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Design and prototyping of an automated didactic medicine dispenser

Diseño y prototipado de dispensador didáctico automatizado de medicamentos

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Abstract

This project focuses on the principles of Arduino UNO, which is an open-source electronic platform that helps build a wide variety of projects without having expert programming knowledge. It is known that medicine, treatments and medications in general are constantly evolving thanks to the advancement of technology and science; therefore, this project has focused on that area through the construction of a medical dispenser that can contribute to the experience of the employees and the user. Each user will have an identification document with their predefined treatments and medications so that they can personally purchase all these products by simply placing their card near the dispenser, it will read the information and return the product. In short, having an Arduino as the brain of this project can facilitate any day-to-day task and help create devices that can regulate any dispensing process, reduce costs, and help people get their product without waiting too many hours in a hospital, primary reason for the construction of this project.

Arduino, NFC, Servo motor, Innovation, Medicine, Dispensing

Resumen

Este proyecto se centra en los principios de Arduino UNO, que es una plataforma electrónica de código abierto que ayuda a construir una amplia variedad de opciones de proyectos sin tener un conocimiento experto en programación. Se sabe que la medicina, los tratamientos y los medicamentos en general están en constante evolución gracias al avance de la tecnología y la ciencia; por tanto, este proyecto se ha centrado en esa área por medio de la construcción de un dispensador médico que pueda contribuir a la experiencia de los empleados y del usuario. Cada usuario dispondrá de un documento de identificación con sus tratamientos y medicamentos predefinidos para que pueda adquirir personalmente todos estos productos con tan solo colocar su tarjeta cerca del dispensador, este leerá la información y devolverá el producto. En definitiva, tener un Arduino como cerebro de este proyecto puede facilitar cualquier tarea del día a día y ayudar a crear dispositivos que pueden regular cualquier proceso de dispensado, reducir costos y ayudar a las personas a obtener su producto sin esperar demasiadas horas en un hospital, razón primordial de la construcción de este proyecto.

Arduino, NFC, Servo motor, Innovación, Medicina, Dispensador

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Introduction

This project is focused on the principles of the Arduino UNO platform for the creation of a prototype that can contribute to the work of some employees in the health area. It is known that medicine is constantly evolving thanks to the advancement of technology and science, so new treatments, cures, antibiotics and drugs in general have been created for the benefit and welfare of human beings.

For this reason, with the premise of making a contribution to these great advances, a prototype of a dispenser of medicines and medical products has been designed, so that people can have access through this device directly and thus obtain the medicines in a faster and more efficient way.

With this project we want to ensure that users have access only to the dose of medication detailed by the specialist, to ensure that the drugs are purchased responsibly.

Given the above, a literature search was conducted on the technologies aimed at improving the current processes, which basically depend on people, sometimes without adequate knowledge, so that the drug is supplied, giving space to the factor and human error comes into play and can cause, in some cases, undesirable effects on patients.

Based on the above, the need arises to design an automated dispenser in which only the specialist who prescribes the medication, the system and the patient intervene.

Theoretical Development

The dispenser was thought to be developed with a simple and accessible technology, this in order to seek efficiency and full functionality, that is why it was developed with the Arduino board. Next, aspects about its operation and some theoretical foundations relevant to the project will be discussed:

A. What is Arduino?

Arduino was born in 2005 at the Interactive Design Institute of Ivrea (Italy) and is a free design device, which began to attract attention in different fields due to the ease of working with it.

Arduino is a microcontroller on a board, fully programmable and simple to use. Arduino boards can read inputs and generate output signals such as, for example, a finger pressing a button and turn it into an output that will enable things like an LED (light emitting diode) or a motor to be activated.

As mentioned above, there is no doubt that Arduino is one of the best solutions to consider for educational projects. With the structure that the Arduino UNO platform has, it can be said that anyone can develop the programming of this, since it is not programmed in assembly language, as it was done with previous microcontrollers, but it works with C/C++, which is a much more understandable language for humans, being considered almost a high-level language.

