International Journal of Engineering Research and Technology. ISSN 0974-3154, Volume 14, Number 12 (2021), pp. 1174-1178

Recognition System from Natural Language to 3D sign Language through Lexical Analysis

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Abstract

In this research article, a text-to-Colombian Sign Language interpreter was designed and implemented, incorporating Spanish as an intermediate language. Allowing people of other languages to communicate with people who have a hearing disability, using the translation of English words as a prototype. Four phases were used: lexical analysis, sign design, program life cycle and efficiency tests. Phase 1 and Phase 3 use the cascade methodology. Phase 2 uses arbitrary containers to represent the transition of the images, and the efficiency tests are carried out through a supervised classification.

The program offers a 64.87% sign language recognition and translation rate, but can increase its effectiveness by adding more words to each dictionary. The program can be used as an initiation to the communication of people with a foreign language and people with hearing problems in Colombia, with more utility in educational processes, and offers the possibility of adding different dictionaries.

Keywords: Colombian sign language, lexical analysis, hearing impairment.

I. INTRODUCTION

Problems with pronunciation, vocabulary, grammar and spelling influence the learning of another language [1], and its teaching area is very complex at any stage of teaching the student is in. Different methodologies have been created that allow to improve the acquisition of a new language through technological tools, combining face-to-face classes with independent work using computer systems; which becomes a global challenge due to the diversity of languages existing in each country. The English language is the most dominant in science [2], and its use in education and commerce continues to increase, to the point of having a great disadvantage in communication if you do not have a good knowledge, and it is in this language where the methodologies for teaching are most focused. Different perspectives such as looking at social, cognitive or affective strategies can be the cause and their improvement lies in the constant training of these skills [3], [4], the role of the teacher is also fundamental, as a motivational mediator, but there are no parameters that can determine its exact influence, however a virtual tutor can increase interest in the activities used with virtual technology [5]. And with the aim of not making long hours routine and demotivating, strategies have been implemented where games provide great interactivity [6], adding virtual reality, which helps in its self-regulation and the reduction in the anxiety of the exams, at the same time that it allows to enter in a comfortable way to the initiation of the different designs of the classes; These didactic strategies take as an initiative the use of the cell phone by grabbing the student's attention, achieving a direct connection from the beginning of learning. Virtuality can make traditional tools forget, because the texts in English are not contextualized in diversity and representation of cultures that help in social immersion, and they pay too much attention to grammar [7]. But we must not forget that traditional activities are a good alternative for learning, tasks such as writing words by hand, visualizing images and phonology when used with reading strategies [8] they remain as efficient alternatives.

If learning languages is complex for people who do not have a disability, it becomes a longer goal and fewer teaching resources for people with hearing problems. It's not just learning a new language, it also requires learning a new sign language. Although there is a universal sign language, each country has generated its own language [9], and the consequence has brought difficulties between the same teachers with knowledge of these signs, and students of another language. In Colombia, the National Institute for the Deaf (INSOR) is in charge of leading and creating public educational and social policies, generating opportunities and equity in the population with a hearing disability [10], and maintains within its platform educational resources for different subjects, as well as a dictionary [11] and questions for the Saber 11 test, which was recognized by UNESCO as one of the six thematic axes in mobile learning [12]. Several investigations have been carried out and implemented using the Colombian Sign Language (LSC) in order to contribute to the study of the language. One of them is to use facial gestures through image processing and feature extraction to generate patterns [13], using the SSD object detection algorithm and neural networks, obtaining results of more than 89% with both techniques, and the reason for the study originates from the way the LSC is taught, which is almost always through manual movements. Translator systems are the most requested and implemented as a starting point for the inclusion of LSC, generally through the incorporation of text boxes and images; one of these jobs creates a virtual translator obtaining favorable results [14] or via FPGA in order to speed up processing [15], the latter only focuses on static signals built into the alphabet. The incorporation of the voice with the images is a more appropriate proposal for people who want to communicate with those who have a hearing problem when using their mobile phone [16], and jobs with image processing have a recognition process under construction that can be useful for people with already acquired knowledge [17]. Those with the highest number of recognized words use online proposals as an approach to the LSC [18]. The definition and modernization of its vocabulary

is necessary to encourage not only communication at the national level, but also with people from other countries and languages, as well as to help in academic processes [19], and are not based on judgment decisions. While it is true that there are already strategies to include teacher training in LSC as a pedagogical strategy for inclusion in higher education [20], only the Colombian language is made to LSC and there is no virtual interpreter that allows a person to communicate in LSC with another language.

