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Augmented Reality (AR) in fingerprint systems for the inclusion in society of people with limited abilities (auditory and language)

La Realidad Aumentada (RA) en sistemas dactilológicos para la inclusión en la sociedad de personas con capacidades limitadas (auditivas y de lenguaje)

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Abstract

At present the various forms of communication are essential in addition to being a paramount parameter for the human being, since it allows and facilitates relating, expressing and, above all; transmit or exchange information. All of the living beings communicate in diverse ways, with the use of symbols, audio, images, movements and most importantly through a language composed of words. It is usual to encounter people with some type of physical or mental limitation. According to data from Instituto Nacional de Estadística y Geografía (INEGI), there is a great number of people with speech and hearing impediments, in Michoacán, for every 1,000 inhabitants there are 69 people with some kind of disability, from which approximately 19.4% of this population can relate directly with speech and communication problems. The majority of the people in any situation lack the ability and knowledge necessary to establish effective communication with people that suffer this type of limitation, like hearing and visual impediment. This is why the presented investigation aims to contribute a model proposal, through the Information and Communication Technologies (ICT's), with the tools of Augmented Reality (AR), that gives and permits the user manipulate accessible and intuitive interfaces, so that the people with hearing and speech disabilities can establish a visual-text communication without the need for intermediaries and with their own sign language.

ICT's, Dactilológico, Auditory Disability, Communication, Augmented Reality

Resumen

En la actualidad las diversas formas de comunicación resultan ser esenciales además de ser un parámetro primordial para el ser humano, ya que le permite y facilita relacionarse, expresarse y, sobre todo; transmitir o intercambiar información. Todos los seres vivos se comunican de diversas formas, haciendo uso de algunos distintivos como lo son los símbolos, las imágenes y los movimientos, sobresaliendo de forma notoria e importante el idioma compuesto principalmente de palabras. Es usual encontrar personas que padecen alguna limitación como una discapacidad física, así como una limitación referida a una enfermedad mental. Según datos del Instituto Nacional de Estadística y Geografía (INEGI), existe una gran cantidad de personas con capacidades auditivas y del habla limitadas, en Michoacán por cada 1,000 habitantes existen 69 personas con alguna discapacidad, de las cuales aproximadamente el 19.4% de esta población se relaciona de forma directa con problemas del habla o para comunicarse. La mayoría de las personas de diversas instancias carece de las habilidades y conocimientos necesarios para realizar una comunicación eficiente y eficaz con personas que padecen este tipo de limitación, como puede ser la discapacidad auditiva o visual. Por ello la presente investigación pretende aportar una propuesta de modelo, mediante las Tecnologías de la Información y Comunicación (TIC´s), a través de herramientas como la Realidad Aumentada (RA), que brinda y permite al usuario manipular interfaces accesibles e intuitivas, para que las personas con discapacidades auditivas y del habla pueda llevar a cabo una comunicación visual-texto sin necesidad de intermediarios y en su propio lenguaje de señas (dactilológico).

TIC´s, Dactilológico, Discapacidad Auditiva, Comunicación, Realidad Aumentada

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Introduction

The communication, is to transmit and receive messages in an alternative way, is based mainly on language. At present it is very common to find people who suffer from physical and mental limitations, communication with people belonging to this sector sometimes presents many difficulties, since most people in any field lack the necessary skills and knowledge To make effective communication with people who suffer from this type of limitation such as hearing or visual disability, the need to have an inclusive society in all senses requires the participation of citizens, government authorities and social organizations, including educational institutions, to benefit equity and equality as well as social justice with people excluded in education and society.

A population with a disability is one that is identified as having some type of physical or mental limitation for more than a period of six months or permanently, which makes it impossible for it to develop its activities within the margin that is identified as normal for a person. Likewise, language disability was defined as the loss or restriction of the ability to produce and transmit an understandable meaning through speech.