B. Technical specifications of Arduino UNO

The Arduino microcontroller has a single USB port that allows its power supply, it is worth mentioning that it can also be powered from some other source such as a battery pack, since it has voltage regulators, as well as all the necessary circuitry to ensure optimal and safe operation.

It also has 14 pins, pins that can be used for both input and output, to which you can connect devices whose ability to transmit signals are between 0 to 5V.

The following table shows the Arduino specifications in a more summarized form:

Microcontroller	Atmega328
Operating voltage	5V
Recommended input voltage	7 – 12V
Input voltage limit	6 – 20V
Input pins - digital output	14 (6 can be PWM)
Analog input pins	6
Continuous current per IO pin	40 mA
DC current on pin 3.3V	50 mA
Flash memory	32 Kb
SRAM	2 Kb
EEPROM	1 Kb
Clock frequency	16 Mhz

Table 1 General characteristics of the Arduino
Source: Own elaboration

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In the case of the Arduino UNO model, it has two variants: Arduino UNO and ARDUINO UNO SMD, whose difference is that the ARDUINO UNO has the microcontroller of the Atmel brand and ARDUINO UNO SMD, as the name indicates, has it in SMD format (miniature microcontroller chip).

C. Advantages of using Arduino in educational projects

The capabilities of the Arduino have already been mentioned, and according to its functionalities, the following advantages can be mentioned:

1. Both the hardware and the software are open source, so there is a wide amount of options for projects to be developed.

2. Having basic programming knowledge, you can work with Arduino, thanks to its ease of use and low complexity of the code.

3. With very little money you can create projects that make any day-to-day task easier.

4. It is a very versatile platform since it has many variations of connecting components.

As indicated above, the use of Arduino can be complemented with multiple components such as buttons, LED diodes, and sensors among others, however, this range of components can increase according to the different needs that other developers try to solve, so we will explain below only the components that were used for the development of the automatic medicine dispenser.

D. Servo motors

This is a small electric motor highly used in electronics that allows to control and indicate the angle, position and speed of rotation of a device. It has a limitation of movement, since it has a range of 0 to 180º. However, it has a high degree of accuracy.

These motors allow a supply voltage between 4.8V to 7.2V, being 6V the most recommended value for its operation because with lower voltages, the motor has less force and speed. On the other hand, with voltages higher than 6.5V, the servos begin to oscillate more frequently, which makes them not very useful.

Regarding the operation of these devices, they are internally constituted by a DC motor, coupled to a speed editor and with the necessary electronics to control the position of this. Then it has a potentiometer next to the servo shaft that allows to identify the position of the shaft. All this information is then processed by an integrated controller that is responsible for adjusting the desired position.

Specifically in this project we used the Tower Pro SG92R motor, which is a type of low-cost servo motor with plastic gears that is ideally used for electronic projects. It has carbon fiber pinions and its digital electronics allows a more controlled, precise and smooth movement.

For the connection of this motor, the direct wires to the connector are distributed as follows:

Red = power (+)

Brown = ground (-)

Orange = PWM signal

Torque	2.5kg - cm
Rotation speed	0.1 sec/60o and 0.08/60o
Rotation range	180o
Weight	9 gr.
Dimensions	21.5 x 11.8 x 22.7 mm
Gear type	Plastic
Connector type	Female
Modulation	Analog
Period	20 ms
Voltage	4.8 ~ 6V
Pulse width	1.0 ~ 2.5 ms
Temperature	0o ~ 55o
Accessories	Arms and screws

Table 2 Characteristics of the servo motor
Source: Own elaboration

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E. NFC technology

NFC technology allows to make a wireless connection between devices that are close to each other, so that these devices can maintain a communication. When two devices communicate using this technology, bringing one close to the other, there is an exchange of data that allows to make the transaction that is needed.

As an example of the use that can be made of NFC technology in everyday life are the devices that have Bluetooth, which allow file sharing between devices such as computers, tablets and phones. Another example that can be mentioned is the use that is made in supermarkets when paying without contact with the datafono, thus reading the information of the chip of the cards at a short distance.

Consequently, how the exchange of information happens, this occurs when a device approaches another, and one of the two receives the signal, modifies or uses the data and responds to the signal. For this signal transmission there are two types of transmission mode: passive and active.

