Automatic Concept Explanation for Deaf Users

Student: André Dias

Infomatics Enginering, Master level, Porto School of Engineering, Polytechnic Institute of Porto
Rua Dr. António Bernardino de Almeida, 431, Porto, Portugal
1140279@isep.ipp.pt

Mentor: Nuno Escudeiro ID

Porto School of Engineering, Polytechnic Institute of Porto
Rua Dr. António Bernardino de Almeida, 431, Porto, Portugal
nfe@isep.ipp.pt

Abstract. *In the learning process, concept explanation plays a crucial role, especially for languages with limited vocabulary like sign languages such as the Portuguese Sign Language (LGP). Due to the small lexicon of LGP, when compared to Portuguese, deaf users face difficulties when encountering words like "Nanotechnology" that have no corresponding sign in their mother language. Available tools, like online dictionaries in Portuguese, are not ideal because they explain the concepts in Portuguese, a distinct language from LGP. The work described in this paper solves this issue using machine learning, summarization, and automatic translation techniques to generate explanations of words or expressions that do not exist in the lexicon of LGP. The solution relies on web scrapping and summarization to gather explanations for a given concept in Portuguese, that are then translated to LGP and produced by a 3D avatar. This approach aims to overcome the limitations of reduced vocabulary, mainly in technical study fields.*

Keywords. Sign language, text summarization, automatic concept explanation, online technical glossary, low-resource languages

1   Introduction

Concept explanation plays a crucial role in the learning process, especially for languages with small lexicons like sign languages. In Portugal, the official language of the deaf community is Portuguese Sign Language (LGP), which has a limited lexicon that cannot represent all words in Portuguese. The lexicon of LGP is com- posed by multiple signs where each one represents a word or an expression in Portuguese. However, the opposite is not true. There are numerous words in Portuguese that don't have a sign that translates them. Thus, LGP users have to rely on tools made for Portuguese speakers to understand certain concepts. To address this problem, a project was developed that utilizes machine learning, summarization, and automatic translation to generate explanations of words or expressions in LGP that are not in its lexicon.

The project comprises three main components: an API for generating explanations, a formula for calculating LGP readability scores, and a web app that displays the generated explanation in plain text and in LGP translation with the help of an avatar. The project is expected to generate accurate LGP explanations and readability scores. The paper is divided into four more sections that provide deeper explanations of the partial solutions available, the developed solution, the project's contributions, and the conclusions.

2   Related work

As previously stated, there is currently a lack of a comprehensive solution capable of translating concepts from Portuguese to LGP. However, there are some partial solutions available that attempt to address this issue. In this section, the researchers will describe these partial solutions, as well as the Portuguese readability metrics that were analyzed in order to create the LGP readability metric.

2.1   Online Dictionaries

One of the most known online dictionaries with LGP content is the Spread the Sign [1]. In this dictionary a user can search for a word and if there is a previously recorded video translation for that word, in the site database, it will be displayed for the user. The search results only display the video of a person performing the corresponding sign, and the possibility to look at the same word in another sign language.

Another online dictionary that provides content for the LGP users is the Infopedia [2]. Although this is a Portuguese dictionary, it also contains a section for searching words in LGP. Here the search results, not only provide a video translation of the word, but also an explanation in Portuguese in how to reproduce the sign shown in the video.

Online dictionaries as a solution are limited by the database of prerecorded videos, and the LGP lexicon. The latter is a problem because they focus on a direct translation, word to sign, instead of trying to translate the meaning of the word.

2.2 Sign Language Interpreter

Regarding the sign language interpreters in Portugal there is CTILG [3], a company that provides professional LGP translation services in workshops, classes, congresses, events and more. This company is responsible for the live translation of some morning TV shows.

A more affordable solution for a regular LGP user is the Serviin [4] which is a service that provides an interpreter to work as a middleman between a deaf person and a targeted service/company. This solution is available as a mobile app, with a very low cost for the deaf user, or through a web app that is free.

This solution is limited by the interpreter's own knowledge and their cost. Also, by utilizing this solution the LGP user is sacrificing some of his autonomy.

2.3 Portuguese Readability Metrics

Readability metrics are used to calculate a score that relates to the level of education a reader will need to fully understand the context of a given text. There are some widely known and used metrics for the English language, such as Flesh Reading Ease, New Dale-Chall, SMOG, Flesh-Kincaid, Gunning Fog and so on.