The implementation and use of Information and Communication Technologies (ICTs), are aimed at enhancing their use and access to them for all users without any distinctive, so that it improves the quality of life through various tools that provide accessible and intuitive interfaces such as the Augmented Reality (AR), which allows one of its many facets to capture specific sign language gestures made in front of a specialized device, thereby improving the accessibility of content for the people with limited capacities. Within this range of communication possibilities, we find several options such as the manual alphabet (dactilological) which is a system that allows communication to be carried out by highlighting its execution and visual or tactile communication.

Communication is mainly done through phonemes (sounds), sometimes it is not possible to use an auditory medium to establish communication, so alternatives are investigated to be able to establish such communication, an essential tool nowadays, using systems such as sign language among others.

Which indicates that the deterioration or lack of this auditory communication is not an impediment to achieve establish the process of transmission of information between one person and another, since you can establish a communication through other alternatives as they turn out to be visual elements, substituting oral or written language.

Therefore, communication is a barrier that must be faced by people with serious problems in their auditory and visual systems. In order to achieve effective communication, it is important to seek and find various alternatives, within which the use of touch, which becomes the most important resource, takes on special importance. The general objective of this research is to generate the design of a model as a proposal through the use of ICTs, in order to carry out the learning and use of sign language to establish effective communication with people with limited abilities auditory and language.

Theoretical Framework

Communication and information have become important tools today, are very important to be informed and communicated, in addition to allowing excel in the day to day in this competitive society, so there is a factor that stands out and plays a role Transcendental is communication, which is properly defined as the exchange of ideas, messages and information. (UNESCO, 2014), as illustrated in figure 1.

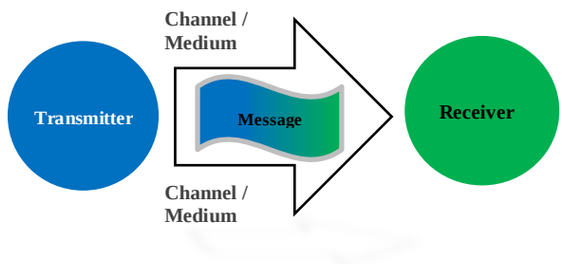

Figure 1 General context of the communication process
Source: Self made

The communication between people is based primarily on the language emphasizing the oral, which consists in transmitting and receiving messages in an alternative way. In general terms, communication is the process by which the Transmitter and the receiver establish a connection at a specific time and space to transmit, exchange or share ideas, information or meanings that are understandable to both. (Thompson, 2008).

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The language is the sum of various sections through which living beings can communicate ideas and / or feelings, either through speech, writing or other conventional signs, using all the senses to achieve communication. The language is of vital importance in the society, since it is an articulator system of conventions between individuals, that makes possible the social practice. Learning language is learning its different modes of occurrence. These modes of occurrence can be reactive or active in nature. (Ribes, 2007).

The main form of communication between human beings is the language spoken through signs (written), but this form is not always given, since for people with different abilities these means can not be used to make their needs or thoughts known. , which is why other means of visual communication are used such as signs, photographs, drawings, gestures, etc..

Languages (oral, written, corporal, gestural ...) influence the perspective of reality and can establish a criterion of the world. Languages build culture and this allows creating and identifying the various social groups. All people are unique, possessing diverse characteristics and living a life different from that of everyone else. More, however, most people have a set of common skills and abilities that usually occur in most people, in different situations and for different reasons, some of them lose or do not develop in the same way that most said skills. Therefore, these people may be affected due to various problems in different aspects of their lives, coping with different types of disability depending on the type of problems or skills or organs that show some variation.

A population with a disability is one that is characterized by presenting some physical or mental limitation for a period or permanently, which makes it impossible for it to develop its activities within the range considered normal for a human being. The General Law for the Inclusion of Persons with Disabilities defines a person with a disability as any person who, due to congenital or acquired reasons, has one or more deficiencies of a physical, mental, intellectual or sensory nature, whether permanent or temporary, and that when interacting.

With the barriers imposed by the social environment, can prevent their full and effective inclusion, on equal terms with others (Official Gazette of the Federation, 2016), it is essential to analyze the context of a person with disabilities (Figure 2), to understand and identify the needs of this sector.

