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Miniaturized Robotic Intravenous (IV) Cannula Injecting System

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Abstract: *With the creation of a Miniaturized Robotic Intra Venous (IV) Cannula Injecting System intended for continuous, emergency, and portable use, this project presents a revolutionary method to intravenous (IV) therapy. Utilizing an ESP32 microcontroller as its core controller, the system interfaces with a servo motor for mechanical cannula insertion, a MEMS accelerometer for motion tracking, and a TCRT5000 infrared sensor for vein detection. Operational status is provided by an LCD-based real-time feedback method. This innovation, which offers automated, secure, and speedy IV access with improved patient safety precautions like automatic emergency cut-offs on excessive patient movement, is especially helpful in high-pressure settings like trauma care, ambulances, and rural outreach clinic.*

Key Word: *Blynk IoT, ESP32, Emergency Use, IV Cannula, Infrared Sensor, MEMS Sensor, Robotic insertion.*

I.INTRODUCTION

In emergency medicine and hospital care, intravenous (IV) cannulation is essential because it frequently serves as the entry point for blood collection, medication delivery, and fluid administration. However, traditional manual IV cannulation is time-sensitive, requires a great deal of skill, and is prone to human error, particularly when dealing with patients who have trouble gaining venous access or in critical care situations. By introducing a robotic IV cannula system that lessens the need for manual dexterity and improves cannulation accuracy and dependability, this study seeks to address these issues. The suggested gadget is perfect for emergency deployments in both urban and rural areas due to its portability and simplicity of integration into portable platforms.

II.MATERIAL AND METHODS

Literature Review

While robotic and semi-automated venipuncture systems have been investigated by a number of researchers and commercial companies, the majority of them rely on sophisticated technologies like near-infrared imaging or ultrasound, which raise expenses and power requirements. WHO studies highlight the importance of safe venipuncture procedures, particularly in environments with limited resources. Some academic prototypes use expensive robotic arms or vein mapping based on vision, which restricts their portability and affordability. This device is unique in that it makes use of inexpensive, easily available sensors and microcontrollers while preserving essential features like vein detection, movement tracking, and safety-triggered emergency halt. An integrated user interface for real-time monitoring and feedback is also introduced.

Methodology

The ESP32 controller, which was used to build the system, was configured to read data from:
The TCRT5000 IR Sensor locates veins by measuring variations in skin reflectivity; calibrated readings between 10 and 30 show the vein's location.
- MEMS Sensor (Accelerometer): Stops cannula insertion by sending an emergency signal when it detects sudden movement from the patient.

When the IR value verifies proper placement and no movement is observed, the servo motor inserts the cannula.
- 16x2 LCD Display: Indicates current system conditions such as "Emergency Stop" or "Cannula Activated."

The Arduino IDE was used to program each of these modules, and a fake forearm configuration was used for controlled simulation testing.

System Design

The prototype, which integrated all electronic components, was set up on a wooden testing board:
- A regulated 5V supply provides the power.

The fundamental component that controls sensor input and actuator output is the ESP32.
There was a tactile push button available for manually starting the system through the software Blynk IOT.
Accurate vein detection is ensured by continuously comparing infrared measurements to predetermined criteria.

If there is any movement, the servo stops right away, and the user is informed on the screen. Emergency stop button for sudden stop of insertion. Buzzer indication for Cannula insertion.

In clinical labs or mobile medical vans, this architecture guarantees affordability, portability, and simplicity of replication.

III.RESULT

When the system detected a vein that was close enough (N > 10, N < 30), the cannula mechanism was effectively actuated. Statuses like 'Cannula Activate' and 'Emergency Stop Activated' were shown on the LCD. The pictures from the live testing are shown below:

Figure 1: Cannula Activation

Figure 2: Emergency Stop Triggered

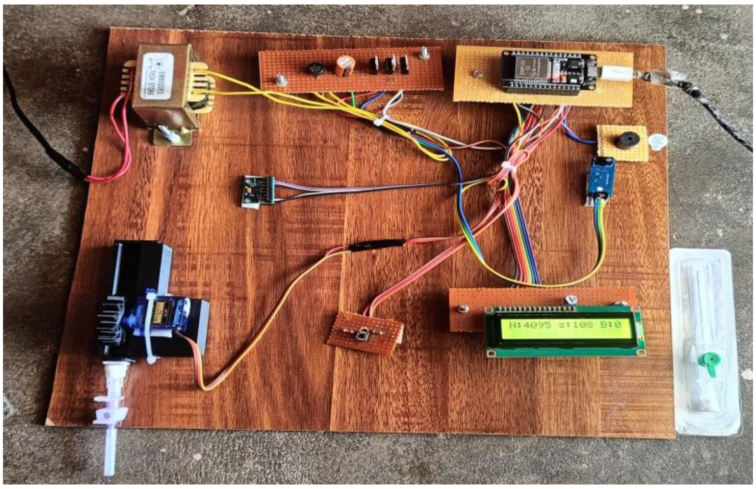

Figure 3: Complete Prototype

Figure 4: Blynk IoT Software Output

IV. CONCLUSION

Reliable automated IV insertion with real-time safety feedback is demonstrated by the developed system. AI-driven motion prediction, wireless control, and camera-based vein visualization are possible future advancements. The approach exhibits great promise for implementation in rural and emergency medical environments.

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