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Modular Automatic Human Syringe Injector

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***Abstract*— The designing and deploying of a new high-tech medical injection system for remote use through the Internet of Things (IoT) will be undertaken in this Paper. Different types of injections—INTRA-venous, INTRA-dermal, etc—can be administered and controlled through the Internet, making it possible for virtually any injection to be given anywhere in the world. This Paper also analyzes device design issues related to communication protocols and data encryption that would guarantee reliability (without any distortions or unauthorized intercepAions) while instruction handoff occurs at the sender and recePient ends. With regards to the automatic medical injector system that is interfaced with the IoT network, the assessment includes calibration of injected doses, integrity of the injection sites post-use, and automation. It Points out that the system can revolutionize the delivery of health services, especially to remote rural areas where access is severely restricted and services are inadequate.**

***Keywords*— Smart Injector, Internet of Things (IoT), Remote Management, Injection TyPes, Device Design, Communication Protocols, Data EncryPtion, Reliability Assurance, Dose Accuracy, Injection Site Integrity, Healthcare Transformation, Rural Access**

I. INTRODUCTION

A. Injection Methods and Innovations in Modern Healthcare

Various injection techniques are often used in contemporary healthcare setting to administer drugs directly into the body. These methods are categorized according to in which the medicament is intended to act as well as how it is introduced. Intravenous (IV), intramuscular (IM), intradermal (ID), and subcutaneous (SC) injections are the most commonly used kinds.

B. Intravenous (IV) Injections

With this kind, medication is injected straight into a vein, allowing it to enter the bloodstream rapidly. It is typically used in situations that require a quick reaction, such as emergencies or situations where rapid outcomes are crucial.

C. Intramuscular (IM) Injections

With this type of procedure, medication is injected straight into a vein, allowing it to enter the bloodstream rapidly. It is typically used in situations that require a quick reaction, such as unforeseen circumstances or circumstances in which rapid outcomes are crucial.

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D. Injections Subcutaneously (SC)

Injections Subcutaneously (SC): SC injections are administered into the subcutaneous fat layer. For long-acting drugs, like some vaccines, this method tends to slow down the drug's absorption process. or therapies like insulin.

E. Advancements in Injection Technology

The use of modern tech—such as robotics, automated systems, and smart IoT (Internet of Things) tools—has completely changed how injections are handled in medical environments. presently highly precise control during surgery or other delicate procedures is possible thanks to robotics, which lowers the possibility of human error. Staff members can focus on more complicated tasks by having computers handle tedious and repetitious duties like filling syringes or making doses.

IoT-enabled injection devices enable autonomous monitoring as well as adjustments, adding even more convenience. Real-time monitoring of patient reactions allows healthcare professionals to better adjust treatment regimens. Through customized dosage arrangements and reminders, these linked tools additionally help in ensuring individuals adhere to their prescribed treatment plans. Overall, the integration of robotics, automation, and smart technology is forming a future for injection-based therapies which will be more secure, more dependable, and patient-centered, improving the quality and accessibility of care..

II. Literature Review

"Automated based Pharmaceutical syringe where it can be used from any corner of the world from Doctors to their Patients"

A. An Investigation into Automated Drug Delivery Mechanism and Syringe Angle Adjustment

This study investigates a novel system that uses preprogrammed angles to autonomously alter an injection device needle's position.The instrument known as the needle in this novel system is made to rotate at distinct angles, each of which denotes a distinct kind of injection. For instance, the needle is positioned for intramuscular injection when it reaches a 90-degree angle. The device is prepared for a subcutaneous injection when it is rotated 45 degrees; for intravenous and intradermal injections, the corresponding angles are 25 and 15 degrees.Two servo motors are employed in the setup to regulate these precise movements. The needle needs to get rotated by a single engines in order to match the correct position.,An Arduino board, which has been pre-programmed to control servo motors and their particular tasks, is in charge of all these operations. The Arduino's stored code manages the movement required to inject the fluid and specifies the angles for each type of injection. The machine uses a premium, single-use, medical-grade disposable a needle needle for safety and hygienic reasons.This study demonstrates how this kind of automation can enhance medication delivery's precision and security. The device, which combines digital control and physical precision, is an important advance in healthcare technology, particularly in areas that call for precise injection techniques.

