International Journal of Recent Engineering Research and Development (IJRERD)
ISSN: 2455-8761
www.ijrerd.com || Volume 09 – Issue 02 || Mar - Apr 2024 || PP. 72-77

IoT Enabled Drug Delivery System using ESP8266

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Abstract: The integration of Internet of Things (IoT) technology in medical devices has revolutionized the healthcare industry, offering remote monitoring, control, and data management capabilities. In this study, we propose the development of a syringe pump system leveraging the ESP8266 microcontroller for IoT connectivity. The syringe pump aims to deliver precise and controlled doses of medication or fluids to patients, enhancing accuracy and efficiency in medical treatments. The ESP8266 microcontroller serves as the core of the system, providing computational power and interfacing capabilities with the syringe pump mechanism. Through the utilization of IoT protocols and communication standards, such as MQTT (Message Queuing Telemetry Transport) and HTTP (Hypertext Transfer Protocol), the syringe pump can seamlessly communicate with cloud-based platforms and mobile applications. A key aspect of our proposed system is the integration with the Android studio app, a user-friendly IoT platform that facilitates the creation of custom graphical user interfaces (GUIs) for controlling and monitoring IoT devices. The Android studio app offers intuitive controls and real-time feedback, allowing healthcare professionals to adjust dosage settings, monitor infusion progress, and receive alerts or notifications remotely. Moreover, the cloud-based nature of the Android studio platform enables seamless synchronization of data across multiple devices and access from anywhere with an internet connection. Overall, our proposed syringe pump system represents a significant advancement in medical device technology, offering improved precision, efficiency, and accessibility in medication administration. By harnessing the power of IoT and leveraging platforms like Android studio, we aim to enhance patient care and streamline medical procedures in healthcare facilities worldwide.

1. Introduction:

In recent years, the convergence of Internet of Things (IoT) technology with healthcare devices has revolutionized medical treatment paradigms, ushering in an era of unprecedented connectivity, efficiency, and precision. Among these advancements, the development of IoT-enabled smart syringe pumps represents a pivotal milestone in the evolution of medical instrumentation. This introduction delves into the technical intricacies of such a system, focusing on the integration of Android Studio application development, ESP8266 microcontroller, and syringe pump mechanics to create a sophisticated and versatile medical device ecosystem. At the heart of this innovative system lies the ESP8266 microcontroller, a powerful and cost-effective solution renowned for its robustness, versatility, and compatibility with IoT applications. Leveraging its integrated Wi-Fi connectivity, computational capabilities, and low-power consumption profile, the ESP8266 serves as the nerve center of the smart syringe pump, facilitating real-time communication, data processing, and remote control functionalities. Complementing the ESP8266 microcontroller is the Android Studio application development environment, a comprehensive toolkit for creating dynamic, feature-rich Android applications. Through the adept utilization of Android Studio's versatile development framework, developers can craft intuitive user interfaces, seamless connectivity features, and advanced control functionalities tailored specifically to the requirements of the smart syringe pump system. From dosage adjustment and infusion monitoring to alarm settings and data visualization, the Android application serves as the primary interface for healthcare professionals to interact with and manage the syringe pump device. In the realm of syringe pump mechanics, precision, reliability, and safety are paramount considerations. The mechanical design of the syringe pump mechanism is engineered to deliver precise and controlled doses of medication or fluids to patients, ensuring optimal therapeutic outcomes while minimizing the risk of human error. By integrating this mechanical precision with IoT-enabled functionalities facilitated by the ESP8266 microcontroller and Android Studio application, the smart syringe pump system achieves a harmonious synergy between hardware and software, culminating in a comprehensive and intelligent medical device solution. In summary, the integration of IoT technology, Android Studio application development, and ESP8266 microcontroller in the creation of a smart syringe pump system represents a groundbreaking advancement in medical device engineering. Through the seamless fusion of cutting-edge hardware and software technologies, this innovative system promises to redefine the landscape of medical treatment delivery, offering unparalleled precision, efficiency, and patient care in healthcare facilities worldwide.