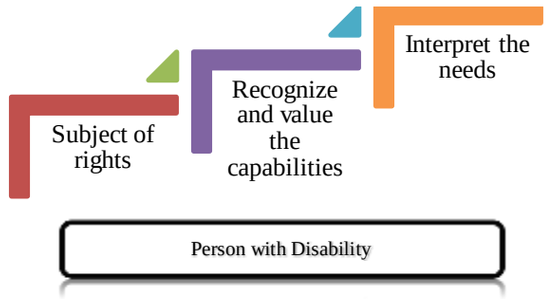

Figure 2 Description of the term person with disability
Source: Self made

The disability by state in Mexico, reflects significant numbers, according to the national survey of population dynamics 2014, it has a population rate with disability of 60 people on average per 1,000 inhabitants (Figure 3).

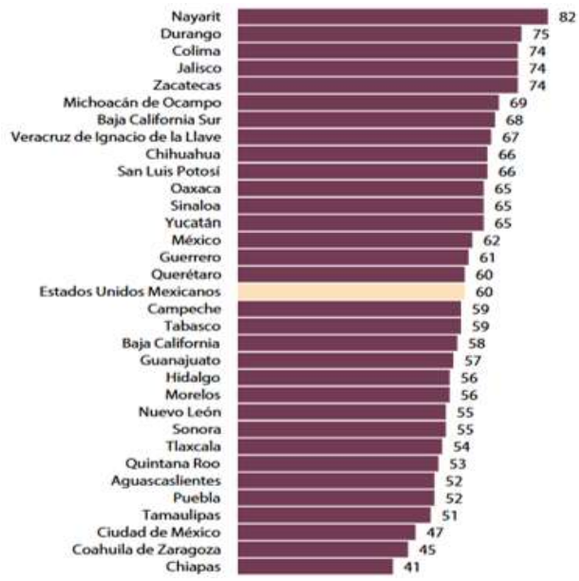

Figure 3 Rate of population with disabilities, by state 2014 (per 1,000 inhabitants)
Source: INEGI. National Survey of Demographic Dynamics 2014. Database. (INEGI, 2017)

There are several disabilities that afflict this sector of the population, among which may be mentioned, **1) physical or motor, 2) visual, 3) auditory or speech, 4) intellectual and 5) psychic**. (Gómez, 2005)

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Pointing out in a timely manner the people with hearing impairment, like other people, require equal opportunities to access all services on equal terms, also associated with language disability, which was defined as the loss or restriction of the ability to produce and convey an understandable meaning through speech.

There are several types of disabilities in the Mexican Republic, as shown in Figure 4, the percentage was calculated based on the total population with disabilities. (INEGI, 2017). The sum of the percentages is greater than 100, since a person can have more than one type of disability.

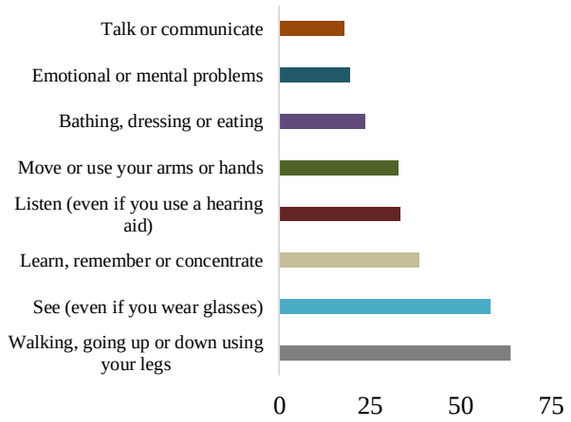

Figure 4 Percentage of population with disabilities, by type of disability 2014
Source: INEGI. National Survey of Demographic Dynamics 2014. Database. (INEGI, 2017)

The primary means of communication for people with hearing disabilities (PDA) is sign language (LS), although they use the textual form (that is, in written form) the disability impacts on the possibilities of educational access for people and approximately 29.9% of PDAs are illiterate. (Sánchez Orea, 2016).