Based on the above, an automatic 3D system is designed and implemented as a text to sign language interpreter, using arbitrary containers, and mediated by text in Spanish. Which would follow the route of entering text in an external language, translating it into Spanish and then representing its interpretation in LSC. As a prototype, the external language used is English, and only a dictionary-based lexical analysis is incorporated. Its applicability can help in academic contexts by increasing the amount of signs and synonyms of each language.

II. METHOLOGY

To build the final project, four essential phases were used: dictionary, signs, program life cycle and results, each phase is divided into an auxiliary phase according to the methodology used, as is the case of software development, as shown Figure 1. The first phase a lexical analyzer was built and the words in Spanish and English necessary for this analysis are stored, where tokens are extracted in both languages to compare them, these tokens can be formed by a single character or a set of characters, but no syntactic or semantic analysis of English is performed. In phase 2 the signs are developed, saving a number of images in a cell array for each image that composes it, and they comprise static and dynamic signs. In Phase 3 the software was developed, using a waterfall methodology where three stages are highlighted: analysis, design and coding. The Matlab language is used for the versatility of mathematical operations and handling of arbitrary containers.

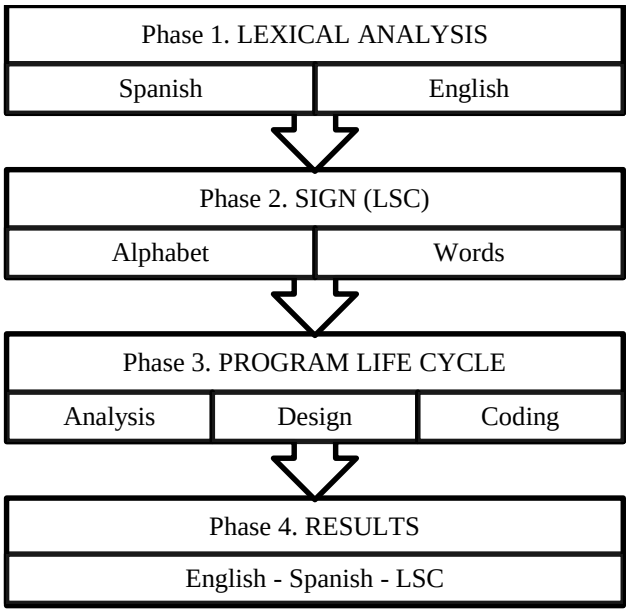

Fig. 1. Design phases

Phase 4 is carried out in a supervised way, that is, an expert in LSC, tested all the signs and words of the dictionary in Spanish. Once all the images have been finalized, the tests are carried out based on the extraction of the words that four children's stories contain, and the error test is based on whether it can be represented or should be spelled.

The sample consisted of 195 words in Spanish, increasing to 323 through synonyms, in English the same number of words is used. The number of signs is 195, but each sign is made up of a different number of images. The children's stories had a word count of: 572, 194, 999, and 124, and comprised the first two pages of each story.

III. RESULT

LSC Design and Cell Array Storage

A virtual agent was used for the design of each movement by sign, through the Virtual agent of Vcom3d, the software gives the possibility of making gestures with the hands, locating the point to be moved with different oscillating lights and a segment copier (Figure 2).

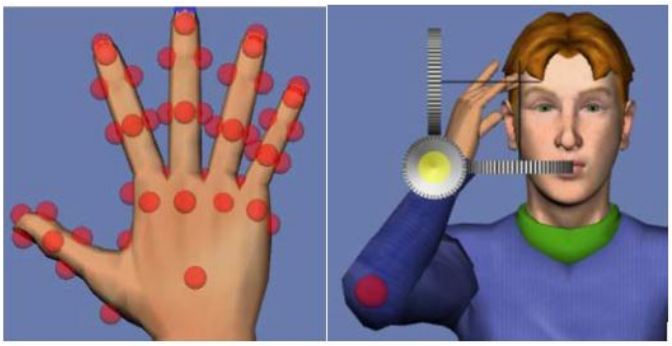

Fig. 2. LSC Design**. Source:** Vcom3d

Although a complete movement could be created, its format does not allow connection with a dictionary of signs, so a number of images had to be made with different positions that allowed a visualization according to the signal. In total 195 signs were designed.

