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Diagnostic for the design of a virtual educational assistant for visually impaired children

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Abstract: This paper describes a guide for developing a prototype of an intelligent virtual assistant (IVA) to aid in the teaching-learning process of children that are visually disadvantaged. The recommendations put forth by experts that participated in the study give direction concerning the characteristics that should be considered in the design of the software agent so that it can interact with a visually disadvantaged user, taking into account her sensorial deficiencies and special education needs through a personalized IVA that functions as a virtual tutor. Currently, in the context of research and application of this technology, there is no software environment adapted to the needs of these students. With this study, we explore how artificial intelligence can be integrated into learning environments with blind and visually deficient elementary school students. This paper presents a general vision of ongoing work aimed at constructing a prototype of the IVA system.

Keywords: intelligent virtual assistant, artificial intelligence, visual deficiency, teaching-learning.

Introduction

Currently, it is increasingly common to hear about Intelligent Virtual Assistants (IVA) present in last generation cell phones, laptops, tablets and desk computers, and intelligent speakers or watches. For example, to cite some of the most well-known (Lamontagne, Laviolette, Khoury, Bergeron-Guyard, 2014; Ibarra, 2020), Apple equipment comes with factory installed personal assistance software called Siri. Smart phones with Android operative systems are installed with Google Assistant developed by Google. In recent technology devices with the operative system Microsoft Windows comes the assistant Cortana, while Samsung uses the assistant S Voice or Bixby, and Amazon speakers use the assistant Alexa.

A virtual assistant is a software agent or program that can interpret human speech and respond with synthesized voices using artificial intelligence techniques, such as natural language recognition, and can interact with the system through voice commands. For this reason, these assistants are also known as voice assistants. These programs can work with another program or with a user and assist through a conversational interface to perform tasks, from asking simple questions about a particular topic, reproducing music or multimedia, administrating email, giving reminders of pending tasks, to manipulating home automized devices, for example turning on lights, activating and deactivating security cameras, doors and window, turning air conditioning and heating on and off, and communication, it can pose a security and privacy risk (Hoy, 2018; Chung & Lee, 2018; Hasan, Shams, Rahman, 2020).

The interaction that is produced between a virtual assistant and a person must be through use of key words or short phrases expressed orally in natural language. The virtual assistant then in listening mode captures the message, processes it, interprets the users request, and gives an answer in a synthetic voice that varies in function of the programming and system configuration.

One of the most important characteristics of the IVA is their great educational potential in the field of visual impairment because it offers the student the possibility of communicating with the device without the need to write with the keyboard or use Braille, so widely used by this community (De Freitas, Martins, Rabello, Rodrígues, Monteiro, 2009). Nor is it necessary to use any other technical aid for the blind; it only requires voice commands. Thanks to the artificial intelligence (AI) behind the design and programming of the system, natural language recognition makes it possible to execute functions that the use requests, such as search for information in the Internet, call a contact by telephone, perform simple mathematical operations, and even tell a joke (Hoy, 2018).

The multinational company IBM, pioneer in the development of virtual assistants, created the virtual assistant Watson, a system that allows creating, training and implementing conversational interactions in any application, device or channel. An important characteristic is that it uses two methods of automatic learning of artificial intelligence called Machine Learning and Deep Learning. This program has been tested very successfully in academic programs in university teaching and functions as an assistant, helping students in private tutoring. Moreover, the assistant follows up on student progress, identifying where there are gaps in

knowledge to offer recommendations for study, according to the strengths and weaknesses detected in each student (Lamontagne, Laviolette, Khoury, Bergeron-Guyard, 2014; Discovery Latinoamérica, 2018; IBM, 2018).

This type of cutting-edge technology is especially interesting for incorporation into learning environments with children that have some type of visual impairment, given that voice recognition helps to maintain a simpler more fluid interaction between the user and the machine. Configuring an IVA as a "technical aid" for disadvantaged persons not only enables physical support to compensate visual deficiencies of the student but, because it has conversation technology, it can function as an automated tutor that can guide students in learning new knowledge.