According to the INEGI, 0.62% of Mexicans have difficulties to listen and, in addition to the discrimination and exclusion to which they are subjected, the biggest problem they face has to do with communication, because the vast majority of them did not learn their natural language since childhood, in adulthood they have affected their cognitive, educational, social and labor development.

The LS represents most of the time the only way of communication for this population. This language is sometimes unknown or there is simply little interest in learning it, which makes an important task for the integration of this population difficult because communication is essential for human relations, especially in the labor field.

The language used by deaf and blind people is an iconic language, also called sign language, which encompasses various forms of non-verbal communication, through body movements that have a specific meaning. Gesturing is another variant of non-linguistic communication based specifically on audio and touch.

There are tools to counteract the hearing disability such as the Mexican sign language, which is defined as the language of a deaf community, as shown in figure 5, consists of a series of gestural signs articulated with the hands and accompanied by facial expressions, intentional gaze and body movement, endowed with linguistic function, is part of the linguistic heritage of this community and is as rich and complex in grammar and vocabulary as any oral language. (Diario Oficial de la Federación, 2016).

Figure 5 Mexican Sign Language -Alphabet- (Seen by the viewer)
Source: (Lassal, 2014)

Within this range of possibilities we find the manual alphabet or dactylographic alphabet which is a communication system used by deafblind people, highlighted by its visual execution for deaf people (due to its visual or tactile communication), considered as a common communication system and unified.

The sign language (from the Greek "daktilos" -dedos-, and "logia" -science-, "science of the fingers") is a communication system that allows to know information through the technique of using the fingers of the hand. This system provides auxiliary support to the phonology of sign language, as well as artificial visual systems to disseminate information. Fingering is the technique of spelling and communicating with fingers or with the manual alphabet. (Del Real & Angel, 2014)

Information and Communication Technologies (ICT) are an invaluable tool at present, since it is considered indispensable in many areas, it provides people with quick access to a large amount of information, serving as a new communication channel that combines almost all media, such as writing, images and sound, is mass-produced, personalized and allows interaction between senders and receivers. ICT are conceptual theoretical tools, supports and channels that process, store, synthesize, recover and present information in the most varied way. (Corrales, 2009).

Likewise, technological resources coexist based on the use of ICT specifically designed to provide the possibility and faculty of accessibility to people with disabilities. Highlighting the use of technology in the creation of new tools to achieve an inclusive society, through innovative methods and techniques such as Augmented Reality (AR). The incorporation of Information and Communication Technologies in teaching and learning processes is gradually displacing traditional methods. (Martínez & Carracedo, 2012)

The RA systems use cameras or any other device that allows to capture the real world image and through another combine the image taken, with virtual objects, to later show by means of some device an image of mixed reality (real and virtual) towards the user, as shown in figure 6.

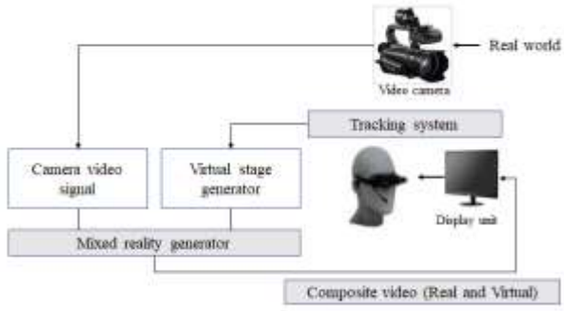

Figure 6 General scheme of augmented reality
Source: (Ponce, Ornelas, Lucio, Padilla, & Toscano, 2015)

The RA is a variation of virtual environments, in virtual reality the user is immersed in synthetic environments and is isolated from the real world that surrounds it. On the contrary, the augmented reality allows the user to see at all times the real world to which virtual objects are superimposed, coexisting both in the same space. (Martín & Brossy, 2017).

The development of the application will be carried out taking into consideration characteristics such as, iterative development, requirements management, use of the architecture (components), visual modeling and verification of the quality.