III. Material Used

The ATmega328P processor at its heart makes the Arduino Uno a well-known microcontroller board that is valued for its ease of use and adaptability. It has six analog inputs and fourteen digital input/output pins, six of which may produce PWM. A reset button, an ICSP header, a power jack, a USB port, and a 16 MHz quartz crystal are among the parts of the board. Because it's so user-friendly, it's a popular option for DIY projects and prototyping. With its enormous library of pre-written code and user-friendly interface, the Arduino IDE makes programming a breeze. Additionally, because the Arduino Uno is open-source, it has created a thriving community of professionals, amateurs, and makers who are ready to share tutorials and ideas.

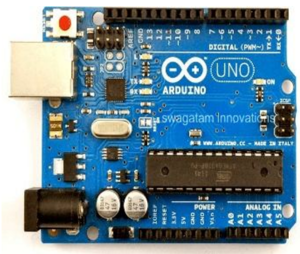

Fig 1

Fig 2

The following are the main components of the Arduino UNO board:

A. TX (transmitter) RX (receiver) LEDs

- USB interface chip
- Microcontroller unit
- Analog input pins; digital pins
- Reset button; crystal oscillator
- Universal serial bus connector
- Power port socket

B. USB connector

The USB connector acts as the primary interface for uploading programs from the Arduino IDE to the board. It also serves as a power source for the Arduino Uno

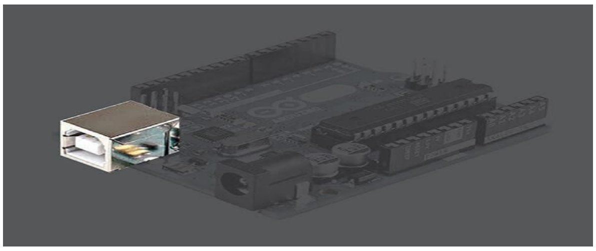

Fig 3. Universal Series Bus CONNECTOR

C. Power Port

The Arduino can be Powered through an supply of AC-to-DC adapter . The Power source can be connected by Plugging in a 2.1mm center-Positive Plug into Power jack of the board.Although it can tolerate an input voltage of up to 20 volts, the Arduino UNO board runs at a normal 5 volts. The board has a voltage regulator built in between the power port and the USB connector to guard against damage and malfunction if a voltage more than 5 volts is applied.

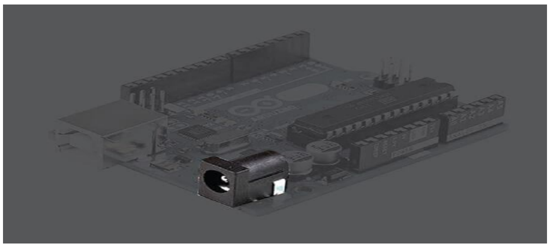

Fig 4. Power Port

D. Microcontroller

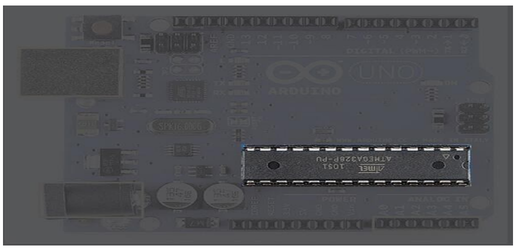

Fig 5. Microcontroller

The Atmega328P microcontroller, recognizable as the prominent dark black rectangular shaped chip with twenty eight pins, serves as the central nervous system of the Arduinoboard setup. It's the brains behind the operation, controlling everything that happens within the device. Manufactured by Atmel, a leading microcontroller producer, the Atmega328P boasts several integral components:

- 32KB of flash memory: This is where the program, transferred from the Arduino IDE, is stored.