According to Feigenbaum and Julian Feldman (1963), artificial intelligence (AI) is a branch of computer sciences. It is a discipline responsible for developing complex systems that emulate human behavior, knowledge and attitudes, simulating thought artificially based on the functioning and abilities of the human brain (Badaró, Ibañez & Agüero, 2013; Herrera & Muñoz, 2017; Ocaña, Valenzuela & Garro, 2019; Budzinski, Noskova & Zhang, 2019).

The behavior of the machine is determined at all times by its configuration and by the read entry data. Alan Turing, who set the bases for AI, defined it as the configuration of the machine as a whole. Depending on this configuration, the machine executes determined actions, and what gives clarity and precision to how it acts is a sheet of instructions called an informatic program, which is the table of conduct or behaviors that specifies the actions or expected results written in a particular configuration sequence that the machine will execute as its algorithm (McCalla & Cercone, 1985; Ocaña, Valenzuela & Garro, 2019; Budzinski, Noskova & Zhang, 2019).

With the current scientific and technological progress, the information and knowledge challenges that society imposes demand an important unprecedented change in the rigid formational precepts of educational systems. Education mediated or supported by artificial intelligence promises a substantial improvement in formation at all school levels, with a qualitative improvement in learning adapted to the measure of physical deficiencies and personalized according to particular needs. In this way, it can achieve the integration of diverse technologies to conform more personalized, more interactive, and more accessible usable learning environments (McCalla & Cercone, 1985; Ocaña, Valenzuela, & Garro, 2019, Ibarra, 2020).

This paper presents the results of a survey on the guidelines that should be followed in the development of a virtual assistant for teaching-learning of visually impaired children at the elementary level recommended by experts interviewed during the study with the intention of improving the way in which students learn in the classroom using technology.

Methodology

This study was conducted in the Home School for Blind Children in the city of Puebla, Puebla, Mexico. This institution is a Center of Attention for Multiple disabilities (CAM), called "Club de Leones", belonging to the Puebla State Ministry of Public Education. Here, children with visual impairment and those that have multiple disabilities (visual impairment as well as some other disability such as intellectual disability, problems with language or learning, Down syndrome, or others) are attended.

The research model is mixed, with a participant action research design, of exploratory nature and descriptive in scope, with the objective of reflecting on informant interpretations concerning the study population and of constructing requirements categories for development of an IVA prototype. Research data was collected using diverse techniques and instruments; those used for this section were the interview and the interview script.

To determine the sources of information on the requirements of the system, we asked the group of persons that directly attend the study population: authorities, teachers, experts, and users. However, the main researcher's knowledge and experience in the educational field and in the development of intelligent virtual assistants was also considered.

The informants in this study were the principal of the institution, five teachers specialists in special education, one expert in education for the blind, one expert in educational technology and psycho-pedagogy, as well as two visually disabled users that are aided by information and communication technology to carry out their daily activities using computers. All contributed to obtaining the minimum requirements of the assistant system to be configured. One requirement of a system is description and delimitation of a condition or characteristic that an informatic program should satisfy, derived from needs of the user or client to whom it is directed and should be clearly specified before beginning the process of developing the system (Ibarra, 2020).

Results

The characteristics of the authorities and teachers that participated in the study are professionals in special education of the Center for Multiple Attention. The Principal of the institution and five teachers, whose experience teaching in this field fluctuates between 5 and 10 years attending children with disabilities, understand very well the particular needs of this student population. Their recommendations are shown in Table 1.