There are arbitrated documents that narrate a proposed solution to communication with people with hearing disabilities, using the sign language of Mexico, of which the following stand out: 1) The identification of signs using image processing techniques (Martínez Gutiérrez, Rojano Cáceres, Bárcenas Patiño , & Juárez Pérez, 2016) and 2) The Mexican sign language translator glove for deaf people (Hernández Sol, et al., 2017), providing the basis for the research carried out.

Methodology

To carry out the research, a study was designed that is based on eight stages, which include the 1) research proposal, in which the objectives and research questions are set out with the objective of identifying the scope and goals to be covered; followed by 2) feasibility of the investigation, stage where the relationships between the direct and indirect variables were identified and it was determined if it was feasible to carry out the proposed investigation.

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3) analysis of research and / or augmented reality models, analysis of PDA needs, people and interviews with experts, in this part of the investigation the analysis of the different proposals and technological tools that are immersed in the generation and RA creation, the needs of people with hearing impairment and the people with a link to them, as well as the views of experts in the generation of RA and LS; 4) Design, where the content, activities, evaluation and the analysis of the tools to be used for the 5) Development / Construction, through the creation of target (markers), was carried out to carry out the interactivity with the devices to perform the, 6) Evaluation / Testing, by the users, people and qualified personnel in the subject, for which part was given to the 7) Implementation, which provides society with an option to carry out the process teaching-learning of the Mexican sign language, besides specifically supporting people with limited abilities (auditory and language). 8) Augmented Reality (AR) in fingerprint systems, development of augmented reality for the inclusion in society of people with limited abilities (auditory and language), in order to achieve the objectives set.

These stages make up the methodological proposal proposed in this research, which is shown in Figure 7.

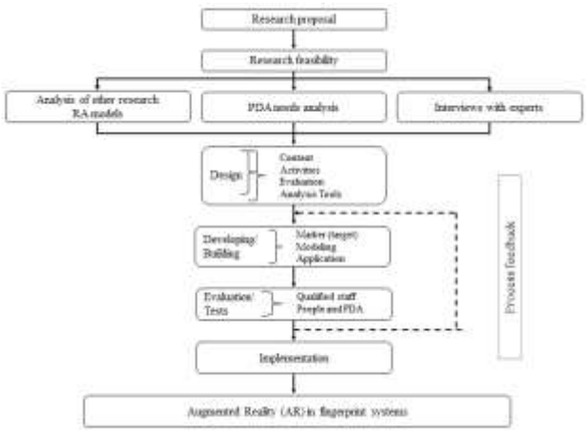

Figure 7 Methodological proposal for the development of augmented reality for fingerprint systems
Source: Self made

Given the multidisciplinary approach of the research, it was necessary to analyze and identify a methodology that would provide the opportunity to establish the development of the proposal for the generation of the application (APP), which resulted in the adoption of the Scrum methodology, used in software development as a quick and agile methodology.

The Scrum methodology is designed to achieve efficient and effective collaboration of teams in projects, which uses rules and defines roles that make up the structure necessary for its optimal functioning, as shown in Figure 8. Scrum uses an incremental approach that is based on the empirical process control theory. (Navarro Cadavid, Fernández Martínez, & Morales Vélez, 2013)

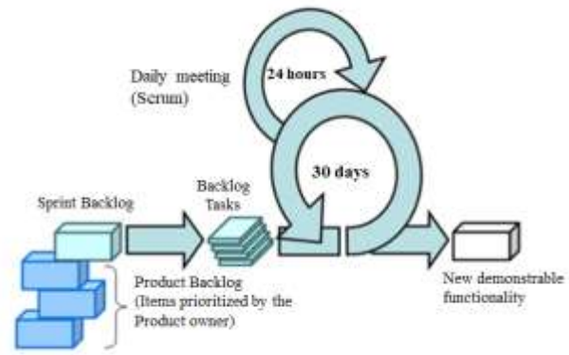

Figure 8 Scrum process
Source: (G. Caso, 2004)

