Inclusion and Technology: A Cultural Journey From Hearing Loss

Maribel Aragón García
Instituto Politécnico Nacional

Eduardo Bustos Farías
Instituto Politécnico Nacional

Yaxkin Flores Mendoza
Instituto Politécnico Nacional

Mexico's fusion between inclusion, culture, and technology has been undervalued. Despite multiple attempts to include people with hearing loss in various cultural spaces, technology is not exploited to reach them. The objective was to design and validate a mobile application that explains a mural through a 3D animation using Lenguaje de Señas Mexicano, (Mexican Sign Language, LSM) so that people with hearing loss do not have to depend on someone to understand the information. The waterfall methodology was used, and each part was created sequentially. As a result, the acceptance of the project reflected the need for technological solutions that support the reality faced by people with hearing loss. The work shows that it is possible to contribute to the reality of those living with disabilities. This proposal is a precedent to begin studies and developments based on the day-to-day experience of the public, whose quality of life is to be improved.

Keywords: *mobile app, sign language, natural language processing*

INTRODUCTION

Currently, within Mexico City, CDMX, there are around 4,637,405 people with hearing impairment (total or partial hearing loss) (INEGI, 2014). The city has 185 museums (Museums of Mexico, 2019); 32 of them are part of "The Network of Museums for the Care of People with Disabilities," of which, 24 have a guided tour by people trained in LSM to give a tour through the museum, and give an explanation of the exhibited works. However, in case of high demand, the group of people could not be properly served. As it could be observed, the problem of inclusion concerning people with hearing disabilities is evident. Most museums do not have support for people with this problem (Mexico City, 2019). This is a limitation for cultural recreation. The project was intended to promote the use of electronic devices and consequently optimize the way of making the tours within a museum room.

On the other hand, there have been projects that sought to support the inclusion of people with hearing disabilities in Spain, where a PDA (Personal Digital Assistant) was used with the information of the museum and guides especially. This promoted the awareness of providing information available to everyone (CNSE Foundation, 2009). Action that in Mexico is still recriminated, it was observed that there

is a very notorious problem of the use of technological material for people with hearing disabilities since despite technological advances, the applications to support inclusion are limited and the existing ones are little oriented to real life. Now, LSM is a natural language with its own grammar, capable of expressing thought through the movement of the hands. It is also about the mother tongue of the deaf and its natural communicative form (Escobedo, 2017).

For this reason, it was proposed to translate the information to the LSM, as this is considered his mother tongue. Animations made the explanation in the Mexican sign language, so the communication was similar to their daily life. On the other hand, we have Natural Language, which is used daily to communicate between humans. Spanish, English, and French are examples of natural languages. They have syntax and grammar and comply with the principles of economy and optimization, although they contain many ambiguities. They have evolved alongside humanity; on the contrary, formal languages are used to transfer information, leaving no room for ambiguities. Some examples of formal languages are mathematics and programming languages. Computer equipment can handle formal languages without problems. However, one of its main challenges is understanding natural language. For this purpose, there is a computer area dedicated to the interaction between computer equipment and the languages spoken by humans called Natural Language Processing (NLP) (Vicomtech, 2018).

While there are already several applications to translate into sign language, most use ASL (American Sign Language), being the dominant language in America (NIH, 2021). However, it is not the most used in Mexico. Besides that, they only offer support for the English language. That said, we see that it excludes a large part of the Mexican population that uses LSM (Mexican Sign Language), being so that the applications that offer the translation service, do not really satisfy the need for communication between people with hearing disabilities and those who want to learn to interact with them. Therefore, these points of reference were taken to establish as an objective the interpretation of Spanish to LSM (General Law for the inclusion of people with disabilities, 2011)

The purpose of this project was to make a mobile application that focused on finding a different option with the aim that people with severe hearing loss (hearing impairment) or deafness could approach the cultural information in a visual way, without having to schedule an appointment for some explanation. In general terms, it works as a guide where the user through a QR code accesses the information of a mural. Consequently, an animation is shown explaining the information about the section of the mural consulted. This is visualized in Mexican sign language. So, this project in addition to promoting inclusion, is also a step to its independence in cultural spaces.

In addition, thinking that the user had access to the application anywhere, the application is portable. It was made for the Android operating system to facilitate interaction throughout the course of the exhibition, taking into account its accessibility among users, in addition to its great recreation through the Mexican market, taken as the most used Operating System (Google Play Apps, 2019).

The system for translating natural language text into Mexican sign language was achieved using neural networks. All the information collected from the objects was recorded in Spanish, using desktop software to perform the translation to LSM. It had the option to make subsequent updates by an administrator user so that the information entered in the desktop application was the input so that the user could visualize it with LSM animations in the mobile application.

