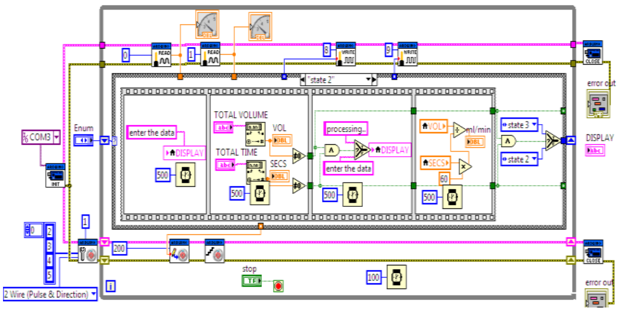


Fig.4 SMA of State 2

STATE 2: Reveals the command as ENTER THE DATA till the data are entered. It parades and processes after the data has been entered.

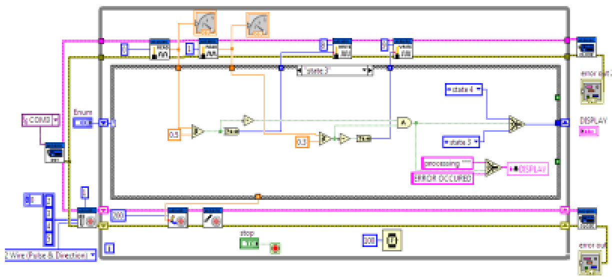


Fig.5 SMA of State 3

STATE 3: It starts programming from the input data obtained from the previous state. If the input data matches with the standard value, it proceeds to next state or if it doesn't match with the standard value buzzer sound is produced along with indication of LED blinking.

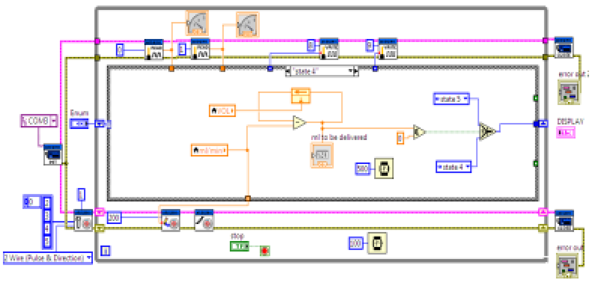


Fig.6 SMA of State 4

STATE 4: The output is obtained for ml/min from which the motor starts rotating with required rpm which also makes the shaft to rotate for pumping the optimum amount of solution to be delivered.

IV. RESULTS

The design and algorithm for the low cost smart infusion pump has been developed with the different parameters for the successful infusion of the drug to the patients at a regular period of time as per the requirement.

Fig.6 Selection mode option for different parameters in Infusion pump

Fig.7 Selection of total time option for transferring the drug in the pump

Fig.8 Developed Low cost smart infusion pump

V. CONCLUSION

This paper presented a way to infuse the drug into the patient at a regular period of time Input data is given virtually and then processed which gives the rpm of the motor. Based on the rpm the shaft gets rotates and thus the drug gets infused.

VI. FUTURE WORK

In future we can develop it to control the pump using remote. It will be very useful for ward nurses. By using single Lab VIEW software program maximum of 4-5 infusion pumps can be controlled.

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