Smart Syringe Infusion Pump

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***Abstract*— Delivery of fluids such as nutrients and medications into a patient's body in a controlled environment is one of the essential prerequisites of a treatment that requires precise flow control. In manual liquid drug delivery systems, fluctuations may occur while operating by a nurse or hospital staff. At present, syringe pumps are used worldwide for healthcare purpose as well as research purpose. Syringe pump is a small infusion pump used for controlled administration of small amounts of drugs or medications to a patient or for use in chemical, biomedical research, etc. With the advancement of communication technology specially internet of things (IoT), there is an opportunity for syringe pumps to be integrated with IoT.**

This project presents an integration of semi-automated syringe pump with IOT for real time monitoring and remote control of fluid flow.

***Index Terms:* Syringe pump, Internet of Things (IoT), Controlled administration of medication.**

I.INTRODUCTION

A syringe pump is a motor-driven precision pump that utilizes one or more syringes to deliver exact and precise amounts of fluid/liquid in high-influence research conditions and also it is a precision based pumping device that can be mounted with at least one syringe for high accuracy conveyance of liquids/fluids/medications. Syringe pumps are generally utilized in clinical area to give a small yet exact measure of medicaments. This is finished utilizing accuracy mechanized frameworks to drive needle cylinders and accomplish desired dosages. Syringe pump settings are utilized to set the measurement in ml for the necessary liquids to be conveyed to patient according to specialist. Syringe pumps are typically mounted on side tables or IV poles for utilization. The settings on a syringe pumps might incorporate direction of flow of the medication, fluid/medication flow rate, time duration for the delivery of fluid/medication has to be done. With this setting we can maintain the delivery of the fluid/medication in desired amounts so as to achieve desired dosages.

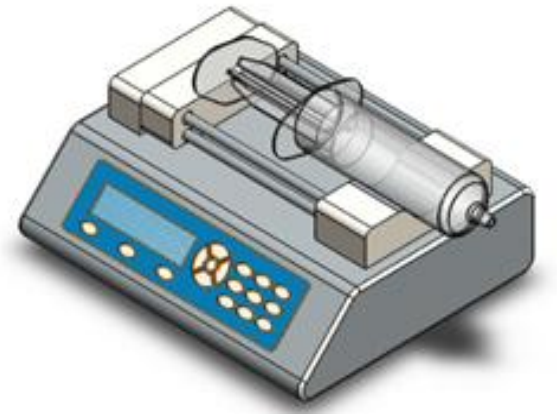

Figure 1: Syringe Pump
Source: https://slidingmotion.com/parts-of-syringe-needle/

This project proposes an Internet of Things (IOT) based syringe infusion pump that can be monitored and controlled by the doctors or staff in charge remotely over the internet. This syringe pump allows the doctor to set, modify the flow of medicament, control the start and stop function of the infusion of pump via the internet as per patient response. The system makes use of a microcontroller to handle the entire processing system, OLED to display settings and other parameters. The device settings may include the adjustment of direction flow, flow rate, syringe size, total dosage to be delivered and so on. Once settings are fed by user offline or over IOT the machine calculates the push rate of plunger. Based on this the motor operates with accuracy to ensure the delivery of fluid gradually at a set flow rate till it delivers the desired and accurate amount of fluid/medicaments and stops automatically with a led alert and online alert signaling the successful delivery of set dosage of the medicament.

II. LITERATURE REVIEW

There are several works conducted to automate the syringe infusion pump, overview of related work done by certain people is given in this section.