2. System Components:

2.1. Hardware Components:

We use several components for the designing of syringe pump. They are,

- ESP8266
- Servo motor (MG996R)
- Potentiometers
- 3D Printed Mechanical Frame Buzzer
- CD Display

2.1.1. ESP8266:

The ESP8266 can serve as the microcontroller responsible for controlling various aspects of the system. The ESP8266 can act as the main control interface for the syringe pump, handling user inputs and commands. It can receive instructions from external sources such as a smartphone app or a web server via Wi-Fi. The syringe pump requires precise control over the movement of its motor(s) to dispense fluids accurately. The ESP8266 can generate the necessary signals to control the stepper motor or other types of motors used in the pump mechanism. By sending appropriate signals to the motor driver, it can control the speed, direction, and steps of the motor to accurately dispense fluids. The ESP8266 can interface with sensors to monitor various parameters relevant to the syringe pump operation, such as fluid flow rate, pressure, and volume. It can read sensor data and make decisions based on this information, adjusting pump parameters as needed to maintain desired fluid delivery characteristics. The ESP8266 facilitates communication between the syringe pump and external devices or systems. It can communicate with a central server, cloud platform, or smartphone app to provide status updates, receive commands, and transmit data related to pump operation. The ESP8266 can implement safety features to ensure the reliable and safe operation of the syringe pump. It can monitor system parameters, detect abnormalities or malfunctions, and take appropriate actions such as stopping the pump operation or triggering alarms to alert users or operators.

Fig 2.1-ESP8266

2.1.2. Servomotor:

The MG996R servo motor offers high precision and accuracy in controlling the movement of the syringe plunger. This level of precision is crucial in medical and laboratory applications where precise fluid delivery is essential, ensuring accurate dosing and minimizing waste or errors. By precisely controlling the rotation of its shaft, the MG996R servo motor regulates the movement of the syringe plunger, thereby controlling the flow rate of the fluid being dispensed. This control allows for consistent and uniform delivery of fluids, making it suitable for applications requiring controlled dispensing rates. The MG996R servo motor's ability to rotate to specific angles enables the syringe pump to adjust the dispensing rate according to the requirements of the application. By modulating the rotational speed and direction of the servo motor, the pump can dispense fluids at variable rates, allowing for flexibility in different scenarios. Some variants of the MG996R servo motor feature feedback mechanisms such as position feedback. This feedback allows the syringe pump system to accurately monitor and adjust the position of the syringe plunger in real-time, ensuring precise control over the dispensing process and enabling closed-loop control systems for enhanced accuracy. The compact form factor of the MG996R

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servo motor makes it suitable for integration into the syringe pump system, even in space-constrained environments. Its lightweight and versatile design make it easy to mount and incorporate into the pump assembly, offering flexibility in system design and implementation. The MG996R servo motor is known for its robust construction and durability, making it suitable for continuous operation in demanding applications. Its reliability ensures consistent performance over time, minimizing the risk of downtime or malfunctions in critical environments such as medical facilities or research laboratories.

Fig 2.2-Servomotor (MG996R)

2.1.3. Potentiometers:

Potentiometers serve a crucial role in syringe pump systems by providing precise control over various parameters, enhancing the functionality and versatility of the device. These variable resistors enable users to adjust and fine-tune critical parameters such as flow rate, volume, and speed of fluid delivery with exceptional accuracy. By incorporating potentiometers into the syringe pump design, operators can manually set and regulate the desired fluid dispensing parameters according to specific requirements or experimental protocols. This level of control is particularly valuable in medical and laboratory settings where precise fluid delivery is paramount for accurate dosing, sample preparation, or chemical reactions. Potentiometers offer a user-friendly interface for adjusting settings in real-time, allowing operators to optimize performance and adapt to changing experimental conditions with ease. Additionally, the versatility of potentiometers enables the syringe pump to accommodate a wide range of applications and fluid types, making it suitable for diverse research, diagnostic, and analytical tasks. Overall, potentiometers play a fundamental role in enhancing the functionality, precision, and usability of syringe pump systems, facilitating precise fluid delivery and enabling a wide range of scientific and medical applications.