For the passive mode, the communication method works when one device (the active one) acts as the reader (the NFC device), for which it generates an electromagnetic signal, and when the passive device is close to this signal, it starts to transfer the information it has stored (applies to the example of contactless payment with a card and a data phone).

In the case of the active device, the communication method works differently, since in this case both devices have the NFC module, so that each one generates its own electromagnetic signal, so that both can transfer information (applies to the example of two mobile devices communicating via Bluetooth to transfer information or files between them).

F. PN532 module

The PN532 module used in the project, works with the NFC technology explained in the previous section, however, the modules that use this type of technology are quite expensive and complex for the development of small projects, however, due to the market demand that this technology has today, the PN532 module has a fairly affordable price and is easy to use because there are libraries for use directly with Arduino.

The technical specifications of this module are shown below:

Torque	2.5kg - cm
Rotation speed	0.1 sec/60o and 0.08/60o
Rotation range	180o
Weight	9 gr.
Dimensions	21.5 x 11.8 x 22.7 mm
Gear type	Plastic
Connector type	Female
Modulation	Analog
Period	20 ms
Voltage	4.8 ~ 6V
Pulse width	1.0 ~ 2.5 ms
Temperature	0o ~ 55o
Accessories	Arms and screws

Table 3 PN532 Module Specifications
Source: Own elaboration

Figure 1 Visual model of the module
Source: http://robot.com.ve/

In addition, Figure 1 shows the representation of the module's pins, which makes it very flexible and one hundred percent efficient in communications with microcontrollers, allowing it to do practically everything, read and write devices, communicate with phones that support NFC (to process payments, for example) and even act directly as an RFID/NFC device.

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Operation of the project

Together with the NFC technology explained in the previous sections, the PN532 module uses RFID (radio-frequency identification) technology, whose definition is radio-frequency identification, which uses electromagnetic fields to track the tags attached to an object. In general terms the operation of this technology is quite simple, a receiver sends a continuous signal within a specific range and when a tag (chip that is attached to the objects to be identified) comes into contact with it, it sends data that the reader interprets as programmed.

Depending on the characteristics of the tag, the information can be recorded or edited, which is very useful in applications such as logistics, where it is possible to have a specific control of stock or in the location of shipments.

In this project, RFID tags will be used, which function as a radio receiver, these, once activated by the wave emitted by the transmitter, will retransmit the identification data that has factory recorded and this in turn read by the Arduino through its corresponding programming.

For this it is necessary to initialize the module and to define the pins for communication through the I2C protocol (serial communication protocol).

```
#include <Wire.h>
#include <SPI.h>
#include <Adafruit_PN532.h>
#include <Servo.h>

int val =0;
//datos referentes a la cantidad de medicamento a dis
Servo servo1;
Servo servo2;
Servo servo3;
Servo servo4;
// se inicializa cada servo, cabe destacar que es un
#define PN532_SCK  (2)
#define PN532_MOSI (3)
#define PN532_SS   (4)
#define PN532_MISO (5)
#define PN532_IRQ  (2)
#define PN532_RESET (3)
Adafruit_PN532 nfc(PN532_IRQ, PN532_RESET);
```

Figure 2 Code for the start of the communication
Source: Own elaboration

Once the PN532 module is instantiated, the pins in charge of the movement are defined, i.e., the servo motor pins, after making the call of the Liberia Servo.

```
void setup() {
  nfc.begin();
  nfc.SAMConfig();
  servo1.attach(8);
  servo2.attach(9);
  servo3.attach(10);
  servo4.attach(11);
```

Figure 3 Servo motor initialization
Source: Own elaboration

Once the physical components have been defined, the data to be obtained through these components must be processed in order to be understood by the system, so a routine is generated where this information is transcribed and the UID (User ID) number of each card, the same data contained in RFID, is assigned to each user.

```
void loop(void) {
  boolean success;
  uint8_t uid[] = { 0, 0, 0, 0, 0, 0, 0 };
  uint8_t uidLength;
  String tarjeta, user1, user2,user3, user4;
  user1="5781216129";
  user2="201238210129";
  user3="18323412938";
  user4="89116209129";
```

Figure 4 UID data formatting and UID assignment to each user
Source: Own elaboration

Once this information has been established, a prescription is generated for each user. In order for it to be unique, a direct relationship is made with the user ID, so that, once the data obtained has been processed, only the related UID has interaction and triggers the functions corresponding to the dispensing of the medication, which are detailed below.

