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# Electronic card applied to the disseminate and collection of information on SARS-CoV-2 in marginalized areas

# Tarjeta electrónica aplicada a la difusión y recolección de información sobre SARS-CoV-2 en zonas marginadas

GONZÁLEZ-SILVA, Marco Antonio*†

*Universidad Autónoma de la Ciudad de México, Academy of Electronic Systems and Telecommunications Engineering, Mexico.*

ID 1st Author: *Marco Antonio, González-Silva* / **ORC ID:** 0000-0002-3327-8047, **Researcher ID Thomson:** U-8432-2018, **CVU CONACYT ID:** 173601

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**Abstract**

According to the World Health Organization, misinformation is a threat to public health. In the case of the SARS-CoV-2 virus, not knowing and rejecting the use of vaccines makes people vulnerable and puts control at risk deaths from contagion in the communities. The information media that have been used to publicize the use of vaccines and other recommendations are mostly digital and radio communication such as Internet sites, mobile applications, radio, and television, which do not have enough coverage in many communities. The development of this project is aimed at showing a portable hardware prototype that allows the disseminating information on the use of vaccines and recommendations to reduce the effects of the SARS-CoV-2 virus in marginalized communities. For this, the design of an electronic card capable of reproducing audio in a chosen language or dialect is presented. The purpose of the audio is to include sectors of the population with communication problems such as illiteracy that could exist in these areas. In addition, the card allows you to save certain geographic data of the places where it is distributed and the possible contagions in it for later analysis.

**Prototype, Disseminating, Geographic**

**Resumen**

De acuerdo con la Organización Mundial de la Salud, la desinformación es una amenaza para la salud pública. En el caso del virus SARS-CoV-2, no conocer y rechazar el uso de vacunas hace vulnerables a las personas y pone en riesgo el control de muertes por contagio en las comunidades. Los medios de información que se han utilizado para divulgar el uso de vacunas y otras recomendaciones son en su mayoría digitales y de radiocomunicación como sitios en Internet, aplicaciones móviles, radio y televisión, los cuales no tienen suficiente cobertura en varias comunidades. El desarrollo de este proyecto va orientado a presentar un prototipo de hardware portátil que permita la difusión de información sobre el uso de vacunas y recomendaciones para mitigar los efectos del virus SARS-CoV-2 en comunidades marginadas. Para ello se presenta el diseño de una tarjeta electrónica capaz de reproducir audio en algún lenguaje o dialecto elegido. El audio tiene la finalidad de incluir a sectores de la población con problemas de comunicación como el analfabetismo que pudieran existir en estas zonas. Además, la tarjeta permite guardar ciertos datos geográficos de los lugares donde se distribuye y los posibles contagios existentes en ella para su análisis posterior.

**Prototipo, Difundiendo, Geográfico**

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* Correspondence from the Author (E-mail: marco.gonzalez@uacm.edu.mx)
† Researcher contributing as first author.

 

## Introduction

According to figures from the World Health Organization (World Health Organization, 2022), on its website on severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), known as covid-19, 519,105,112 cases of infection have been reported worldwide, with Mexico in 21st place with 5,745,652 registered cases. These figures correspond to the month of May 2022.

This virus, which is transmitted between people, has mutated naturally, producing new variants, some of them more contagious (Islam, 2022). In various regions of the world, strategies have been implemented to reduce its spread, such as patient isolation, home quarantine, hygiene, closure of public places, vaccination of the population and dissemination of information through different media such as radio, television, Internet, mobile applications, among others. However, there have also been outbreaks, i.e., an increase in the number of cases of infection and deaths. This is why it is important to maintain some of these measures, such as vaccination and the dissemination of timely information to the population.

In this context, the United Nations (UN) has published that this pandemic has disproportionately affected the population, with indigenous peoples being the most vulnerable due to widespread discrimination. In the information published by this organisation, it is mentioned that governments in each country have had a mixed response, that is, while some implement exclusive programmes dedicated to dealing with the virus in marginalised areas, others do so in a limited or non-existent manner (United Nations, Human Rights, 2020).

Recent studies show that socio-economically vulnerable communities and individuals are at higher risk of COVID-19 infection and death (Watchler et al 2020). This inequality is related to, among other things, poor access to and lack of knowledge about information.

