International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

Speech Synthesizer Module for a Taximeter

Gabriela León[1], Cesar Hernandez[2]
[1]Faculty of Engineering, Universidad Distrital Francisco José de Caldas, Bogotá D.C., Colombia, gleonc@udistrital.edu.co
[2]Technological Faculty, Universidad Distrital Francisco José de Caldas, Bogotá D.C., Colombia, cahernandezs@udistrital.edu.co

Abstract—*The taximeter is a digital device that calculates the final fare for passengers when using the taxi service. This instrument only informs the user of the amount to be paid visually, where only the cost in Colombian currency is indicated. Segmenting the population of foreigners who do not understand the Spanish language is why the price is paid. For this reason, this article proposes a taximeter model, which, in addition to the visual indication of the final cost of the fare with the date and time to give more security to the user, has a hearing aid in English, obtaining results with a percentage of 84.22% clarity for speakers of this language. Abstract*.

Keywords— *Taximeter, Speech synthesizer, Microcontroller, Pricing, Performance.*

I. Introduction

Public service vehicles and taxis have a digital device that allows them to calculate the cost of a ride (journey) made by passengers from the moment they get into the vehicle until they get off, called a taximeter. [1] The model of the taximeter currently used is similar to the one presented by Rodríguez Rodríguez. [2] This device considers the fare established by law to charge the tour cost and, if necessary, adds the required surcharges such as airport, night, or holiday; it must have some essential characteristics regarding dimensions and visibility. [3]

Currently, in Colombia, taximeters only inform the passenger visually of the amount to be paid using a numerical value, which generates a segmentation for its understanding of visually impaired passengers or foreigners who visit the country and use the service. Additionally, this way of presenting the cost of the race makes it difficult to understand the fee and the corresponding surcharges, sometimes causing excessive charges to passengers who do not understand the fare collection. [4][5]

To solve the problem presented, this article proposes an additional tool to improve the service provided by this means of transport, presenting more complete and transparent information visually, supported by the auditory explanation in English. Acoustic support was provided by a speech synthesizer module (TTS) that can play sounds in Chinese and English. At the same time, the display was improved by utilizing a larger LED matrix display and the clock module to display the current date and time continuously.

Finally, the following article is structured as follows: the related works section, where some pieces that have worked on taximeters and their improvements are presented; the methodology section, where the process carried out for the implementation of the model is exposed; the results section, where the circuit and the different images resulting from the work are evidenced and finally the conclusions section where the findings of the project are presented.

II. Related Work

In different countries, people who use taxi services suffer from confusion when paying the cost of the trip because the meters have been degraded or, due to the little information provided, they are unclear. For this reason, several developments have been advanced that allow additional functionalities for their greater understanding or to prevent their adulteration, such as those presented in the following works.

Chamorro and Antonio propose a prototype of a digital taximeter with a billing printer using GPS technology in the implementation of a digital taximeter using an atmega324P microcontroller. This prototype has a serial communication port through which the current tariff is reprogrammed, taking into account mechanisms against adulteration of the device. [6] Considering the functional tests in a vehicle for data comparison with an approved taximeter and calibration, the results show a remarkably accurate approximation between the total sum of the calculated displacement and the actual kilometers traveled by the vehicle. Additionally, it is concluded that the equipment can be adapted to other GPS equipment and thus increase its characteristics, although it would imply a higher cost.

Esparza Echeverría in Touch Digital Taximeter with built-in anti-theft security presents a model of a taximeter built by taking signals from a VSS sensor (odometer sensor), which transforms mechanical movements of the tires into digital electrical signals to be interpreted by the microcontroller to be able to generate the distance of the trip, elapsed time and the cost of the ride. You have the option to pause, Continue, or reset the values that are displayed. Additionally, the device has a vehicle safety system that controls the ignition of the engine using a four-digit key. The ignition is done using a touch screen, and after three incorrect keys, the system is locked. In the same way, a GPS module is attached, which allows the vehicle to be tracked and alert signals to be sent through text messages to five previously registered cell phones. The results show a better understanding of the cost of the ride by showing the start, time, distance, and fare on the taximeter. [7]

Rodríguez and Gamboa, in Design of a Non-Adulterable Taximeter Mobile Application for the City of Bogota, propose to provide a solution to the problems of adulteration through the design of a taximeter application for the city of Bogota, with the possibility of supervising its registration in real-time from the user's cell phone. This implementation significantly impacted the community, showing positive effects on the community and the authorities. However, there was an impact on the union derived from the taxi sector caused by the incursion of mobile applications for taxi applications. [8]