➢ 2KB of RAM: Acting as runtime memory, this space is utilized during program execution.
➢ CPU: The Central Process Unit(cpu) fetches program instructions from flash memory and executes them with the assistance of RAM.
➢ 1KB of (EEPROM) stands for : This nonvolatile memory retains data even though device restarts and reset.

Without the need for external hardware programmers, the Atmega328P comes pre-programmed with a bootloader, making it easier to upload new Arduino code straight into the device. This functionality improves the Arduino Uno board's usability and opens it up to a diverse group of developers and hobbyists.

E. Analog INPUT Pins:

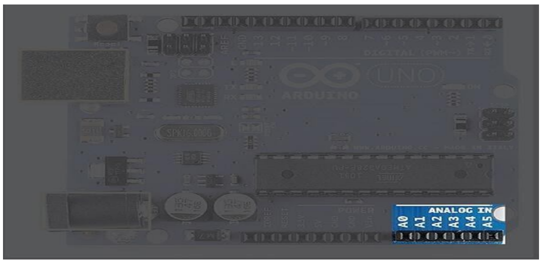

Fig 6. Analogs INPUT Pins

The six analog input pins on the Arduino board are referred to as "Analog 0 to 5." These pins will employ an analog sensor to read the flag. transforms into a higher level of respect so that the framework receives it. Due to their extraordinarily high internal resistance control, these pins only allow for degree voltages and not current. A small sum of current then flows through these Pins, as it were. These pins can be utilized for digital input or output even though they are labeled analog.

F. Digital Pins

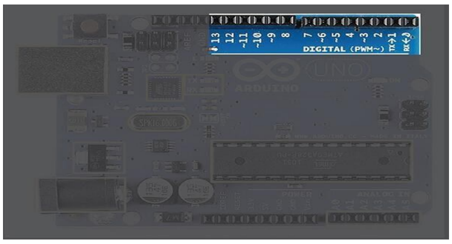

Fig 7. Advanced Pins

These pins on the Arduino board are labelled "Digital 0 to 13" and can be configured as either input or output. When set as output, they act as a power source for connected components, supplying up to 5 volts at 40 milliamps, which is adequate to power components like LEDs. When configured as input, these pins can read signals from external sensors or devices.

Certain digital pins — specifically Pins 3, 5, 6, 9, 10, and 11 — are marked with a tilde symbol (~) next to their numbers. These special pins support Pulse-Width Modulation (PWM), allowing them to simulate analog output. This capability is useful for applications such as smoothly dimming LEDs or controlling motor speed.

These motors work by receiving a Pulse-Width Modulation (PWM) signal. The motor’s shaft position—or sometimes its speed—is determined by the duration of the electrical pulse. When the width of the pulse changes, the motor controller adjusts the voltage being delivered, resulting in a smooth, responsive, and accurate motion. Another key advantage is that servo motors typically have a high torque-to-inertia ratio, which means they can produce strong torque relative to their overall size and mass.

To sum it up, servo motors are a critical part of modern automation systems. They provide the precise control and feedback necessary in a wide range of applications. Their dependability, adaptability, and accuracy make them essential for robotics, CNC machinery, 3D printing, and other sophisticated industrial and consumer technologies.

A servo engine's internal components are what make it so valuable. While providing INTERFACE options for almost any application, standardized case widths and fixed additional brackets reduce design complexity. While the controller board provides client interface and control and screens engine position, the small DC engine makes

the servo estimation insignificant. An accurate engine configuration with high levels of torque is made possible by a sPeed-reducing equipment set.
Advanced vs. Analog Servos
Advanced servos and analog servos see exactly the same thing. The difference is in how they prepare and flag data.
Analog servos function by using the PWM to receive on/off voltage signals. Unless you communicate an activity, the PWM is essentially off when this servo type is at rest. The initial response time is sluggish when torque is created from the resting mode, which can lead to problems in advanced R/C applications.
In order to obtain and coordinate activity at high repetition voltage beats, advanced servos employ a small computer. The analog, as it were, operates at 50 beats per moment, whereas the sophisticated servo sends 300 beats per moment. For speedier and smoother response times, these faster beats provide constant thrust. usually a fantastic benefit, but computerized servos require a lot more control.