In Mexico, the National Institute of Indigenous Peoples (INPI) has carried out prevention and communication actions towards these communities to address covid-19. These actions include:

a) Distributing food packages in substitution of what is offered in indigenous children's homes and canteens.

b) Liaison with the Inter-Institutional Technical Group (GTI) to obtain information on public health, which in turn is transmitted to the communities. It is not specified how this information is disseminated.

c) Informative actions in social networks and based on indigenous languages on prevention measures to be followed. Use is made of Internet portals.

d) Dissemination of information through cultural radio stations (SRCI).

e) Production of cultural, educational and health materials. The published information does not specify how this material is delivered to the communities.

Although these actions are a great step towards the containment and mitigation of the effects of covid-19 in indigenous areas, it is considered that it is necessary to monitor the results obtained. Some of these actions may even have a short reach, that is, the information is not reaching the whole community, but only certain areas or groups.

The lack of communication technology, which is very common in these regions, limits the coverage of territories far away from the central areas, where the information is disseminated in the first instance. Furthermore, the inclusion of groups with learning and communication deficiencies, such as illiteracy, has not been considered.

The incorporation of new strategies to inform certain sectors of the population and the constant monitoring of all geographical areas is of utmost importance if the spread of the disease is to be controlled and the number of serious cases of infection reduced. An alternative is the use of media that are easy to transport and distribute in hard-to-reach areas where there is little or no communication technology.

## Hypothesis

The design and development of a prototype of a printed and electronic information medium (e-card/e-brochure) will help to disseminate information about covid-19 in hard-to-reach geographical areas and inform groups of people with reading difficulties. In addition, it will be possible to collect information on cases of infection and vaccinated persons in a certain region.

## Objective

To design an electronic booklet capable of reproducing audio and storing geographic data that is linked to information variables about covid-19 in a population. The circuit, which forms the electronic part of the prototype, should be hidden inside a paper leaflet for easy transportation.

To define the structure of the circuit and its operation, this work was based on a prototyping methodology with a quantitative approach. For the hardware part, a development platform with an Arduino microcontroller was used, where the various components were integrated to test their operation and interconnection.

The structure of this work is organised as follows. In section 2, methodology, the techniques used in this project are mentioned. Section 3, development, details the structure, implementation and functional testing of the proposed board. Section 4 presents the tests and conclusions of this work. Section 5, references, shows the documentation consulted.

## Methodology

Because of its evolutionary approach, the prototyping methodology has been used in many of the hardware developments where integrated circuits are used (Poure et al 2000), allowing short-term improvements to be planned and adapted to the needs detected.

In this project, a descriptive prototyping methodology was used. As such, there is no client to specify the functional requirements, but these are defined through the descriptive analysis method and adapted to the needs defined in the context of indigenous communities.

*Requirements gathering and refinement:*

Needs: Disseminate information quickly and concisely in hard-to-reach communities on the use of vaccines and recommendations against covid-19. Adapt information to existing language diversity and reading comprehension problems. Store geographic data on where information is disseminated. From the areas covered, store information on possible covid-19 cases and people with or without a vaccination schedule.

*Functional requirements:*

Prototype to allow audio message to be recorded and played back in different languages or dialects. Allow basic iteration for a user to save binary responses about covid-19. Saving geographic coordinates is desired. Avoid, to some extent, redundancy of saved data.

*Non-functional requirements:*

Maximum hardware dimensions of 20 x 15 cm, for easy transportation and incorporation into printed material (brochure). It does not require the use of the Internet or manipulation with a smart device.

For a better use of the card, it is considered the premise that only one of them can pass from hand to hand between users and be placed in different places for consultation.

*Rapid design:*

Prototype based on electronic cards, playing audio with some switch. The audio will be a message about the use of vaccines and recommendations against covid-19 in different indigenous languages. Use of a controller circuit capable of receiving binary responses from users by pressing two buttons that are included, the responses expected to be received from users have to do with whether or not there are covid-19 cases at home and whether or not the person is vaccinated. This binary data will be stored in an internal EEPROM memory of the circuit and will be related to geographical coordinates that are obtained periodically through a GPS sensor. By means of an algorithm running on the circuit, a spatial distribution of covid-19 cases and vaccinated persons in a given area can be generated.