G. B. Tejashree, S. Swarnalatha, S. Pavithra, M. C. Jobin Christ and N. Ashwin Kumar together developed a microcontroller-based syringe pump for microfluidic application. In this proposed method the rate of flow of fluid is controlled by LCD screen attached to the DC motor which works on the command of microcontroller, the developed device can control the flow rate of one or more infusion pump simultaneously with different flow rate. The developed device was capable of delivering volume as small as 0.2ml to volume as large as 3ml at the flow rate of 6.25micro litre/sec. [1]

A.S. Samokhin developed an open source syringe pump which is based on Arduino microcontroller. Here the rate of flow is controlled by stepper motor and it consists of a clipper to hold the syringe in position. The developed device can infuse the liquid and refill the empty syringe, infuse and refilling can be done by selecting the mode of operation on the LCD screen. The device can hold syringe with a diameter of 6cm to 25cm. it was observed that for 10ml glass syringe dispended volume was 1 and 5ml with systematic error less than 0.1% and random error less than 3 micro litre. [2]

Linda.M Amarante, Jonathan Newport, Meagan Michheli, Joshua Wilson and Mark Laubah developed an open source syringe pump controller for fluid delivery of multiple volumes. It consists of microcontroller to control the motor which in turn controls the speed of motor to deliver three different volume of fluid with a set duration of time. [3]

Ashish Kumar Patel, Asmita Jha, Amit Patwardhan, Pratik More, Prakesh Viswanathan, Jayant Power and Rabinder Henry together designed and developed an infusion pump foe controlling the flow rate of solution for synthesis of nanoparticles. The device is based on Arduino UNO which controls the stepper motor, stepper motor in turn controls the flow of fluid. The speed of motor is based on the amount of fluid and time selected by the users. [4]

Md. Rakibul Islam, Rushdi Zahid Rusho and Sheikh Md. Rabiul Islam implemented a low-cost syringe pump which is based on IOT for real time monitoring od patient. Here armature voltage of DC motor is varied to generate different flow rates, microcontroller is employed for controlling motor and to communicate between motor and the GSM module which helps in wireless communication. [5]

Surya V, Srutartha Bose, Shreya Kulkarni and Kathirvelu. D developed an automated ocular drug delivering system which is based on open source controller. Arduino is used to control the entire process I.e. motor control for pump movement, input setting for fluid delivering etc., Here the input are given in terms of required drug dose, this drug dose is converted into the number of steps required to run the stepper motor which regulates the flow of fluid. It was observed that for 42 steps a drug volume of 30 micro litre is dispensed with the drop volume ranging from 33.8 micro litre to 63.4 micro litre. [6]

Hasnna Elkheshan, Ibrahim Deni, Alla Baalbaky, Mohammad Dib, Lara Hamawy and Mohamad Abou Ali in Internal Conference on Computer Science and Application presented an integrated system between patient monitoring system and a syringe pump. This idea was presented by considering the absence of patient response during delivery, by this method patient parameters from patient monitor along with the syringe pump can be recorded simultaneously for the estimation of patient condition. [7]

Mohsen Jafarzadeh and Fardad Farokhi together developed an infusion pump which is used for patient who are unable to receive food and drug orally. Survey of foreign country infusion device in Ardebil hospitals and ambulance were made. Incorporating advantage and disadvantage of surveyed device, they developed an automatic syringe pump whose performance was high and speed of injection was to approximately 6s for 1cc during drug delivery. [8]

Muhammad Ahmed Khan, Osam Mazhar and Sameed Tehami designed a microcontroller-based syringe pump for small volume drug delivery. This syringe pup is based on lead-screw mechanism which is driven by stepper motor which itself is based on the microcontroller 89s52, to display the exact amount of fluid delivered or to be delivered is displayed on the LCD screen and also keypad id interfaced with the device so the user can specify the volume of drug to be delivered and the rate of flow of fluid. It is observed that the device was capable of delivering volume as small as 0.1ml to volume as large as 12ml at the delivering rate as small as

0.1ml/hr to delivering rates as large as 999.9ml/hr. [9]

III. METHODOLOGY

In this proposed system microcontroller is the core of the system, it is the communication module between the other general components and the IOT. According to the command given by the user via internet the microcontroller initiates the motor driver circuit to drive the motor in the set speed for particular rate of flow, with a desired amount of fluid.