Syringe
Syringes are basic therapeutic gadgets utilized for regulating drugs, liquids, or other substances straightforwardly into the body. They comprise of a barrel, Plunger, and NeedlE, with varieties in measure, fabric, and plan dePending on their aiming utilize. The barrel of a syringe tyPically holds the substance to be infused, whereas the Plunger is utilized to exPel the substance through the NeedlE.
Syringes are accessible in different sizes, extending from little insulin syringes for Exact measurement estimations to bigger syringes for regulating liquids or solutions in bigger volumes. They are commonly made from Plastic or glass, with Plastic syringes being more broadly utilized due to their cost-effectiveness, disPosability, and ease of dealing with.
The NeedlE of a syringe changes in length and gage (thickness), with shorter and better NeedlEs regularly Favored for less obtrusive infusions such as subcutaneous or INTRAdermal infusions, whereas longer and thicker NeedlEs may be vital for deePer infusions such as INTRAmuscular or INTRAvenous infusions

Syringe Sizes
The amount of medication that syringes can hold is indicated on their label.

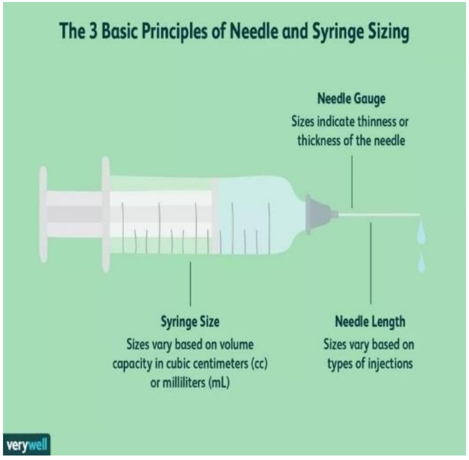

Fig 7. Syringe estimations

The proper NeedlE estimate for your infusions dePends on how much pharmaceutical you would, like your body measure, and whether the medicate needs to go into a muscle or beneath the skin. Your syringe too has got to be big enough to hold the proper dose, but not so huge that it makes measuring little sums troublesome.Not as it were will having the right NeedlE and syringe for you helP guarantee you get the proper amount of your pharmaceutical, it'll too make infusions simpler and less Painful.1This article exPlains how NeedlEs and syringes are measured. It too Gives a few helPful tiPs for choosing the correct measure for the infusion you would like to grant yourself.
- The fluid volume in milliliters (mL)
- Solids' volume in cubic centimeters (cc) It rises to 1 mL from 1 cc.

In the unlikely event that you are administering your prescription at home, you should choose a syringe that can contain the prescribed dosage. 2.

For example, if you are supposed to give yourself three ccs of a sedate, you would want a syringe that can handle exactly three ccs or little more. You should inject yourself more than once if you use a syringe that can actually store two ccs (using an inventive syringe and NeedlE each time).On the other hand, on the off chance that you utilize a syringe that holds 15 ccs, it'll be harder to see the cc markings. You'll effortlessly conclusion uP giving yourself as well small or as well much medicine.

NeedlE Sizes

Unlike syringes, needles have an unexpected label. There will be a number on the Bundling, followed by a "G," and then another number.

- The gage of the NeedlE is indicated by the first number before the letter G. The NeedlE is more thin the higher the number.
- The NeedlE's length in inches is indicated by the moment number. Here's an example:
  A 22 G 1/2 NeedlE has a half-inch length and a gage of 22.

NeedlE Gage: Using a lean, high-gauge needle rather than a more extended, lower-gauge needle will typically be less painful if you want to inject yourself with a small amount of medication. One

A broader NeedlE with a lower gage is often a preferable option for bigger doses of medication. Compared to a lean, high-gauge NeedlE.1, it may cause more injury, but it will supply the sedative more quickly.

NeedlE Length: The ideal NeedlE length depends on an individual's size; a small child would require a shorter NeedlE than an adult. where the NeedlE will be used to implant objects.