Finally, although the three works presented above aim to increase comprehension and confidence in the rate offered when using the service, none of them has an auditory aid that allows them to understand what is presented visually. A speech synthesizer module can be used as a listening aid, which is a text-to-speech (CTH) system, or Text-to-Speech (TTS) in English, which allows an input text to be transformed into a voice signal, maximizing the quality of the wave, being of great help to disabled people (Monzo, 2010, p. 70). [9]

III. METHODOLOGY

The development of the model presented in this article is divided into four phases, each of which is a selection of the speech synthesizer module to be used, the choice of the microcontroller, programming, and adjustments of the speech synthesizer module, and the integration of the speech synthesis module with the taximeter (microcontroller, visual and clock module).

Selecting the Speech Synthesizer Module

In the initial phase, the speech synthesis module was selected, starting with a search in the market for existing modules that are compatible with what the taximeter is looking to implement. Once found, a comparative table was presented in TABLE I, in which properties such as reference, price, characteristics, and image are evidenced. According to the search and comparison of the different voice modules, having as selection parameters the delivery time, the cost, and compatibility with the possible microcontrollers proposed for the project, it is decided to use the option to reduce the chance of the voice module (TTS) SYN6988 that can play in Chinese and English languages and has a shorter arrival time when purchased.

TABLE I. Comparison of Speech Synthesizer Modules.

Reference	Characteristics	Price Approximate (USD) (4.000COP)
SYN6288 (see Fig. 1)	Accurate Synthesis: It has a clear, natural and accurate Chinese speaking synthesis effect, it can synthesize any Chinese text, and support English letter synthesis. Control Commands: Supports a variety of control commands, including: synthesis, stop, pause synthesis, continue synthesis, baud rate change, etc.	$18.625
XFS5152 (see Fig. 2)	Speech Synthesis Transmission Module TTS Chip AI Development Board Arduino Compatible	$40.500
XFS5152CE (see Fig. 3)	TTS Speech Synthesis Module Speech Module, Support for Encoding, Decoding, English Chinese Speaking, Arduino SCM Compatible & DIY Board Module Kits -1 x XFS5152CE Speech Synthesis Module	$30.750
SOMO-14D (see Fig. 4)	It's a small audio module that allows you to easily play saved sounds from virtually any embedded device. It supports 4-bit ADPCM formats from 6 Khz to 32 Khz.	$49.000
Diitao 2 (see Fig. 5)	Voice Playback Module, MP3 Player, Music Voice Board, IO Trigger, UART Series Adapter, Micro USB Control Playback Module, I/O Transmission Function, Amplifier Card Compatible with DY-SV5W SD/TF Card	$22.250
SYN6899 (see Fig. 6)	Clear, natural and precise Chinese and English speech synthesis effect. The chip supports the synthesis of Chinese and English texts. Two communication modes: The chip supports two communication modes, UART and SPI. When the user's UART serial port resource was. When you're busy, you can choose to use the SPI interface.	$25.000
DEVMO (see Fig. 7)	Voice Playback Module, Music Player, Voice Messages, Voice Transmission Device, MP3 Trigger Amplifier, Class D, 5W, 64MBit, Arduino Compatible Flash	$24.500
PEMENOL (see Fig. 8)	12V 24V 20W PEMENOL Voice Playback Module High Power Sound Board 64 Mbits MP3 Player Flash Storage 8 Ohm Mono MP3 Support for Arduino	$22.250
Emic 2 (see Fig. 9)	The Emic-2 was designed by Parallax in conjunction with Grand Idea Studio to make speech synthesis a total no-brainer. The module contains all the intelligence needed to parse text into phonemes and then generate a sound naturally, all your controller has to do is send serial strings.	$75.000
EasyVR Shield V3 (see Fig. 10)	It is a multi-purpose speech recognition module designed to add versatile and robust speech recognition capabilities to any application. EasyVR is the third version of the successful VRbot module and builds on the features and functions of its predecessor, in addition to the functions of EasyVR 3.0, such as up to 32 user-defined Speaker Dependent Commands (SD) and 26 built-in Speaker Independent (SI) commands for the basic out-of-the-box controls, the card has an additional inline/headphone audio output, and access to the I/O pins of the EasyVR module.	$55.400 – $100.000

Fig.1. SYN6288

Fig.2. XFS5152

Fig.3. XFS5152CE

Fig.4. SOMO-14D

Gabriela León and Cesar Hernandez, "Speech Synthesizer Module for a Taximeter," *International Research Journal of Advanced Engineering and Science*, Volume 9, Issue 1, pp. 138-142, 2024.