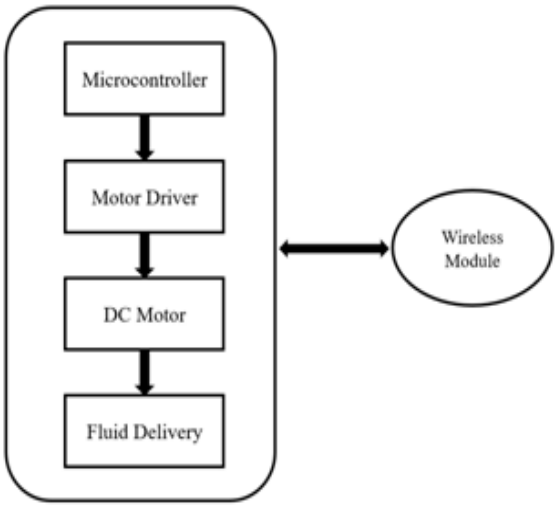

Figure 2: Proposed System

Figure:4.2 shows the schematic block diagram of the proposed system. The proposed system consists of a microcontroller (Node MCU) to control the communication between IOT and other modules present in the circuit, DC motor driver module to control the speed and direction of DC motor, DC motor to drive the syringe module, Key pad to set the required flow rate manually, OLED display for display the settings for fluid control (manual or IOT). Microcontroller its self-acts as a wireless module, where the person can control the device remotely. According the preference set by the user the microcontroller triggers the motor driver circuit to drive the motor which drives the syringe, the value of fluid to be delivered or is delivered from the syringe is displayed on the OLED display screen.

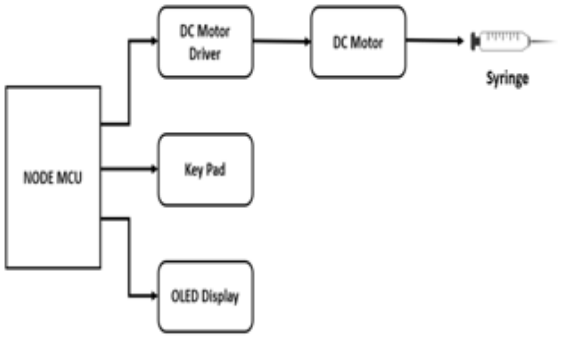

Figure 3: Schematic Block Diagram

Implementation is carried out in two steps:

- To design semi automated syringe infusion pump.
- To design a webpage and interface the webpage with developed syringe infusion pump

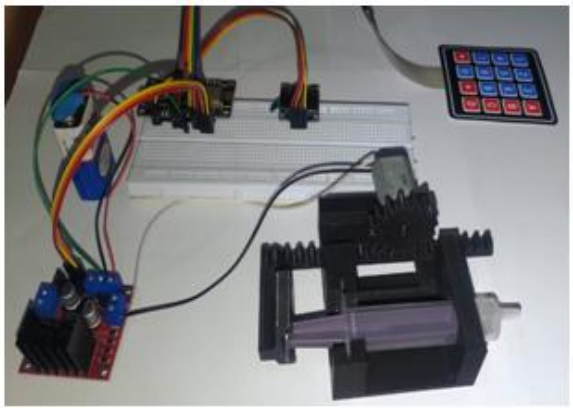

Figure 4: Hardware setup

Above figure shows the hardware setup of the developed syringe infusion pump. Gear mechanism is incorporated instead of screw lever mechanism which drives the motor, motor exerts pressure to the shaft/plunger of the syringe which helps in fluid delivery.

Design of syringe pump is incorporated for 15ml syringe.

To drive the syringe of 15ml have incorporated 0.5v to 6v DC motor with 2000rpm whose speed can be controlled by making use of motor driver circuit. Gear system used are of 16 teeth – driving gear and 16 teeth – driven gear.

The device can be controlled in two conditions:

- Manual condition.
- Virtual Condition.

For manual operation flow is set by using keypad. The amount of fluid/medication to be delivered is set with the help of keypad, according the range set manually the microcontroller triggers the motor driver circuit to run the motor in the desired speed which exerts pressure on the syringe plunger for the flow of medication.