Scrum is defined in a study based on 4 stages which include 1) requirements, for the development of the software the Product Backlog is established, which contains all the tasks necessary for the validation of the model, 2) analysis and design, planning the tasks that are carried out in the iterations defined in Scrum, as well as the choice of material for the RA application, 3) implementation, the tasks defined in the Sprint Backlog of the RA application, as well as the elaboration of the material that is not I could have obtained; at the end of each iteration the Sprint Review will be done to review the product and 4) Tests the application tests will be done before the Sprint Retrospective, once the software is finished, performing the validation of the technology.. (Solano Villanueva, Casas Díaz, & Guevara Bolaños, 2015)

Given the software's intangibility, obtaining requirements and / or requirements is the most important phase in order to interpret the need and therefore develop a solution. (Sommerville, 2005).

The importance of identifying the objects of study is essential to institute the set of descriptive features that will provide useful information in the process.

The technique used for the collection of information is the interview, which had as its main purpose to identify the needs of a proposed technological system supported with augmented reality to achieve the inclusion in society of people with limited hearing and speech capabilities.

The questions applied allowed us to identify the importance of creating an inclusive society, highlighting the problem of limited auditory or speech capacity, in a specific sector of the population, as well as identifying knowledge and availability to carry out learning and use of a sign language system, using for this purpose specific tools in the area of information technologies, such as augmented reality, linked to accessible technological devices, considering these as equipment or services that can be used to promote the functional capabilities of the people with disabilities in their daily lives as an independent and / or in their environment, supporting communication at all times with a sector of the population that has an auditory or speech limitation.

The collection of information was carried out in higher education institutions such as the University of Morelia, specifically in videogame engineering, applying the reagents to students and academic staff, as well as the Technological University of Morelia in information technology careers and communication, mechatronics and industrial maintenance.

The research investigates essential aspects such as knowledge of the subject, the difficulty of establishing a communication with this sector of the population, the perspective of carrying out the implementation of information technologies as a support tool for people with limited abilities.

The knowledge or manipulation of communication tools with people with hearing and language disabilities, with which the specific terms were detected as dactilological, allowing with the above to clearly identify the requirements and interested parties.

Having as a first stage resulting from the surveys, the proposal for the creation and design of a technological model to facilitate communication with this sector of the population supported by ICT's.

The software prototype to implement is an independent product created exclusively to achieve the communication of this sector with the rest of the population through the teaching-learning of the sign language. (sign language). The main function of this model proposal is to provide a technological tool for learning and teaching Mexican sign language (dactilological). Through the model and creation of friendly elements so that the application is usable. In addition, to identify that the proposal meets the requirements established for its development and for the user.

Results

The first element of the methodological proposal refers to the analysis of data that will allow to manage and compile the information collected for years, this allows to have the security of the information collected, identifying at the same time, the needs of the PDAs, as well as the different points from the perspective of experts in the field and of people who have innovated in this form of communication due to different circumstances, in such a way that the relationship of the various instances in the generation of augmented reality for the teaching process can be carried out learning in fingerprint systems.

After having carried out the design, the implementation and the RA generation process are combined, through the design of content such as phonemes, models, pronunciation and gesticulation to achieve in a definite way the necessary feedback to the user of being carried out. learning correctly, through the proposal of various applications and / or tools such as Unity, visual studio, blender, vuforia, adobe CC audition, linked with image capture devices such as webcam and smartphone.

The next stage is the development / construction through the creation of markers (target) consisting of defined images, which emanate with the conjugation of RA and Mixed Reality (MR), in hardware implemented in various image capture devices and movement, which allow obtaining models developed in Unity, programmed with Visual Studio and the assessment of our target created with the SDK (Software Development Kit) of Vuforia which provides a platform for the development of RA and MR applications, devices and applications used for the conformation of the RA are illustrated in table 1.