In 2019, Antunes and Lopes published an article [5] that adapted the values of the metrics used to calculate the readability of text in English so it could be applied to Portuguese. The adapted readability metrics are presented in table 1.

Table 1. Adjusted Portuguese formulas.

	Formula
SMOG	$16.830 \times \sqrt{CW} \times 30 \div SE - 23.809$
Flesch-Kincaid	$0.883 \times WO \div SE + 17.347 \times SY \div WO - 41.239$
ARI	$6.286 \times CH \div WO + 0.927 \times WO \div SE - 36.551$
Coleman Liau	$5.730 \times CH \div WO - 171.365 \times SE \div WO - 6.662$
Gunning Fog	$0.760 \times WO \div SE + 58.600 \times CW \div WO - 12.166$

CH - characters, CW - complex words, SY - syllables, WO - words, SE – sentences.

3 Automatic Concept Explanation

In order to solve the previously mentioned problems Automatic Concept Explanation was created. The main functionality of this solution is to allow the LGP users to search for a word or expression in Portuguese and display its explanation as well as the respective LGP translation.

All the components can be seen in Figure 1.

A user interacts with the web application that was developed in React, an open-source JavaScript framework for building user interfaces. Here the user can search of the desired concept as well as changing the page language. This is also the place where the generated explanation is shown in plain text or in LGP by the avatar. After each explanation, it is also presented their LGP Readability Score, which is presented more in depth in the following subsection as well as feedback options. If one of the presented explanations is not acceptable, it is possible for the user to request a new one.
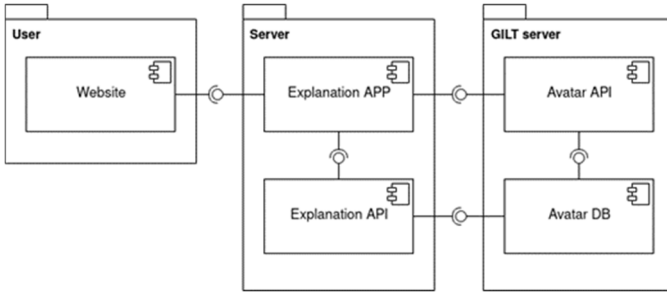
Figure 1. Component Diagram.

When a concept is searched for, the input is sent to an API that was developed in Flask, a lightweight open-source Python web framework. This API will generate a list of explanations using Text Mining, Information Scraping and Information Retrieval techniques. The list is sorted based on each explanation LGP Readability Score.

The avatar and its database are projects that were previously developed by GILT and that are used to enhance this project.

3.1 LGP Readability Score

The API generates multiple explanations, especially for words with different meanings depending on the context. These explanations must be sorted to provide the best options to the user. For regular languages, readability score metrics can be used to classify and sort each expression based on how easily readers can comprehend them. Although there are several readability formulas for Portuguese (shown in Table 1), there is no such formula for LGP. However, after analyzing LGP signs, the common variables in every written text were identified, with the goal of creating a new readability calculation formula:

- Hand configurations (CF) - The hand shape in a particular moment.
- Moments (MT) - The position of the hand in relation to the body.
- Hands (HS) - Both hands or only the dominant hand.
- Facial expressions (FE) - Motion or position of the face muscles.

Using those variables, the following formula was created:

$$(0.7 \times CF + 0.3 \times MT + 1 \times FE) \times (0.5 \times HS) \qquad (1)$$

The formula was tested using the signs from the avatar database and the constant values, that initially were set to 1, were manually adjusted to produce a more compact interval of results. However, the constant value for the facial expressions were unaltered due to the current version of the avatar not supporting them. In table 2 is shown an example of some signs and its readability score.

Table 2. Readability scores example.

Sign	CF	MT	HS	Score
Javali	1	1	1	1.00
Fornecedor	2	6	1	2.09
Auxílio	2	4	2	3.59
Consumo	4	6	2	5.60
Esclarecer	7	7	2	8.00

4 Conclusion and Future Work

This article provides an overview of a project that is currently in development, with additional features yet to be implemented to better serve its target audience. The primary functionality yet to be integrated is the avatar responsible for translating explanations from plain text to LGP. In addition, the project will include displaying the LGP readability score for each explanation and the ability for users to request a new explanation if needed.

Looking ahead, future work on the project could expand its reach by adding support for other languages, with the avatar capable of translating from plain text to the corresponding sign language. Additionally, the API developed for this project could potentially enhance the capabilities of other GILT projects, both present and future.

References

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