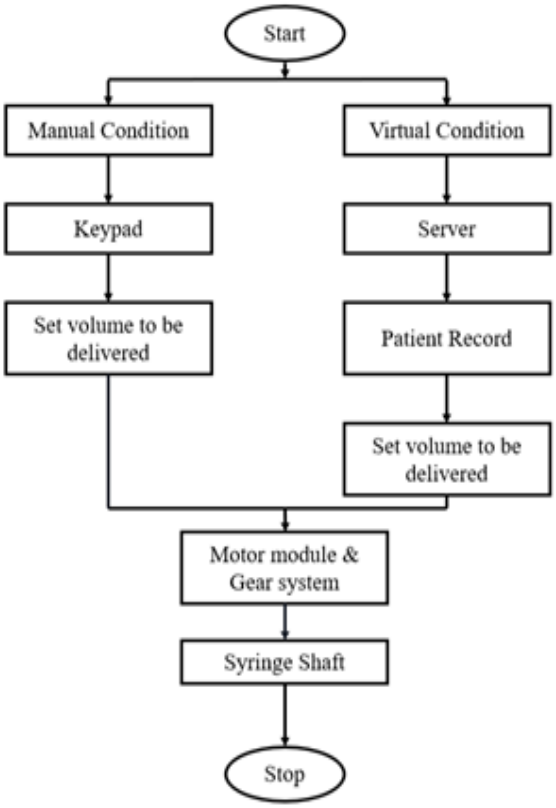

Figure 5: Work flow of Complete system

For Virtual condition the designed syringe infusion pump is interfaced with IOT (Internet of Things), so that the doctor or staffs who is in charge for patient care can control the medication virtually. In virtual condition the required medication volume is set via webpage, once the volume is set (data is requested), microcontroller is initialized (data is requested to the server) which triggers the motor driver circuit for fluid/medication flow. This virtual control of syringe makes the device to be smart.

IV. RESULT AND ANALYSIS

Experimental setup for testing the designed smart syringe infusion pump is same as shown in figure 6.1. Syringe loaded with medication is mounted to the syringe holder, once the device is initialized the user can choose the mode of operation (manual operation or virtual operation). If the user chooses manual operation then the value for volume of medication/fluid to be delivered has to be set with the help of keypad, once the fluid/medication is delivered the amount of fluid delivered with successful drug delivery message is displayed on the screen.

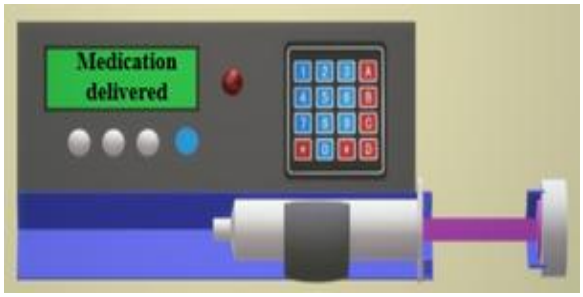

Figure 6: Manual condition result

If the user chooses virtual operation then the value for volume of medication/fluid to be delivered has to be set in the webpage which is being designed.

The designed webpage consists of a data of patients who are in emergency or in ICUs in hospital, the data consists of basic information of patients like ward number, patient ID, patient name, doctor name who is treating the patient, medicine which is loaded in the syringe, amount of medication present in the syringe and the volume of medication/fluid to be delivered. The user who is setting the amount of medication can scroll the green slider to set the volume, once the value is set the user has to submit.

After delivery of fluid/medication message of fluid and volume being delivered is displayed on the webpage.

Figure 7: Webpage for flow control

Figure 8: Message display on the webpage

To know the exact volume of fluid delivered equation of continuity is employed which states that the volume of fluid entering the hole at one end is equal to the volume of fluid leaving the hole at another end, Flow rate is calculated by using the formula:

Q =

Where, Q – Flow rate in m3/sec

v – Volume of fluid

t - time

with this formula the designed syringe pump was able to deliver 15cc of fluid in 45sec, 10cc of fluid in 35sec, 5ml of fluid in 25seconds respectively.