Tabla 1. Basic characteristics that the IVA system should have, according to authorities and teachers

Num.	Characteristic	Suggestions of authorities and teachers
1	Voice type	Female voice
2	Tone of voice	Formal, like that of a teacher
3	Basic personalization	Include words commonly used by the child as voice commands because they have poor vocabulary. The assistant should address the child with respect.
4	Speech speed	Response at medium slow speed so that the children can understand the assistant
5	Capacity for Internet search	Capacity to search for information on the Internet for their homework.
6	Capacity for text edition and dictation	It should allow them to use a text editor and to dictate.
7	Capacity to execute applications	Use of other informatic applications such as Word, Excel, PowerPoint
8	Capacity to calculate	It should allow them to do basic mathematical operations such as addition, subtraction, multiplication, and division
9	Capacity to read	Read aloud books and digital texts
10	Capacity to read and send email	Read and send email
11	Capacity to reproduce music and videos	Reproduction of music and videos

The two visually impaired adults, (a man and a woman, 31 and 34 years old respectively) that were interviewed independently as representatives of the system's final user that motivated this research project consider that, according to their experience in using technology as an aid, usability and accessibility of the system play a preponderant role. The valuable information that they contribute in defining the set of preliminary essential characteristics that the IVA design should have are shown in Table 2.

Table 2. Basic characteristics that the IVA system should have, according to visually impaired users

Num.	Characteristic	User suggestion
1	Basic personalization	1. Possibility of giving the assistant a name that is easy to remember. 2. Include a way to register the name of the user with whom the system will interact so that it can address her personally. 3. Be able to change the assistant's voice type to be pleasant for the user.
2	Avatar	Include a virtual image to represent the system that would help a person with weak vision more than a blind person to know with whom she is interacting.
3	Name	The possibility of calling it by its name
4	Voice activation	Activate by voice using its name
5	Type of voice	Be able to select male or female voice
6	Language	Spanish
7	Personality	Respectful, formal, kind
8	Speech speed	Have the possibility to select, and for children, to select slower speed for better understanding in their interaction.
9	Understand word variants for the same command	Allow for saying the same command in different common forms
10	Know at all times what the system is doing	It should report what action it is performing so that the user knows that the command was executed correctly

The experts in educational technology, one of whom also functions as an expert in special education of

the visually impaired at CAM, considered twelve characteristics that would be important to consider in the development of the IVA, whose aim should be to help the student reach independence. Besides those expressed by the authorities and teachers, they recommended some other characteristics, which are shown in Table 3.

Table 3. Basic characteristics that the IVA system should have, according to the experts in educational technology

Num.	Characteristic	Suggestions of experts in educational technology and education for the visually impaired
1	Interaction	Better dynamics in the interaction through free questioning of the user to the assistant. Use large letters in the web page contents to be learned so that it is suitable for students with visual weakness. Use of mouse and voice commands
2	Instruction design or techno-pedagogy	Define pedagogical resources such as pedagogical approach, learning activities, materials and media to be used in the course.
3	Comprehension	Emphasize repetition of content as many times as the student needs to help comprehend contents and concepts.
4	Educational materials	Use physical aids to teach determined concepts
5	Teaching methodology	Approach explanation of topics from general to specific.
6	Accessibility and usability	Permit the student to request repetition of the menu options and course content
7	Educational media	Use podcasting to explain contents
8	Learning activities	Include learning activities in course contents
9	Evaluation	Evaluation of content learning
10	Audiobooks	Use audiobooks to aid learning
11	Video games	Include educational videogames to aid learning and make it more attractive
12	Pedagogical approach	Pedagogical theory that supports the teaching-learning process.

Discussion and Conclusion

Discussion

Both the authorities and teaching staff of CAM greatly emphasize the need to personalize the Virtual Assistant in two perspectives. The first is to characterize the system; most coincide in giving the IVA a female voice, Latin accent, formal tone of voice like that of a teacher in the region, except for a totally blind teacher, who emphasized that synthetic voices sound robotic and suggested that a more natural voice be used, and for children, that a child's voice be used with a happy tone that is more attractive for the infant community.