## Development

According to the rapid prototype design, the block diagram of the electronic circuit is shown in figure 1.

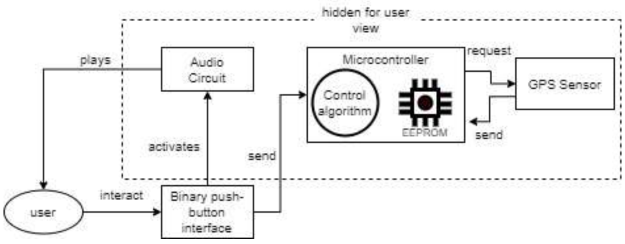


**Figure 1** Block diagram of the electronic circuit of the portable multimedia prototype

The components of the above diagram are discussed below.

A. Audio Circuit. The purpose of this element is to store information in audio format for broadcasting. According to Have and Stougaard 2020, the incorporation of audio in reading materials allows information to be adapted to various needs. In this case, illiteracy, use of different languages or dialects in marginalised communities would be needs to be covered.

For this project, the Ashata FLR100A-B V.1.6 circuit was used. This circuit is capable of recording audio for up to 120 seconds. By means of a push button the user can play back the previously recorded audio.

B. Binary push-button interface. Another objective of this project is to obtain information about covid-19 from the community where the electronic cards are distributed. For this purpose, two push buttons, which are visible to the user and connected to the microcontroller, were used. By means of the information printed on the card or the playback of the recorded audio, the following questions are asked:

- Are there currently COVID-19 positive cases in your household?

- Are there any unvaccinated COVID-19-positive adults in your household?

By means of the buttons, the user enters his answers and these are stored in binary format in the microcontroller according to the status of the button:

Pressed = 1 (affirmative answer).
Not pressed = 0 (negative response).

By joining both binary responses, the following four combinations can be obtained: 00, 01,10,11. Where the first bit in each combination is the answer to question (a) and the second bit is the answer to question (b). This defines the following coding of table 1.

| | Question (a) | Question (b) | Decimal coding (dc) |
|---|---|---|---|
| Response values | 0 | 0 | 0 |
| | 0 | 1 | 1 |
| | 1 | 0 | 2 |
| | 1 | 1 | 3 |

**Table 1** Coding of responses on COVID-19

Push-button data generation has been used in various automation and variable sensing projects, where fast interaction and easy adaptation to prototypes is required (Knapen and Holmgren, 2020).

The pushbuttons used in this project are of the simple open-circuit switch type.

C. GPS sensor. A global positioning system known as GPS (Global Positioning System) can obtain geographical coordinates of any object on earth. For some applications such as tourism, route finding and navigation, the accuracy of these systems is sufficient for their operation, ranging from 3 to 6 metres (Castro et al., 2020).

For this project, the GPS module model GY-GPS6MV2 was used, which has a ceramic antenna and a baud rate of 9600.

D. Microcontroller. When in an electronic system it is desired to control the operation of a given task, the most common solution is to use microcontrollers. Currently, these are integrated circuits that execute instructions stored in their memory and once programmed only serve to perform the planned task (Palacios et al., 2014).

There are development boards with microcontrollers on the market that are the basis for embedded systems solutions, the internet of things, automation, etc. Among the development boards most commonly used in the design of these prototypes is the Arduino from Atmel (Badamasi, 2014).

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For this project, an Arduino nano ATmega328 board equipped with a 1 KB EEPROM was used.

It is in this EEPROM memory where the data obtained from the GPS module is stored. Through the TinyGPS library, compatible with all Arduino architectures, it is possible to decode the signal sent from the GPS and display the latitude and longitude values in decimal coordinates. The format of the possible values obtained for these two variables is shown below:

$$\text{Latitude}_{\text{tyni}} \,/\, \text{Longitude}_{\text{tiny}} = \text{sign} + num_{integer} + num_{fractional} \qquad (1)$$

Where:

- $\text{Latitude}_{\text{tiny}}$ / $\text{Longitude}_{\text{tiny}}$: These are the numeric values of the latitude and longitude variables, respectively, returned by the TinyGPS library.
- sign: positive or negative sign of the returned number.
- $\text{num}_{\text{integer}}$: integer part of the returned number.
- $\text{num}_{\text{fractional}}$: the fractional 6-digit number returned.