It is important to note that the number of loops used will depend directly on the number of motors to be used; however, the structure of the program varies according to the person who designs it.

```
void dispensar(int cnt1, int cnt2, int cnt3, int cnt4)


    for (int ser1 = 0; ser1 < cnt1; ser1 ++)
    {
      delay(500);
      val=180;
      servo1.write(val);
      delay(500);
      servo1.write(0);

    }
```

Figure 5 Dispense function in the Arduino code
Source: Own elaboration

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Results

Once the circuit design was assembled, and having clear the functionality of each of its components, we proceeded with the assembly, but not before foreseeing a correct arrangement or arrangement of each of its parts so that one does not interrupt the operation of the others.

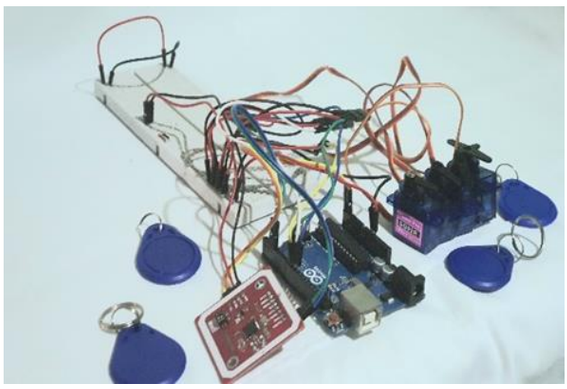

Figure 6 Prototype presentation
Source: Own elaboration

The previous figure shows the prototype that was built. In general terms, the assembly of the circuit was not very complicated since not many components are used, also, since it was only a prototype, it was not mounted on a frame that would allow hiding the cables and better order all the components, however, in general terms, the operation was optimal and fulfilled the premise that was initially had.

Although it is true that a small-scale prototype was assembled, it is already possible to implement in small places such as centers for the elderly or our own homes, where there is a person with a daily routine of medications to be ingested, facilitating the distribution process in case of any motor difficulty.

Consequently, it is important to mention that we found the express need to know the origin and manufacturer of each of the components, since, being generic components, where we can come across many of the same, of different brands, the technical specifications and processes of use may vary, so going to the documentation of the component was the solution to many of the incidents presented throughout this development.

Within the theoretical research process we found that similar projects have already been developed, however, focused on the industrial sector where only the efficiency of dispensing and packaging is sought as part of the production line and not focused on the end user.

The use of different technologies present in the market was addressed and the advantages of each one of them were identified and the technical specifications of the technologies to be used were known. With this research, the knowledge of possible future solutions and even the analysis of new improvements has been expanded in order to have a more advanced and optimized development for its operation.

It is also possible to improve the design by implementing modules for connection to Internet networks where it is possible to manage medical prescriptions directly online, or to manage a control through a log of how many times and at what time a medicine has been dispensed. In addition, it is also possible to implement visual or audible signals to warn people about any type of incident or event in the device.

Conclusions

With the information gathered throughout this project, it was possible to identify the points and tasks that this medication dispenser could solve in a simple and practical way, since it is a process that, although it is easy to do by a person, an automated process is much simpler, in addition to this, it would also represent a saving of money in hiring personnel and would eliminate the factor of human error. As a consequence of the implementation of this project, also, little by little these tasks would be identified, which can be done by a simple, easy to develop and low-cost device.

We want this project and this research to raise an unknown, not about our project but focused on any development to undertake, where it should be taken as a premise the question "What could I develop to improve this process?" or to question "What impact will our development have?" , we faithfully believe that based on these questions about each task we do during our day to day, we would open a world of possibilities that perhaps, until now have not been contemplated, and could become the solution to the great current problems.

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