The prototype used the synthetic voice of Nuance Vocalizer Expressive, which, although it has extraordinary quality, sounds artificial. In one of the preliminary tests conducted using a male voice (Jorge de Loquendo), the digital voice version of the Spanish actor Abel Folkde Gilsanz, the first impression that some of the children had when they heard it was surprise and a little fear. When we asked for the reason, they answered that while they were silent, they suddenly heard a loud male voice that scared them because they did not expect it. For this reason, they showed certain rejection.

Although it is one of the most frequently used voices in YouTube videos and even in videogames, movies and cartoons, the reactions of the children suggested that they had not heard the voice before or that it was too aggressive because it was a male recorded at high volume, and for them the tone was not pleasant.

This condition of synthetic voices has an explanation in their nature. To record a natural voice and convert it into a digital format, the artificial intelligence (AI) algorithms try to create an audio signal as close as possible to the original voice. It is important to point out, however, that it is not trying to reproduce the human speech apparatus, it attempts to reconstruct the acoustic waves emitted by that apparatus, and therefore, the result will not be 100% true to the original voice.

According to Janer (2018), AI algorithms seek to identify patterns in the acoustic characteristics detected in the sound signals such as intonation, intensity, speed, emotion, among others, to produce the synthetic voice. However, the result may be different from what is expected because of the process through which sound virtualization must undergo. Latest generation artificial voices are created with advanced AI techniques such as automatic learning and deep learning. To this end, different voice recordings of the same person are used, taking into account the speed, intensity, tone, and emotions, as mentioned above, to produce a voice as close as possible to the original voice. It is important to underline that the same voice quality is not obtained with one minute of recording as with 10 hours. The quality and humanization of the voice is directly proportional to the number of samples incorporated into the AI system. This means that the more recordings of

the original voice, the better the level of expression of the original voice characteristics, and vice versa, the fewer the recordings the more robotized it will sound.

Although scientific advances in AI are making new methods and the process of digitalization more efficient and rapid, it is still not possible to obtain a voice quality with the maximum detail of the original. However, with the results that have been obtained, it is now possible that an assistant can pass for a human in a telephone call and not be detected by the caller. This is the case of the new version of the virtual assistant Duplex of Google. In 2018, the executive director of Google Sundar Pichai, during the event for Google IO developers, demonstrated the enormous capacities of the virtual assistant in making calls for the telephone owner without the interlocutor noticing that it is a robot. The demonstration consisted of making a couple of direct calls. The first was to make an appointment at a barber shop and the second to make a reservation at a restaurant. This technology is still in an experimental phase, but later it will become a commercial product of the company. To date, the assistant communicates in English; its voice sounds more natural than robotic, and the person at the other end did not detect that he was talking to a digital assistant (Zegarra, 2018).

Nevertheless, synthesizing a human voice at 100% takes us to ethical terrain because it becomes increasingly more difficult to distinguish a real voice from one that is not, making it possible to misuse artificial voices. This and other ethical dilemmas are emerging in all fields of development and application of AI in the real world. Ethics of AI is now on the international agenda and discussion tables in many countries where there are relevant advances in this science.

But why is this relevant to the use of a synthetic voice and how does it affect an IVA oriented to attending the educational needs of children with disabilities? For the teaching staff of CAM, it is highly relevant since the characteristics of the teacher can affect the child's academic success. Although this point may be debatable, in the case of a virtual assistant configured as an educational tutor with a synthetic voice, the informants suggest that it is preferable to use a female voice, sweet and pleasant, whose volume can be graduated to increase acceptance by the student community. Analogously, as occurs with a real teacher when she addresses a student, it is here that the teacher-student relationship comes into play. The interaction between these actors in education is based on trust and on carrying out the labor of teaching caringly. In the case of children with visual disabilities, because they are not able to see their teacher's facial expressions, they may imagine things that probably do not exist and begin to distrust. In the case of an IVA that is to be used as an educational tutor, this can limit a student's use and interaction with the IVA system.