Since the values of these variables are stored in binary format, then the following maximum and minimum conditions must be taken into account for their storage:

The possible integer values you can take from the variable $\text{Latitude}_{\text{tiny}}$ are [-90,90].

The possible integer values you can take from the variable $\text{Longitude}_{\text{tiny}}$ are [-180,180].

To eliminate rounding errors due to fractional conversions between decimal and binary systems when storing the values, and taking into account conditions (i) and (ii), it is proposed to use a long type variable in Arduino to store the coordinates returned by the GPS.

Since a long type of variable can only store integers, a conversion will have to be made to eliminate the fractional part of $\text{Latitude}_{\text{tyni}}$ and $\text{Longitude}_{\text{tiny}}$ but without reducing the precision of the numerical value obtained. For this purpose, the following formula is used:

$$\text{Latitude}_{\text{integer}} = \text{Latitude}_{\text{tiny}} * 1000000$$
$$\text{Longitude}_{\text{integer}} = \text{Longitude}_{\text{tiny}} * 1000000 \qquad (2)$$

Where:

$\text{Latitude}_{\text{integer}}$ and $\text{Longitude}_{\text{integer}}$ are the GPS coordinate values of a point whose decimal point was shifted 6 positions to the right.

In Arduino, long is a variable that can store signed numbers between -2, 147, 483, 648 and 2, 147, 483, 64, and requires 32 bits of space. Thus, each stored location point will occupy a space of 8 bytes in the EEMPROM.

Linking COVID-19 responses with GPS coordinates.

According to the explanation of the components Binary push-button interface and Microcontroller, the electronic board obtains COVID-19 data from a community and GPS coordinates.

To make the relation between both data the following formula is used where one of the values obtained in (2) is used

$$\text{Latitude}_{\text{final}} = (\text{Latitude}_{integer} * 10) + dc \qquad (3)$$

Where:

$\text{Latitude}_{\text{final}}$: value linking COVID-19 responses to latitude data of an area.

dc: coding value defined in table 1.

This way the data is stored as shown in figure 2.

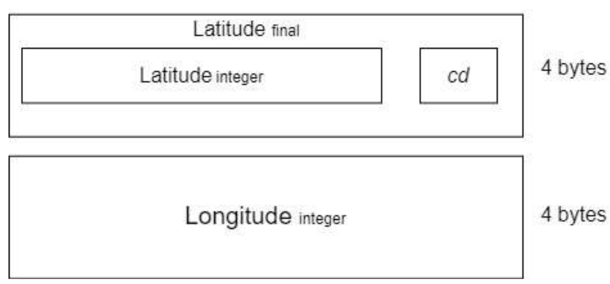


**Figure 2** Storage format of GPS coordinates and COVID-19 responses in EEPROM

To illustrate this process, the following example is described:

It is assumed that a user's answers to questions (a) and (b) had a dc value of 2, according to table 1.

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The data obtained from the GPS in format (1) were:

$Latitude_{tiny}$: 19.426991
$Longitude_{tiny}$: -99.167646

Applying (2) we obtain:

$Latitude_{tiny}$: 19,426,991

$Longitude_{integer}$: -99,167,646

Applying (3) to $Latitude_{integer}$ gives:

$Latitude_{Final}$ = (19,426,991)*10+2 = 194,269,912

As can be seen in this example, in the result of $Latitude_{final}$ the least significant figure indicates the value of cd which seems to have been concatenated to the value of $Latitud_{entire}$. This composite and encoded value, obtained from (3), is the one that is stored in the EEPROM memory. When retrieved, the reverse process is done to obtain the cd and $Latitude_{tiny}$ data for further analysis. For the case of $Longitude_{tiny}$, it does not carry any linked response and is stored in memory as obtained from formula (2).

Control algorithm. This element is the code executed by the microcontroller to coordinate the tasks of the circuit, including data storage.

According to Figure 2, 8 bytes are required to store the geographic coordinates of a point (latitude and longitude) and the responses at that location from a user on covid-19 data in cd-encoding. If it is known that the microcontroller has a memory of 1024 bytes, then up to 128 different points can be stored on a single card.