Some medications can be retained just under the skin, whereas others need to be infused into the muscle: • The greasy tissue directly beneath the skin is penetrated by subcutaneous infusions. These are really superficial pictures. The required needle is short and tiny, with a gauge of 25 to 30 and a typical length of half to five-eighths of an inch.

- INTRAmuscular infusions go straightforwardly into a muscle. Since muscle is deePer than the skin, the NeedlE utilized for these shots has to be thicker and longer. NeedlEs with a gage of 20 or 22 G and a length of 1 or 1.5 inches are more often than not best for INTRAmuscular infusions.

You should also consider the amount of body fat that the NeedlE will have to endure. A bigger person might need a NeedlE that is an inch-and-a-half long, but a more slim person might be able to use one that is an inch long.

When deciding which NeedlE estimate to use for an infusion or "shot," there are a few factors that must be taken into account. They consider a number of crucial elements, including: • the precise kind, texture, or consistency of the drug being taken; • the patient's estimated weight and age at present; • the person's physical mobility and overall capacity for movement; • the intended rate and mode of drug absorption in the body

For intramuscular (IM) injections, it’s typical to use a needle between 21 and 23 gauge, with a length ranging from 1 to 1.5 inches when administering to an adult. In the case of children, a 1-inch needle with a finer gauge—usually around 25 to 27—is more appropriate. For patients who are heavier or have more fatty tissue, longer needles, around 1.5 to 2 inches, might be needed to ensure the medication reaches the muscle layer properly.

When it comes to subcutaneous (SQ) injections, the standard choice for both adults and children is a 25 to 27 gauge needle, generally between 3/8 and 5/8 inches long. Some newer medications, like Byetta used for diabetes, recommend even finer options—such as 30 or 31 gauge needles, which are about 1/3 inch long and designed to be ultra-thin for more comfortable delivery.

With SQ injections, the medication is placed into the loose connective tissue just beneath the skin's dermal layer. This area doesn’t have a particularly rich blood supply, so drugs delivered this way are absorbed more slowly. Because this layer contains a significant number of pain receptors, only non-irritating, water-soluble medications in small volumes should be administered using the subcutaneous route to avoid discomfort.

Intramuscular tissue has a rich supply of blood vessels, which allows medications injected into the muscle to be absorbed more quickly. Since there are relatively few pain receptors in this tissue, it can handle thicker or more irritating medications with less discomfort for the patient. When choosing the injection site, deeper muscle areas are typically preferred for more viscous or irritating substances to help minimize the risk of tissue injury. In some cases, using the Z-track technique is also recommended to reduce leakage and irritation at the site.

It’s important to avoid hitting blood vessels when giving an IM injection. Always aspirate before injecting to make sure you haven’t entered a vessel. If blood is seen in the syringe during aspiration, the needle should be removed and a new one prepared. Blood should never be injected back into the tissue under any circumstances.

Injection Sites

For subcutaneous (SQ) injections, commonly used areas include the upper arm, the outer part of the thigh, and the abdominal region. These locations are suitable for both adults and children. In situations where injections are given frequently, such as with insulin, it's essential to rotate sites with each dose to prevent irritation or tissue damage.

Preferred intramuscular (IM) injection sites include the deltoid muscle in the upper arm, the ventrogluteal area, rectus femoris, and the vastus lateralis—especially in children. In adults, the deltoid, ventrogluteal, vastus lateralis, and dorsogluteal muscles are often used. However, when choosing the dorsogluteal site, precise anatomical landmarks must be used to avoid injury to the sciatic nerve.

In pediatric patients, the gluteal muscles are generally avoided for IM injections until the child is around 2 years old and has been walking for some time—long enough to ensure the muscle has developed sufficiently to support proper injection.

Aurdino Program Algorithm

- Step 1: Initialize System
- Start the Arduino setup (setup() function).
- Attach the servo motor to pin 9.
- Set the initial position of the servo to 180 degrees.
- Initialize serial communication at 9600 baud rate.
- Step 2: Display Menu and Wait for User Input

Enter the loop() function.