Cf. 5. Diitao 2

Fig.6. SYN6899

Fig.7. DEVMO

Fig.8. PEMENOL

Fig.9. Emic 2

Fig.10. EasyVR Shield V3

Microcontroller Selection

Then, the second phase began with selecting the microcontroller where the Arduino Mega and the ESP32 were compared in characteristics, number of pins, price, and size, as evidenced in TABLE II. Based on the comparison, the ESP32 was selected because it had enough hooks to connect the voice module, the clock module, the visual module, the GPS module (to be implemented in the future) and the buttons for taximeter configuration.

TABLE II. Comparison of Microcontrollers.

Characteristics	**ARDUINO MEGA 2560 (see Fig. 11)**	**ESP-32 CARD (see Fig. 12)**
Device Size	101.52 x 53.3 x 24.9 mm	(18.00±0.10)x(25.50±0.10)x3.10±0.10) mm
Approximate price (COP)	$80.000 - 260.000	$38.900 – 77.000
Pin	54 pins with 49 usable pins	30 Usable Pins 38 Micro Pins
Quantity of TX (UART)	2	2
Amount of RX (UART)	2	2
TX (I2C)	0	1
RX (I2C)	0	1

Fig.11. ARDUINO MEGA 2560

Fig.12. ESP-32 CARD

Programming the Speech Synthesizer Module

Subsequently, when the SYN6988 voice module arrived in the third phase, its programming began, as shown in Fig. 13. First, it started by installing the libraries in the Arduino integrated development environment (IDE) so that the microcontroller could recognize the module and thus work with it. Then, we tested the examples in the two languages the module handles to show their correct functioning with the library and their clarity when speaking. Finally, the basic programming of the TTS module begins, where the test is performed to say different numbers that could be fares obtained from a ride on the taximeter and words related to the project.

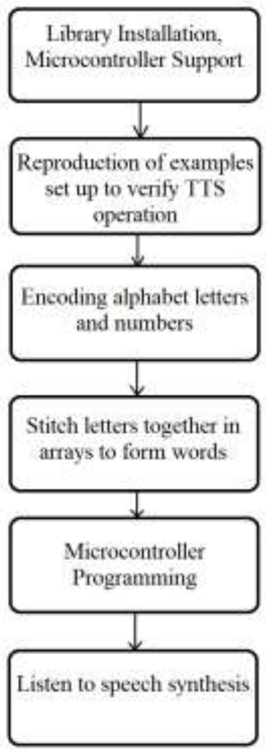

Fig. 13. Flow chart of the speech synthesizer module.

International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

Pricing Module

The last phase was the union of the different parts of the taximeter, following the path established in Fig. 14, which began with programming the operating logic, considering the Colombian legislation given in Resolution 88918 of 2017. [10] Therefore, first, the variables and constants required for calculation and processing were defined; secondly, the taximeter operating modes were defined:

S: When the speed of the taxi is less than the crossing speed, the taximeter should only run for time. When the taxi's speed is equal to or greater than the crossing speed, the taximeter should operate only by distance.

D: The taximeter works with double fare, time and distance, each gradually increments according to the time delta and distance delta, without restarting.

T: The taximeter works in combination with time and distance, if the time is met first, it increments one unit and resets the time and distance, and if the distance is met first, it increments one unit and resets the time and distance.

Once the constants to be used in the taximeter were defined, the clock, visual and voice synthesizer modules were configured so that once the fare was calculated, it could be viewed and listened to in English.

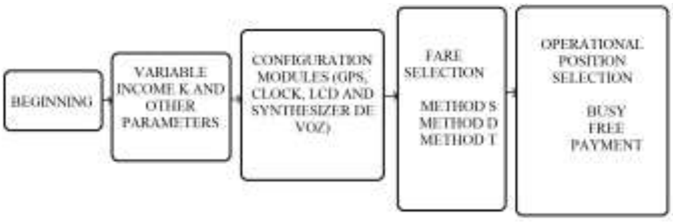

Fig. 14. Flow chart of the pricing module.