Fig 2.3-Potentiometer

2.2. Software Components:

2.2.1. Arduino IDE:

The Arduino Integrated Development Environment (IDE) serves as the primary software tool for programming Arduino microcontroller boards, providing a user-friendly platform for writing, compiling, and uploading code. With its intuitive interface and simplified programming language based on Wiring, the Arduino IDE democratizes electronics and microcontroller programming, making it accessible to beginners and experienced developers alike. Its robust set of features includes a code editor with syntax highlighting, serial monitor for debugging, and a vast library of pre-written functions and examples, empowering users to quickly prototype and develop a wide range of projects. Furthermore, the Arduino IDE supports a diverse ecosystem of Arduino-compatible boards, shields, and sensors, fostering innovation and creativity in fields such as robotics, IoT, and wearable technology. Whether used by hobbyists, educators, or professionals, the Arduino IDE remains a versatile and indispensable tool for realizing creative ideas and bringing projects to life.

2.2.2. EMBEDDED C:

Embedded C, a variant of the C programming language, is specifically tailored for embedded systems programming, where memory and processing resources are often limited. It provides a structured and efficient approach to developing software for microcontrollers and other embedded devices. Embedded C offers features such as bit manipulation, direct memory access, and access to hardware peripherals, allowing developers to interact closely with the hardware of the target system. Its syntax and constructs are optimized for resource-constrained environments, emphasizing speed, efficiency, and reliability. Embedded C programmers must often work with low-level hardware interfaces and manage system resources manually, requiring a deep understanding of the hardware architecture and system constraints. Despite its challenges, Embedded C remains a fundamental skill for embedded systems development, enabling the creation of firmware and applications for diverse applications, including consumer electronics, automotive systems, industrial automation, and IoT devices.

2.2.3. Android Studio:

Android Studio is a powerful integrated development environment (IDE) specifically designed for Android app development. Developed by Google, Android Studio offers a comprehensive suite of tools and features tailored to streamline the process of building, testing, and deploying Android applications. The IDE provides a user-friendly interface that simplifies the development workflow, allowing developers to focus on coding and designing innovative mobile experiences. Android Studio offers robust code editing capabilities, including syntax highlighting, code completion, and refactoring tools, to enhance productivity and code quality. It also features a built-in emulator for testing apps across various Android devices and versions, speeding up the testing and debugging process. Additionally, Android Studio seamlessly integrates with the Android SDK, enabling developers to access a rich set of APIs and libraries for building feature-rich and interactive apps. The IDE supports various programming languages, including Java and Kotlin, offering flexibility to developers in choosing their preferred language. Android Studio further extends its functionality through plugins and extensions, allowing developers to customize their development environment according to their specific requirements. Overall, Android Studio empowers developers to create high-quality Android apps efficiently, driving innovation and creativity in the ever-evolving mobile landscape.