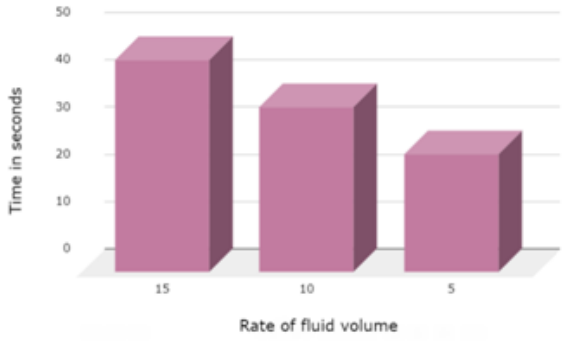

Figure 9: Fluid flow rate graph

V. CONCLUSION

The main objective of this project was to design a syringe infusion pump and interface the designed syringe infusion pump with the IOT, so that the user (doctor or staff in charge) can control the flow rate of medicine/fluid. Designed smart syringe pump can be controlled manually as well as virtually by using webpage and this pump is based on the gear mechanism which exerts required amount of pressure on the syringe shaft/plunger to deliver the fluid.

This smart syringe infusion pump is designed for 15ml capacity syringe, which was able to deliver 15cc of fluid in 45sec, 10cc of fluid in 35sec, 5ml of fluid in 25seconds respectively.

VI. FUTURE SCOPE

This project in future can be made still more accurate which can provide wider application area further we upgrade the device with following features: The device only infuses the fluid, withdraw of fluid can to be done.

- The device can be made fully automated so that there is no human intervention at all while handling the syringe.
- Webpage can be designed for dynamic data.
- Device can be tested with higher volume and size so that it can be utilized in different filed application as well.

REFERENCE

[1] Tejashree, G.B., Swarnalatha, S., Pavithra, S., Christ, M.J. and Kumar, N.A., 2021. Microcontroller-Based Variable Rate Syringe Pump for Microfluidic Application. AI and IoT-Based Intelligent Automation in Robotics, pp.355-369.

[2] Samokhin, A.S., 2020. Syringe pump created using 3D printing technology and arduino platform. Journal of Analytical Chemistry, 75(3), pp.416-421.

[3] Amarante, L.M., Newport, J., Mitchell, M., Wilson, J. and Laubach, M., 2019. An open source syringe pump controller for fluid delivery of multiple volumes. eneuro, 6(5).

[4] Patel, A.K., Jha, A., Patwardhan, A., More, P., Viswanathan, P., Pawar, J. and Henry, R., 2019. Design and Fabrication of Infusion Pump to Control the Flow Rate of Solution for Synthesis of Zinc Oxide Nanomaterial. International Journal of Applied Engineering Research, 14(5), pp.1091-1097.

[5] Islam, M.R., Rusho, R.Z. and Islam, S.M.R., 2019, January. Design and implementation of low-cost smart syringe pump for telemedicine and healthcare. In 2019 International Conference on Robotics, Electrical and Signal Processing Techniques (ICREST) (pp. 440-444). IEEE.

[6] Surya, V., Bose, S., Kulkarni, S. and Kathirvelu, D., 2018. Ocular drug delivery system using open-source syringe pump. Asian Journal of Pharmaceutical and Clinical Research, pp.152-157.

[7] ElKheshen, H., Deni, I., Baalbaky, A., Dib, M., Hamawy, L. and Abou Ali, M., 2018, August. Semi-Automated Self-Monitor-Syringe Infusion Pump. In 2018 International Conference on Computer and Applications (ICCA) (pp. 331-335). IEEE.

[8] Jafarzadeh, M. and Farokhi, F., 2016. Design and construction of an automatic syringe injection pump. Pacific Science Review A: Natural Science and Engineering, 18(2), pp.132-137.

[9] Khan, M.A., Tehami, S. and Mazhar, O., 2015, October. Designing of microcontroller-based Syringe Pump with variable and low delivery rates for the administration of small volumes. In 2015 IEEE 21st International Symposium for Design and Technology in Electronic Packaging (SIITME) (pp. 135-138). IEEE.

AFFILIATIONS

Neuome Technologies Pvt. Ltd. having its registered office at Bangalore Bio-innovation Centre, Helix Biotech park, Electronics city phase-1, Bangalore, Karnataka-560100 has been accorded affiliation to my project related guidance.

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