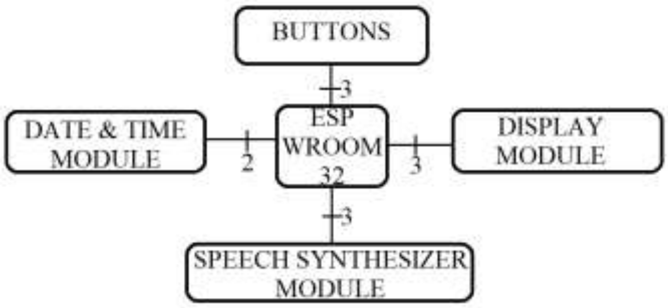

Fig. 15. Block diagram of the taximeter model.

Finally, Fig. 15 shows the block diagram of the implementation with the number of pins used to connect (not counting the power pins). First of all, there are three buttons where the first one is responsible for selecting the type of mode for charging the fare (S, T, and D); the second is in charge of changing the state in which the vehicle is (free, occupied and paid); and the third button is responsible for turning the device on and off. Then, there is the connection with the display module, an array of LEDs that allows you to graphically observe the units, the date, the time, and the rate to be charged. On the other hand, the speech synthesizer module allows the auditory publication of the total fare of the tour in English. Finally, the display module presents the connection to the date and time module.

IV. RESULTS

This section presents the results obtained by joining the different modules to the microcontroller.

Visualization Module

As first tests, the units and the final rate obtained with respect to them were verified; To this end, the units that can be obtained by making a tour of the service are graphically presented in Fig. 16.

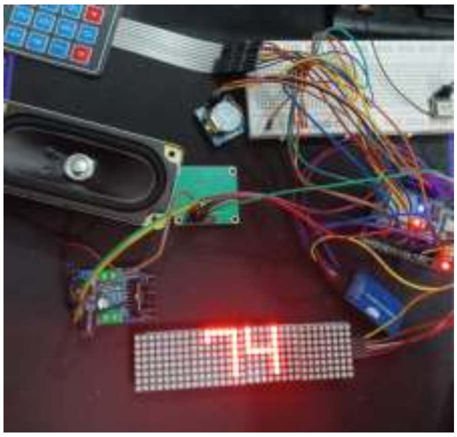

Fig. 16. Display of the final fare of 74 pcs.

Similarly, the device shows the time and date visually; In this way, the user can be sure that the device calculates the cost of the fare for their tour in real time.

As can be seen in Figs. 16 to 18, the display is presented in a clear and large enough way to allow the user to correctly understand the units and the fare to be charged from the back seat of the vehicle.

Speech Synthesizer Module

On the other hand, the tests carried out for the speech synthesizer module began with verifying the delay times that can be presented when playing the final rate after being calculated. TABLE III shows the execution or delay times for four different example rates, which are less than one second, so they do not affect the instantaneous perception of obtaining the fare immediately after the end of the journey.

TABLE III. Delay times presented by the speech synthesizer module SYN6988.

Final Fee / COP	Runtime of the TTS/ms
5.758	116
7.696	116
18.548	116
1.297.153	120

Finally, two tests were carried out to verify the clarity of the speech synthesizer module at the time of reproducing the final rates in English. The first was based on placing five resulting audios to be listened to by Google Translate to see if they could understand them and write the information presented. The information presented in four of the five cases was written

Gabriela León and Cesar Hernandez, "Speech Synthesizer Module for a Taximeter," *International Research Journal of Advanced Engineering and Science*, Volume 9, Issue 1, pp. 138-142, 2024.

punctually, while it was written with some variation in the remaining cases. As a second test, five audios were presented to five people with English language proficiency; in TABLE IV, the results of the intelligibility of the sentences are observed, taking into account the definition given by the RAE (2022) intelligible is something that can be understood and whose measurement can be in two ways: subjective or objective, these can be represented in two scales: STI and CIS of the IEC 60268-16 standard, where 0 is incomprehensible and one is perfectly understandable.[11][12][13][14]

TABLE IV. Intelligibility of the output of the voice module SYN6988.