A major challenge facing language processing is the wide variety of language processing with different grammatical rules and regional variations for the same language. This causes a lack of generalities in the proposed solutions. Therefore, the algorithms often have to be adapted specifically for each language, or they work only for one of them.

In recent years the use of artificial neural networks has boomed for many applications of artificial intelligence, and language processing is no exception since several neural network architectures have been adapted for it, in particular deep networks of recurrent type, in which it is about understanding multiple levels of increasing complexity and abstraction. (Moreno, 2017).

SOFTWARE DESIGN AND METHODOLOGY

The project was carried out between August 2018 and December 2019. the methodology used w"s "Casc"de" (Pressman, 2010), better known as the classic model, since the development will flow sequentially by knowing the requirements of the system flowing linearly. When having sporadic contact with the museum, the requirements must be specified from the beginning having adequate planning for the software. The methodology included 5 stages: analysis, design, coding, testing, and maintenance.

It began with the analysis of the system, focused on knowing the technological and social requirements to reach the objective. The next thing was to make the design proposal for the interface of the mobile application and one for the desktop. With this the coding was carried out, once finished tests and maintenance were carried out to identify if something required adjustments.

In the first stage, the requirements of all the system elements were established. Technological solutions were assigned to each requirement to understand and assign the relevance of the implementation according to the objective for which it was created, considering the main characteristics of the mobile application and the desktop application, as well as the functionality they must have.

The second stage was developed in order to facilitate its use to the user. A simple design was proposed, visually adapted to be intuitive because it must guide the implementation of the requirements as described, which are relevant for the increase of the project, immediate creation of a design prototype for those requirements that are difficult to model. The design can be continuously modified as construction progresses (redesign). At the end of this stage, the Use Cases are documented.

The third stage corresponds to the coding at the end of the Use Cases. Unit tests of the groups or submodules developed are carried out.

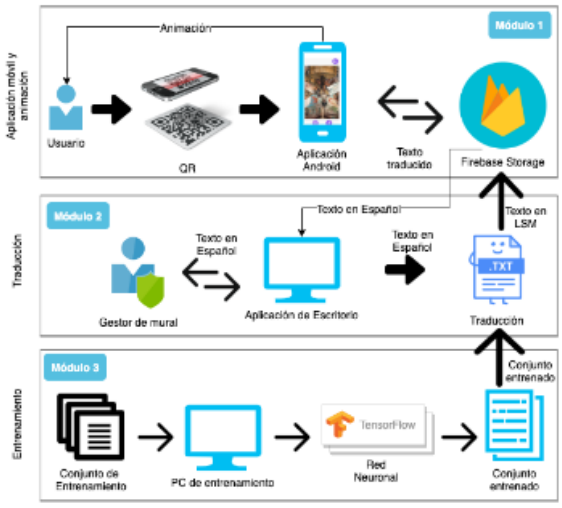
The fourth stage corresponds to the tests from verifying that the unit tests that are created must be implemented with the use of a structure that allows them to be automated in order to notice if the specific objective of each Use Case has been met, based on what the client specified, and on the other hand, note possible changes or improvements to be made about the operation or the business. At this point acceptance tests are performed.

The fifth and last part is maintenance at the end of the tests, performing corrective maintenance in case of having found failures in any module (development of a Use Case), or evolutionary maintenance for when possible improvements were detected to the performance of the application or the effectiveness of the algorithm that has been implemented.

Design and Architecture

The modules were defined according to the functionality, which can be seen in Figure 1, determining that there would be three, which are divided into components. Each component has a specific task that is directly related to each other.

FIGURE 1
SOFTWARE ARCHITECTURE



Source: Authors.

Module 1 corresponds to the mobile application and animation. Module 2 corresponds to translation using the desktop application. Module 3contemplates training.

Training Module

Natural language processing allows us to perform different operations on a text, from classifying, interpreting, and even translating from one language to another.

A set of data was defined to be able to train the neural network according to the context required needed in the translation. In terms of the mural, it was historical context about capitalism and socialism. This set was divided into a training set and another for tests so that a series of sentences translated from Spanish to LSM determined this file. We had to seek support to understand the world of LSM since it is a task that requires a lot of time and effort. In addition, personnel were trained in the language to verify that the sentences were correctly written and confirm that the translation was also correct.

Recurrent neural networks do not have a defined layer structure but allow arbitrary connections between neurons, even being able to create cycles. With this, it is possible to create temporality, allowing the network to have memory. These are very powerful for everything that has to do with the analysis of sequences, such as text analysis, sounds or video (Google Developers, 2018). These neural networks can “memorize” parts of the inputs and use them to make predictions.