3. Proposed Work:

The proposed system aims to design a syringe pump controlled remotely via an Android Studio application using an ESP8266 microcontroller and a servo motor. This system integrates hardware and software components to create a versatile and user-friendly solution for precise fluid delivery in various applications, such as medical devices, laboratory equipment, and automated processes. The hardware components of the system include an ESP8266 microcontroller, a servo motor (such as MG996R), a syringe mechanism, and associated circuitry. The ESP8266 acts as the brain of the system, facilitating communication between the Android application and the servo motor to control the syringe pump's operation. The servo motor is responsible for actuating the syringe plunger rate, and dispensing time. These inputs are transmitted wirelessly to the ESP8266 microcontroller via Wi-Fi communication protocols. The microcontroller receives these commands and translates them into precise movements of the servo motor, thereby controlling the syringe pump's operation accordingly. The proposed system offers several advantages over traditional syringe pumps. Firstly, the wireless control capability provided by the ESP8266 and the Android Studio application enhances convenience and flexibility, allowing users to operate the syringe pump remotely from a compatible smartphone or tablet. Additionally, the use of a servo motor offers high precision and repeatability in fluid dispensing, ensuring accurate delivery of fluids even in delicate or critical applications. Moreover, the modular design of the system facilitates easy integration with existing laboratory setups or medical devices, offering scalability and adaptability to different environments and requirements. Furthermore, the open-source nature of both the Arduino IDE (used for programming the ESP8266) and the Android Studio platform enables customization and further development of the system according to specific user needs or application scenarios. Overall, the proposed system provides a versatile, user-friendly, and precise solution for fluid dispensing applications, leveraging the capabilities of ESP8266, servo motor technology, and Android-based control interface to meet the demands of modern research, healthcare, and industrial settings.

3.1. Working:

The syringe pump project employs an Android Studio app to interface with users, providing intuitive control over fluid dispensing parameters. Utilizing an ESP8266 microcontroller, the system connects to local Wi-Fi networks, enabling communication with the Android app through platforms like Blynk. Acting as the central control unit, the ESP8266 interprets commands from the app and orchestrates the actions of the servo motor, specifically an MG996R, responsible for precise fluid delivery. When initiated via the app, the ESP8266 activates the servo motor to rotate the syringe plunger, facilitating fluid dispensation at user-defined rates and volumes. Real-time monitoring of dispensing progress is facilitated through the app. Feedback mechanisms, possibly incorporating sensors or encoder feedback from the servo motor, ensure accuracy and reliability by detecting and addressing deviations from desired parameters. This integrated system offers a user-friendly solution for fluid dispensing applications, providing seamless control and monitoring capabilities through the Android app, ESP8266 microcontroller, and servo motor.

3.2. Block Diagram:

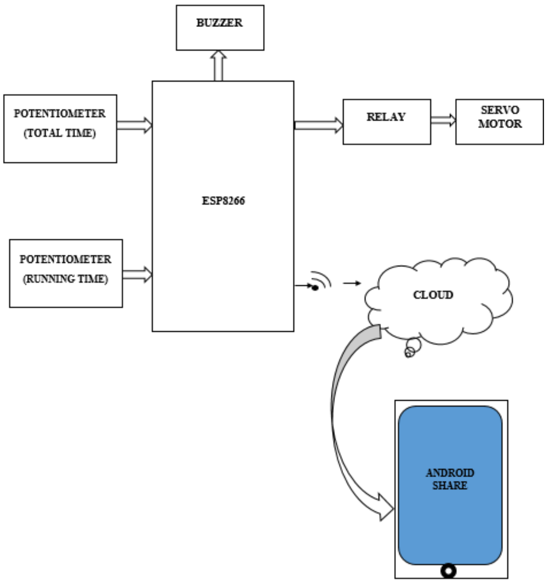

Fig 3.1-Block Diagram of our proposed system

4. Result and Conclusion:

The smart syringe pump successfully integrates the ESP8266 module for IoT connectivity, allowing control and monitoring via an Android Studio app. The syringe pump accurately delivers specified doses of medication or fluids based on commands received from the app. By leveraging the ESP8266 module and Android Studio app development, the smart syringe pump project demonstrates the feasibility of remote monitoring and control of medical devices. This innovation has the potential to improve patient care by enabling healthcare professionals to administer treatments more efficiently and accurately, while also providing real-time data for better patient management. Further refinement and testing are recommended to ensure the system's reliability and safety in medical settings.

Fig 3.2-Output of the app interface

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