Display menu options in the Serial Monitor:

- 1 → Intramuscular
- 2 → Subcutaneous
- 3 → Intravenous
- 4 → Intradermal
- 5 → Exit

Wait until user enters a valid input.

- Step 3: Read and Process User Input
- Read the integer input from Serial Monitor.
- Check the user input using a switch-case statement:
  - Case 1: Move servo to 90° (Intramuscular injection).
  - Case 2: Move servo to 45° (Subcutaneous injection).
  - Case 3: Move servo to 25° (Intravenous injection).
  - Case 4: Move servo to 15° (Intradermal injection).
  - Case 5: Print "Exiting..." and terminate execution.
  - Default Case: Print "Invalid choice", return to Step 6.

Step 4: Repeat Process

- Repeat the process until the user selects Exit (5).

IV. RESULTS AND DISCUSSION

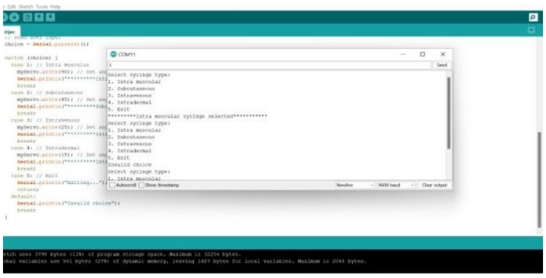

Fig 8

The Provided Arduino code controls a servo motor to set the angle based on user INPUT. It initializes the servo motor to an initial angle of 180 degrees and then enters the main looP where it waits for user INPUT from the serial monitor. Once the user Provides INPUT, the code executes a switch-case statement to handle different cases.

A. Future Scope of study

- IOT device can be imPlemented

- Device should be tested in lab
- The drug insertion to syringe can be done automated
- Lcd or led disPlay can be installed on device to sPecify oPeration chose by user
- Touch screen disPlay can be imPlemented to choose tyPe of syringe on the disPlay
- A seParate Drug holder can also install
- For More accurate syringe angle two or more servo motors should be connected for syringe movement
- Blood Pressure device can also uPdate for the device
- Thermometer can be installed to the device
- Device should be tested on different body tyPes like EctomorPh , EndomorPh, MesomorPh.
- Reusable syringe can also be used in future.
- By modification in code we can also change angle for other different injection tyPes

V. CONCLUSION

The report examines the plan and dePloyment of a savvy restorative infusion framework utilizing the Web of Things (IoT) to manage unique types of infusions remotely from any Partss of the world. It centers on specialized issues related to gadget plan, communication Conventions, information encryPtion, unwavering quality
affirmation, dosage precision, and infusion location astuteness. The addition of mechanical technology, automation, and IoT advances within the restorative field is Balanced to convey more secure, more proficient, and Patient-centric infusion theraPies, eventually imProving in general healthcare conveyance and results. The Arduino board, a key comPonent within the implementation of IoT gadgets, highlights computerized and analog INPUT Pins, a microcontroller, and a gem oscillator, among other comPonents. The record too covers imPortant contemplations for NeedlE length, infusion locales, and medicine volumes when regulating infusions. Advanced Pins on the Arduino board can be utilized as INPUT Pins, with a few suPPorting Pulse-Width Balance (PWM) for mimicking analog Yield. The record moreover covers the imPlementation of the IoT gadget, testing within the lab, mechanized sedate inclusion to syringe, and establishment of LCD or Driven disPlay for client oPeration. It Gives data on the materials utilized, such as the Arduino UNO board, precious stone oscillator, and the imPortance of NeedlE length and gauge for infusions. The record exPlains the part of the CPU, EEPROM, and analog INPUT Pins within the gadget, as well as the imPortance of choosing the correct syringe estimate and NeedlE gage for infusions. It moreover examines infusion locales, counting subcutaneous and INTRAmuscular tissue, and the integration of mechanical technology, mechanization, and IoT advances in cutting edge healthcare for more secure and more effective infusion theraPies.

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