As for coding, when using Neural Networks, translation was achieved, taking into account the semantics and ambiguity of the sentences in a given text. It used an encoder-decoder architecture with an attention mechanism called Bahdanau. Both the encoder and decoder had GRU cells. The trained set contained the checkpoints for translation in the translation module.

Translation Module

It was required that the end user who administered the desktop application had the following installed: Python 3.7, TensorFlow 2.0, and Scikitlearn, to make the translation works. In other words, the use of the neural network had to be functional. The text entered in Spanish by the user had to be concise, simple, and grammatically understandable since it is how the neural network could perform the translation with fewer complications and more accurately. The translated file in LSM was stored in Firebase Storage, to be able to perform queries from the mobile application in module one.

Mobile Application and Animation Module

Through the mobile application, the animations of the explanation of the interpretation of the mural were visualized, thus making the query through the QR code with the ID belonging to the mural.

Animating an object to show the movements of the signs in LSM was essential because it is the closest way to explain in the most accurate way possible how a sign person communicates, emphasizing that making animations is not a simple task. They required the validation of a person with extensive knowledge in the language and likewise of deaf people.

At the end of the development, according to the architecture, unit tests of the groups or submodules developed were carried out to validate that the objective of being understandable and easy for the user was met. Corrective maintenance was carried out for cases in which points of improvement were found to the application's performance or to the effectiveness of the algorithm implemented to finally move to the acceptance tests carried out by people with hearing loss.

RESULTS

A dataset of 1437 words was obtained for the training; the network yielded a percentage of success of 83, in which the context of murals was used, specifically of capitalism and socialism, with phrases or short sentences to more extensive. The animations were validated by personnel with constant use of the LSM language, making observations regarding body position, speed or fluidity of the animations, correct rotation of the limbs, the position of each joint of the fingers, and in some cases, even gesticulation. The mobile and desktop application was used, evaluated, and accepted for ease, usability, and design issues by sign language users. The applications allow you to add more sections of the mural, as well as modify the content of these.

In addition, it contains additional information about the author of this. You can reproduce the explanation of the mural consecutively from beginning to end or in sections, as required by the user. Another good aspect is that the mobile application has an introductory video in LSM that explains how to use the application.

DISCUSSION

During the research, some applications developed around natural language and sign language were found (Sign Telling, ProDeafTranslator, Mimix Sign Languahe Translator, and the bilingual Mexican sign language for better access to people with hearing and language problems at the regional history museum of Aguascalientes). However, none focused 100% on the reality of people with severe hearing loss or deafness, causing them to have certain deficiencies not in functionality but in usefulness for their day to day.

As for the use of devices on loan to make the tour, it was identified as a limitation since it has been seen on different occasions as proposals like these are feasible for a limited period given that when used by multiple people, the devices run a greater risk of lowering their performance and consequently not responding adequately for an optimal experience and even begin to have fewer devices. Consequently, it is considered that the use of loan devices is not the best option in the long term. If we add another factor to this shared usage, such as that all people have full knowledge of the use of the device, this is another dependence so they could take the journey as autonomously as possible since not everyone has the same level of technical knowledge. What we are looking for is not to add the complexity of use, but to be a facilitator in activities that we should all be able to enjoy in the same way. That said, the app adds value in terms of language familiarity and the fact that you can use a personal device.

CONCLUSIONS

There is a vulnerable or little-recognized sector in terms of the need to relate to everything and everyone, particularly when we talk about culture. There is a lot to contribute to the deaf society and a lot of work to be done in order to really include them in the hearing society.

As for the cultural sector, there are several tours in museums with translators. However, no system has really cared about understanding deaf people. The systems that exist, for the most part, have been created by hearing people, which means that few existing projects take into account the reality of the lives of deaf people and their way of learning when creating them, so these systems are useless. As for documented knowledge, no texts mention the importance of gesticulation when communicating with signs.

As future work remains much ahead, this project can be extended to more than one mural, considering other contexts, not only culture. For this, it is necessary to widen the neural network training set to have a higher percentage of success in the translations. Additionally, many more animations would have to be created, and each of them must be approved by a deaf person or with extensive knowledge and frequent use of LSM, to know that the sign is really understood. Another important point would be to be able to make a dictionary endorsed by deaf people, which can be included in the dictionary from basic words to words that, for a deaf person, could be difficult to understand. Include not only a short definition but complementary to it, that is, a series of examples where each word could be used. This, among many other things that, as a society, we need to be intentional to be able to affirm that there really is an inclusion to this group of people.

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