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Devices / Applications	
Hardware	Software
- Webcam - Kinect - Smartphone	- Unity - Vuforia (SDK) - Visual Studio - Blender - Adobe Audition CC - MySQL Server

Table 1 Computer tools devices and / or applications used for the generation of RA
Source: Self made

Figure 9 graphically describes some tools used, as well as tests performed to corroborate the function for the generation of augmented reality, which consisted of the use of selected technologies and implemented for the development of the RA, to perform the customization of the desired interface

Figure 9 graphically describes some tools used, as well as tests performed to corroborate the function for the generation of augmented reality, which consisted of the use of selected technologies and implemented for the development of the RA, to perform the customization of the desired interface.

Figure 9 Tools used for the implementation and RA generation process
Source: Own source

Initially, the identification of the markers based on the Mexican Sign Language (LSM) will be done, by means of which the image that will have as a background the marker can be selected, so that later it will be related to the personalized marker. Once the above is achieved, the evaluation of the users of the developed interfaces supported by technological tools such as the RA is carried out.

Next step will be the implementation in various devices with elements that facilitate and allow detecting movements and images to correctly identify the section and carry out the relationship for the teaching-learning process.

- **RA proposal in fingerprint systems**

The proposed operation of the augmented reality system (RA), will have as its main objective to evaluate if the user who is learning the sign language is correctly executing the Mexican sign language, so the system will allow the user practice both vowels and consonants as shown in figure 10.

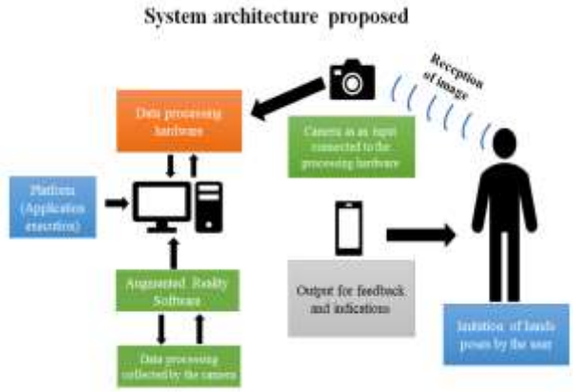

Figure 10 RA system proposal for learning of the Mexican sign language
Source: Self made

In the operation of the augmented reality system for the learning of the Mexican sign language, each one of the elements necessary for the operation of the system is identified, it is worth mentioning that its use by the user is also explained.

- **Hardware for data processing**

This device will store the augmented reality software (APP), in server mode, which will be interacting with each of the movements provided by the user, making the corresponding comparisons. It will have a database stored through MySQL server where each image will be saved and managed to carry out the comparison.

- **Camera**

It will act as input (data entry), be connected to the processing hardware, collect information provided by the movements that the user makes and send it to the data processing hardware, which in turn has the Augmented Reality platform installed and the base of data.

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- **Output**

This device can be a tablet or a smartphone, it will serve for feedback and instructions for the user, so it will have an RA system installed in client mode.

- **Data treatment**

a) Storage of personal data. - Through a database (MySQL) the user's data will be stored, such as his general profile and his progress in the advancement of learning.

b) Storage of images. - The images with which the movements made with the hand by the user will be compared, said images will be developed through models that will be carried out in Blender (application for 3D modeling), they will be stored in a database to later take to complete an evaluation. The images correspond to the vowels and consonants of the Mexican sign language.

- **Augmented reality software**

It will be the person in charge of processing the information, it will be installed both on the server and on the client, this application will be made through applications such as Unity and Vuforia, with the purpose of creating interactive experiences of RA, through a specific response generated by the interactivity of a target, which will allow the user to manipulate the application and at the same time receive feedback. The models to be implemented would be developed through the Blender application (modeling).

- **Operation by the user**

Then, in figure 11, the process of user interaction with augmented reality software is shown.