On the other hand, it is desired to reduce the redundancy of stored data, i.e., not to store the data of a point and its close surroundings more than once. It is considered that, if the data of a point p1 is already stored, neighbouring points located at a distance ≤ X from p1 provide information of the same group of persons.

For this purpose, we consider implementing a function that calculates the distance between two geographic points using Haversine's formula, used in place mapping and information analysis projects (Vinayak et al., 2016), and shown below:

$$d = 2r\sin^{-1}\left[\sqrt{sen^2\left(\frac{lat2-lat1}{2}\right)+\cos(lat1)\cos(lat2)\,sen^2\left(\frac{lon2-lon1}{2}\right)}\right] \quad (4)$$

Where:

d is the distance obtained between two points

r is the radius of the earth (6371 km)

lat1, lat2 are the latitude values and lon1, lon2 are the longitude values of any two points.

In case the distance calculated by (4) between the current point and any other point stored in EEPROM is ≤ X, then that data is not stored. The value of X could vary according to the populations, in rural areas dwellings follow a less uniform dispersion pattern than in cities.

**Tests and Conclusions**

To test the functionality of the proposed circuit, data collection tests were conducted in a square and inhabited area of approximately 39,416 m², located in the municipality of Villa de Tezontepec in the state of Hidalgo, Mexico. Due to the dispersion of houses in this place, an X value of 10 metres was considered, mapping the area as shown in figure 3.

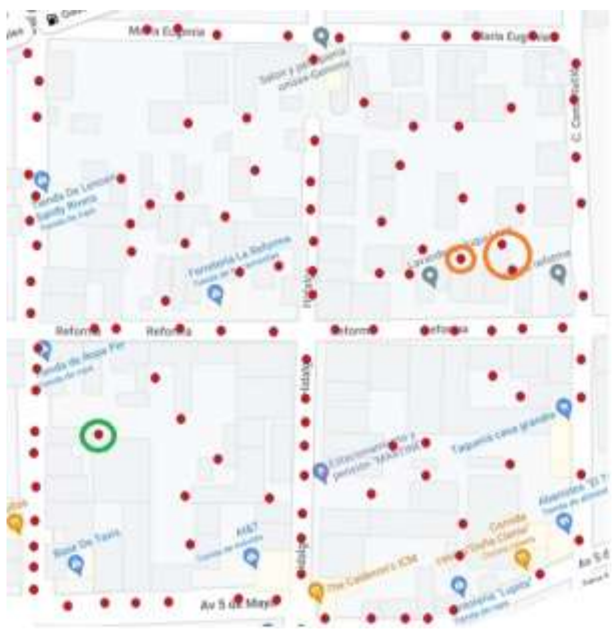

**Figure 3** Measuring data collection via the portable electronic card in an urban area

Figure 3 shows the test area with the location of the data collection sites (red dots). According to the information on the map there are approximately 140 houses and/or businesses in this area, of which 121 samples were obtained, representing 86%.

The collection tests consisted of manually moving the electronic card to each house and/or business located in the area and to which access could be gained. At each location, the prototype was handed to a person who answered the questions via the button interface.

According to the sub-directorate of epidemiology of Hidalgo, in its technical report of April 2022 (Sinave, 2022), there are no active cases of covid-19 in this locality. However, during the sampling, three responses with positive cases were recorded; these points are encircled in orange in Figure 3.

These three points represent 2.4% of the total number of infected samples, which is very close to the 0% that should have been obtained according to official data from the region. It is considered that, due to the proximity of two of these points, it could be the same case; another option is a misinterpretation by the user when using the prototype, generating a false response, or real data, but not officially recorded.

With regard to the cases of adults without any vaccination schedule, only one case was recorded, which is shown in a green circle.

From the data obtained from these tests, it can be seen that there is a favourable trend in the collection of data that coincide with the real data of the population. In addition, a high percentage of the population of an area with certain characteristics can be covered with a single card.

In the next phase of this project, the aim is to carry out tests in areas where there is no control over the prototype's route or assistance to users in handling it.

It will also be sought that the dispersion of houses is greater and test the coverage that can be achieved.

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