There is a belief in this educational sector that children have a better teacher-student relationship with a woman than with a man because culturally it is the mothers who are responsible for care of children until they can take care of themselves. Authors such as Albisetti (1989) and Preston (1993) argue that the natural disposition of women, who in their role as mother dedicate their lives to the care of children and therefore have a better attitude toward children. Bazant (1993) and Galván (2002) comment that women displaced men as teachers because the early programs in pre-school, primary or secondary education in the normal schools considered that it was suitable and well-viewed by society for young women who wanted higher education, mainly because of their loving and kind character traits, among others, that help to establish good teacher-student relationships, making women suitable for educating children.

There are multiple studies on the teacher-student relationships and how it influences student academic success (García, García & Reyes, 2014). Therefore, it is very likely that acceptance of the IVA in the student population is better with a female voice. In this respect, Berlo (1969) points out that interaction based on empathy is vital for the communication process. Apparently, for the CAM teaching staff, these characteristics play a preponderant role in gaining self-confidence, learning and independence that they strive to achieve in the education of this community. For a child with visual disability, attaining independence is one of the prioritary objectives that special education pursues.

Another aspect to consider in the design and development of the IVA is context. Most of these blind children at the primary level have very limited vocabulary. Therefore, it is necessary to consider including common words from the child's vocabulary to define the voice commands with which she will interact with the system (Lamontagne, Laviolette, Khoury, Bergeron-Guyard, 2014). Nevertheless, the system requires the use of highly concrete commands to carry out the tasks the user requests because it is complicated for a machine to understand human language. Experts in IBM consider that making an artificial intelligence system understand human language as people do is a highly complex task for a machine. It requires an advanced computer, that is, one with advanced computational features to be able to process and understand all the characteristics of natural language. It must implement advanced artificial intelligence algorithms, like the debate technology developed by IBM with the assistant Watson to achieve a system that interacts rapidly with its interlocutor using human language coherently and efficiently (IBM, 2018).

Another finding of the analysis of the study population is that, according to the teachers, a characteristic of these children is that they generally speak a lot and without pauses, making it difficult to

understand their message. For this reason, a relevant task of the teacher is to regulate them so that they are concrete in the construction and presentation of their ideas. It is important to highlight that, technically, having this ability would help the children to have better communication between the user and the system and would greatly facilitate human-computer interaction. Therefore, regulating their speech is a great challenge for students and teachers to obtain an acceptable level of concretion in their language for effective use of the system.

The challenge is great both for teaching from the educational perspective of the study population and for development of the IVA technically. However, the scope and limitations of this project include only the proposal of development and configuration of a well-structured functional IVA prototype system that can be installed in the standard computers that are property of the institution where the study was conducted. With the limited characteristics and technological resources, the proposed IVA should be well-accepted by the children in terms of friendly characteristics and capable of interacting with a visually impaired child with limited language development using natural language.

The two experts in educational technology emphasized the techno-pedagogical aspect, that is, besides considering what the technology can do, it is important to consider the pedagogical support of the IVA system to be constructed. In the technological aspect, the system should allow user-computer interaction broadly and freely so that the user can ask whatever her conditions of disability allow using natural language. It is worth noting that although this is possible, the technological resources the institution has is insufficient to support a more robust system, it is beyond the intention of this study, which is only to create a prototype. For the system to be able to interact with the student more naturally using different grammatical structures and forms to communicate freely with the IVA, there are different technical implications. Making the system understand any grammatical structure of natural language is complex and requires more powerful computational resources both for development of AI algorithms to search for, analyze and process data and for data storage (big data).

Language is very broad and, as IBM researchers have explained, it requires the use of distinct AI techniques, as well as an advanced powerful algorithm for the system to understand different grammatical forms of a sentence that a user could come up with and to be in conditions to learn to construct sentences that the IVA system will use to respond to the user. These grammatical or lexical variants have been denominated in this study as conversational variants for effects of the proposed system. With this, we refer to the different forms of natural language the user can use to request the same thing. This ability would give the user the possibility of freely asking the IVA for whatever she wants. But this technical complexity is what justifies the creation of only one prototype system for effects of this research. Therefore, for the first version of the system, we considered only some common cases of conversational variants in the context of the subjects of this study.