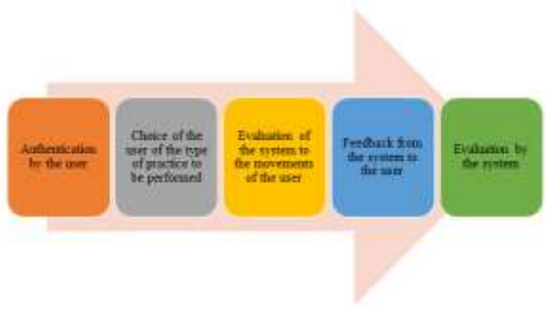

Figure 11 User-System RA interaction process
Source: Self made

Conclusions

Communication has become a primary weapon in society, research pursues the purpose of creating a methodological proposal with the use of information technologies, specifically augmented reality, which will support and encourage the learning of Mexican sign language (sign language).

The proposed general model consisting of eight stages allowed a proposal to be made, feasibility was approved, as well as the identification of other investigations in order to identify parameters and cases analyzed, also receiving the support of people related to PDA and the valuable opinion. of experts in the field to identify even the smallest characteristics to develop a proposed quality solution, leading the planning of a design that allowed identifying the content to be developed along with the activities necessary to achieve the learning of the LS with RA, the evaluation to identify a quality product, as well as the computer tools to be used in space-time movement capture hardware, such as Kinect, webcam, smartphone to name a few and in the software part the use of reconfigurable models by adaptation and learning used for recognition of patterns, such as Unity, Vuforia (SDK), visual studio, blender and audio editors, subsequently developing the RA model construction, which will lead to tests to identify inconsistencies on the part of PDAs, users and experts, performing the pertinent modifications taking the evaluation back to a useful outline, to carry out the implementation of Augmented Reality (AR) in signatory systems.

The research of theoretical sources focused on obtaining knowledge of the dactylological alphabet, helped to understand the way in which projects of this type with similar characteristics were developed. In addition to contributing with ideas about the development of the model to be implemented and finally the research contributed to understand the need that exists in developing applications of teaching the alphabet dactilológico (Sign Language Mexican).

Applications for mobile devices can help solve problems in society in various fields such as the individual or the general, due to its mobility and ubiquity characteristics.

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The use of augmented reality shows that the learning process can be much more effective if it is performed in a dynamic, fun, entertaining, or in a way that can clearly visualize the object of the study in question, in the case of learning of the Mexican sign language the user is interested in the basic knowledge of signs, its ease of use, the realization of tests that identify the interpretation of what has been learned, with the latest technology tools that provide portability and friendly interface.

At present, technological support provides one way or another to improve intrapersonal communication, and aspects related to the personal sphere. These technologies are created and adapted to benefit people in any field such as education, social, communication, and aspects related to the field of culture..

We must emphasize the description of the development of a system integrating hardware-software to automatically identify the fingerprint language used by PDA. The hardware in the development proposal for the system is composed of a device that captures the gestural movements of the hand of an individual, in terms of a series of signals in space time, the software poses a computational model for adaptation and learning, which allows the automatic recognition of said movements in terms of a particular sign language.

The model proposal aims to become a useful instance that guarantees reliability and effectiveness in the learning of the Mexican sign language, with a greater range of didactic content that allows the user to see and identify from different perspectives the signs that make up the sign language. Creating with it the bases to carry out the creation of an inclusive society with the support of avant-garde technological tools. Because the proposed model incorporates a mechanism for adaptation and supervised learning with feedback.

These gestural movements used will validate the recognition system when used for an individual without any limitations in the field of speech-listening, in addition and thanks to the wide range of temporal gestures used for the representation of the same vowel, the model can be used to be identified by any individual for the Mexican sign language.

The development of the model seeks the teaching-learning of sign language in a more interactive, dynamic and immediate way, in order to reaffirm an identity as a community of people with hearing impaired people and people who do not suffer from this limitation, with the abrasive the task of building an inclusive society. Through an application that also encourages the interaction of users, breaks with the classic passive learning experience providing a richer and more effective learning.

Without neglecting the constant assessment of qualified personnel, people closely linked to hearing impairment and PDA. With which it is intended to generate an application that far from those created to date allows to assess the teaching-learning process of users to achieve the correct communication with this sector and to be able to carry out the creation of an inclusive society.

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