A sign can be more extensive in movement than another, which entails a greater or lesser amount of transitions and images to store. This is similar to a real situation, for example an office which is made up of people, tables, chairs, lights, etc., forming different types that when storing them in vectors or matrices encountered the inconvenience of data types and dimensionality as shown. You can see in Figure 3 and 4. Arbitrary structures or containers solve this problem, and according to the language they can speed up processing, that is why Matlab's cell arrays are used.

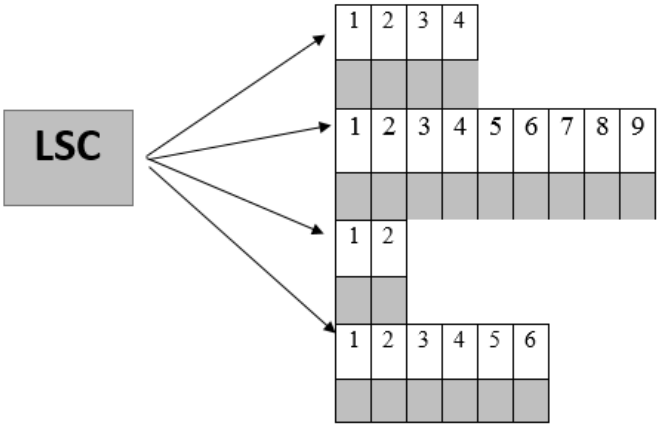

Fig. 3. LSC storage structure

Fig. 4. Image transition

The dictionary maintains 5 fields where the number of letters in Spanish, word in Spanish, number of letters in English and the word, finally the address of the sign, which shows the number of images that the component with its location. An example of words in the dictionary is shown in table 1, which is used to correlate the tokens extracted from the text entered by the user.

Table 1. Structure Spanish - English dictionary - LSC

Spanish	Number Spanish	English	Number English	LSC
Casa	4	House	5	4
Buenos días	10	Good morning	11	9
RR	2	RR	2	2
A	1	A	1	1

Token extraction

The extraction of tokens is developed through the lexical analysis of the entered text, this means extracting each word, converting it into a token, and later dividing it into each of its characters. From the word Good Morning it extracts two tokens and then converts it into 12 spaces in a cell array (Table 2). The limit of each tokens is determined by the white space that divides each word, this operation is very similar to the compilation process of a source program, which converts the encoding to machine language.

Table 2. Token extraction using lexical analysis

Index	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Source	GOOD MORNING												
Tokens	G	O	O	D		A	F	T	E	R	N	O	O N
	G	O	O	D		E	V	E	N	I	N	G	
	G	O	O	D		M	O	R	N	I	N	G	

The cycle of the translation process first finds the English text in the container and extracts its translation into Spanish, and with that tokens it finds the corresponding images in the cell array to create a transition of them (see Figure 5), turning into a movie or animated image, which can be incorporated into the dictionary, when they are widely used phrases.

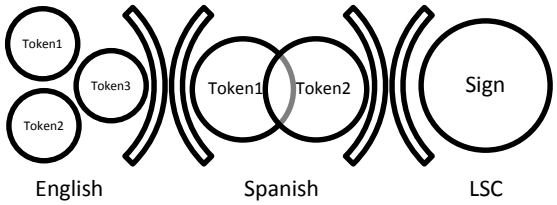

Fig. 5. LSC translation cycle

The program has functions that allow you to delete, add, update, export, spell and add a new dictionary of languages, in figure 6 the text in English is shown, and the words of the dictionary in Spanish that it is going to correlate, until finding them for later show the LSC.