Test	Description	Percentage of Intelligibility	Remarks
Item 1	“the payment is 13.516”	75%	Completely understandable after more than 3 attempts
Item 2	“the payment is 7.696”	88.4%	
Item 3	“the payment is 6.656”	92%	
Item 4	“the payment is 5.200”	95%	Test audio trimmed at the end but doesn't affect intelligibility
Item 5	“the payment is 5.825”	91.8%	

Finally, taking into account the results obtained, the speech synthesizer module has an average intelligibility average of 84.22% based on the two tests performed, which on the STI scale is Excellent.

V. CONCLUSIONS

The evidence presented above shows that it is possible to make a taximeter model with an audible indication of the amount to be paid after using the taxi service using a speech synthesis module.

The use of the speech synthesis module can be of great help to the population of foreigners who make use of the taxi service and do not understand the amount to pay because being indicated in English and having an average percentage of intelligibility of 84.22% will allow this part of the population to have a better understanding of the fare charged.

Finally, the visual presentation of the date and time, together with the units and the final rate, gives the user a high degree of assurance that the price charged is the fairest.

REFERENCES

[1] "Application Regulations for the Use of Control and Safety Devices for Passengers of Vehicles That Provide Transport Service in Conventional and Executive Taxis," Agencia Nacional de Tránsito, 2011, Quito.
[2] 2 M. V. Rodríguez, "Taximeter with clock based on the 8749 microcontroller," 1993, April 1, http://bibdigital.epn.edu.ec/handle/15000/10568.
[3] 3 District Secretary of Mobility, 2014.Decree 400 of 2014. District Registry 5439 of 2014.
[4] 4 L. P. Ballén, "Yellow Fever in Bogota, Taximeters Out of Control," 2013, http://repository.urosario.edu.co/handle/10336/4339
[5] 5 "Ministry of Mobility investigates taxi driver who overcharged tourists," 2023 District Secretariat of Mobility, Retrieved September 25, 2023, https://www.movilidadbogota.gov.co/web/node/553.
[6] 6 C. Chamorro, & M. Antonio, "Implementation of a prototype of a digital taximeter with billing printer using GPS technology," 2014, XXV Conference on Electrical and Electronic Engineering. https://bibdigital.epn.edu.ec/bitstream/15000/17150/1/2014AJIEE-31.pdf.
[7] 7 J. A. Esparza, "Touch Digital Taximeter with Built-in Anti-Theft Security," 2014, Master's Thesis, Universidad Técnica del Norte, 2014, Retrieved from http://repositorio.utn.edu.ec/handle/123456789/2348.
[8] 8 A. M. Rodríguez & J. F. Gamboa, "Design of a Non-Adulterable Taximeter Mobile Application for the City of Bogotá," (2017), Retrieved from: http://hdl.handle.net/11349/6087.
[9] 9 S. C. Monzó, "Modeling the quality of the voice for the synthesis of expressive speech," 2010, Doctoral thesis, Universitat Ramon Llull, TDX Tesis Doctorals en Xarxa, http://hdl.handle.net/10803/9145.
[10] 10 Resolution 88918 of 2017, Superintendence of Industry and Commerce, 2017, Retrieved September 22, 2023, https://www.sic.gov.co/sites/default/files/documentos/022021/Resolucion-88918-de-2017.pdf
[11] 11 "Intelligible. In the Dictionary of the Spanish Language," Real Academia Española, RAE, Retrieved September 29, 2023, from https://dle.rae.es/inteligible.
[12] 12 D. ProAudio (DoPA), "Intelligibility and Its Measurement, Prediction and Improvement. STI," 2019, 8 December,Retrieved from: https://www.doctorproaudio.com/content.php?2480-inteligibilidad-medicion-sti-rasti-stipa.
[13] 13 S. F., "ITS Voice Intelligibility," NTi Audio, Retrieved from: https://www.nti-audio.com/es/aplicaciones/sistemas-de-evacuation-y-megafonia/inteligibilidad-de-la-vozb sti#:~:text=The%20norm%20IEC%2060268-16,"Common%20Intelligibility%20Scale").
[14] 14"Spanish Association for Standardization", 2021 UNE-EN IEC 60268-16:2020 (Ratified), Retrieved from:https://www.une.org/encuentra-tu norm/seek-your-norm/norm?c=N0064962.

Gabriela León and Cesar Hernandez, “Speech Synthesizer Module for a Taximeter,” *International Research Journal of Advanced Engineering and Science*, Volume 9, Issue 1, pp. 138-142, 2024.