Moreover, these informants suggest emphasizing the instructional or techno-pedagogical design to plan how the teaching-learning process mediated by the IVA system will be carried out. It is necessary to make important decisions related to the selection of pedagogical strategies and to development of educational resources, pedagogical theory that will give support, as well as evaluation and maintenance, such as the pedagogical approach, learning activities, materials and educational media to be used in the course. To this end, it has been considered to follow the structure that intelligent tutors pose, which are characterized by application of AI techniques to the development of computer-assisted teaching systems and simulate the teacher-student interaction, based on models of knowledge that experts in a field have.

The components that are proposed in Intelligent Tutor Systems are the student module that considers the knowledge status of the user, the pedagogical module that refers to the teaching process, and the module of teaching dominion that refers to the body of knowledge that will be transmitted to the learner. Taking advantage of the characteristics of accessibility and usability of virtual assistant systems allows putting in practice the theory of guided learning, following the structure of the elements used in intelligent tutor systems with the objective that in the case of IVA can guide the student in acquiring concepts of natural sciences using a constructivist approach of education by using the theory of activity in teaching proposed by Nina F. Talízina. This theory would permit going beyond the behavioralist approach that is assumed by the educational technology used in the 20th century. In this way, it permits the student to construct knowledge in stages that the pedagogical theory proposes with the help of the IVA system (Talízina, 2009). Indeed, because it is an interactive system, the student can request the IVA to repeat the information described in the course contents, because she did not understand the virtual assistant, because she was not paying attention, or because she could not memorize the course options and contents.

Another educational theory proposed by this type of informants was the incorporation of the theory of games, from the perspective of didactic games. This is necessary to design play activities to mediate in learning concepts since it is an important ingredient in developing abilities and skills, and at the same time, it is a learning motivational factor for this sector of the infant population. Playing games is inherent to children's nature, and for a vulnerable community lacking visual capacity, the experts consider that it is even more relevant in this educational environment.

The informants with visual disability mentioned that priority should be given to accessibility and usability of the system when developing systems directed toward people with disabilities. These two characteristics they propose correspond to the qualities of the software endowed by software engineering and guarantee that the system can be used by any person regardless of their physical or sensorial abilities or disabilities and that it is easy to use and makes natural interaction possible between human and computer (Lamontagne, Laviolette, Khoury, Bergeron-Guyard, 2014).

Conclusion

In general, to correctly use the instructional potential of artificial intelligence technology, and particularly, intelligent virtual assistants, the authorities, teachers, experts and visually impaired users suggested characteristics that an intelligent virtual assistant (IVA) prototype should have to help visually impaired children to learn concepts about science.

The recommendations concern characteristics and capacities of the IVA system to interact efficiently with a visually impaired student, considering her sensorial deficiencies and special educational needs through a personalized system. They emphasized the following:

- Develop an instructional or techno-pedagogical design of educational intervention because it permits suitable didactic planning to give pedagogical meaning to a course mediated by technology.
- Before developing educational intervention mediated or supported by technology, educational theories that can pedagogically support the teaching-learning process should be evaluated.
- Consider the characteristics of the population and where intervention will take place to contextualize development of the IVA system.
- The theory of activity applied to teaching and the theory of didactic play as pedagogical support for the IVA system as educational tutor are ideal to achieve learning objectives pursued in the acquisition of science concepts in interactive learning environments with visually impaired children.
- Attractive, fun learning activities focus the student's attention and, by involving positive emotions in the teaching-learning process, promote more meaningful, lasting education.
- Assistive technology is applied to education of students with visual impairment; however, authorities, teachers, experts, and users indicate the need for technology infrastructure and pedagogical support.
- Information technology like IVA is an important tool in the inclusion process and can promote independence and autonomy of students with visual impairment.
- Emphasize user security and privacy when designing and developing an IVA for visually impaired children.

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Author Profile

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