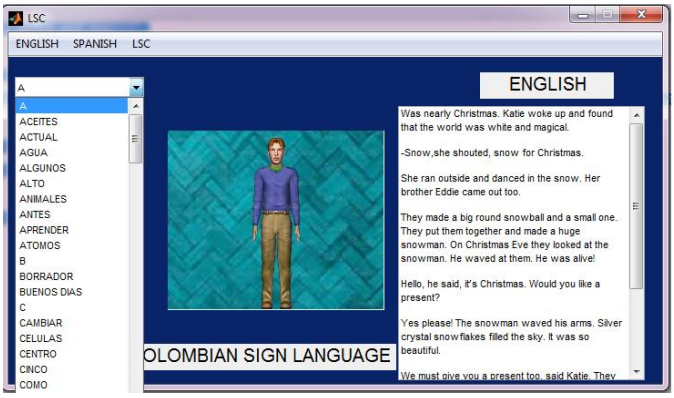

Fig. 6. User interface

Effectiveness test

Eight pages of different children's stories were analyzed as a measure to know the level of recognition, which can be affected by the amount of stored signs, this test gives an idea of the level of translation. Each page is decomposed into tokens and later into characters, although the spelling of a word not found in the dictionary is left as an option, the words are translated literally. Equations 1 and 2 show how to measure each page according to the number of words included in each one. Where CPP is the number of words extracted per page, CPS is the number of words in Spanish in the dictionary

$$Porcentaje\ de\ acierto = \frac{CPP * 100}{CPS} \quad (1)$$

$$\text{Acierto total} = \sum_{1}^{8} \frac{porcentaje\ de\ acierto}{8} \quad (2)$$

It can be seen that pages 1, 3, 5 and 7 are the first page of each story and it recognizes them with more words for later translation (Figure 7)

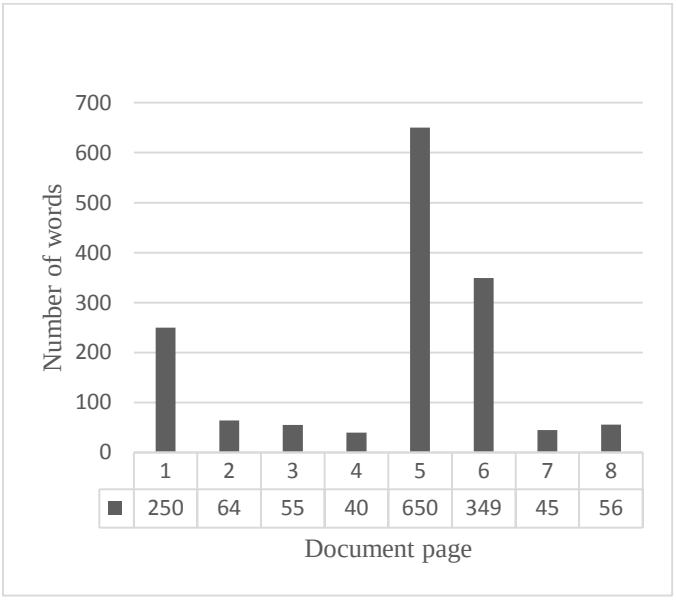

Figure 7. Number of words per document

The total percentage of correct answers is 55.28%, and after including synonyms in English it rose to 64.87%. Although the hit rate is not that high, it is due to the number of words included and the taking of basic categories from the LSC dictionary (table 3), which maintains a general format not focused on the words that are used the most, that is why The most used words in English should be searched for, to improve effectiveness in the translation and samples of signs, likewise the tests were supervised with expert personnel in signs, but not with an English translator, which makes it a system with errors syntactic and semantic. These variables must be included so that the system has all the possibility of making a good classification.

Table 3. Effectiveness test.

Words	Pinocchio	Man on the moon	Snow white	The Snowman
Token English	572	194	999	124
Token Spanish	314	95	358	101
Percentage of success	54.89	48.96	35.83	81.45

IV. CONCLUSION

This research article proposes a computer system that allows translating words from a language to the LSC, based on dictionaries and a 3D sign model, performing a lexical analysis of the words entered. The results show that it can be a useful tool in teaching, as an initiative for foreigners who do not know sign language. The results were obtained using English words as prototypes. As future work, a syntactic and semantic analysis must be added that allows the words or phrases to be translated correctly into Spanish and then converted into LSC.

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