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Tradutor bidirecional de linguá gestual portuguesa

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Bidirectional Translator of Portuguese Sign Language

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Dissertation for the Master degree in Computer Engineering, Specialization in Graphics system and Multimedia

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Dedicatory

This thesis is dedicated to all the people that help me to achieve this moment.

This thesis is dedicated in special to my parents and to my girlfriend, they have been with me since the beginning of my journey.

Resumo

Uma das maiores preocupações da Sociedade é promover a igualdade de oportunidades e a inclusão social. Este é um tópico chave na agenda Europeia, em particular ao nível do Ensino. Apesar do esforço que tem vindo a ser realizado por inúmeros investigadores e instituições, as dificuldades inerentes à comunicação entre ouvintes e surdos continua a ser uma barreira significativa para a inclusão. O elevado ritmo de desenvolvimento da tecnologia assistiva possibilitou o aparecimento recente de várias soluções para promover a inclusão da comunidade surda um pouco por todo o mundo. No entanto, no que respeita à língua gestual portuguesa, as soluções atualmente disponíveis são ineficientes e não cobrem as necessidades da comunidade.

A criação de um tradutor bidirecional entre português escrito e língua gestual portuguesa permitirá uma comunicação mais fluída e eficiente entre ouvintes e surdos, gerando igualdade de oportunidades e promovendo a inclusão da comunidade surda na sociedade. O objetivo desta tese consiste na promoção da inclusão social da comunidade surda, tornando a comunicação entre surdos e ouvintes mais eficaz.

O tradutor automático desenvolvido neste trabalho, denominado VirtualSign, tem capacidade para traduzir gestos em texto e texto em gestos usando um modelo de tradução desenvolvido especificamente para o efeito. O tradutor de gestos para texto utiliza um par de luvas de dados com 14 sensores para reconhecimento da configuração manual e o Kinect para reconhecer os movimentos corporais efetuados pelo utilizador. Os sinais recebidos destes dispositivos são convertidos num modelo de tradução que alimenta um componente de aprendizagem automática para identificar os gestos que estão a ser produzidos.

A tradução de texto para gestos utiliza um avatar 3D criado para reproduzir as animações que representam o texto a traduzir. Estas animações representam palavras e expressões da língua portuguesa de sinais que são armazenadas numa base de dados. Um dos aspetos inovadores deste trabalho consiste no facto destas animações serem modeladas com recurso a uma linguagem de scripting o que reduz significativamente o espaço. Esta característica torna possível a utilização do sistema de tradução em dispositivos móveis e em outros contextos em que o espaço de armazenamento seja um aspeto crítico.

Para apoiar os surdos e intérpretes de língua gestual a carregar a base de dados de gestos com animações for desenvolvido o VirtualSign Studio; uma aplicação de apoio à configuração de gestos em quaisquer línguas ou dialeto e a geração automática dos scripts correspondentes através da manipulação direta do avatar, ou seja, sem necessidade de conhecimentos técnicos da área informática. Este sistema de configuração está a ser utilizado por uma equipa de surdos e intérpretes de vários países incluindo: Portugal, Brasil, Alemanha, Reino Unido, Eslovénia, Grécia e Chipre.

O sistema de tradução VirtualSign está em fase de pré-produção estando a ser desenvolvidas várias aplicações para o dia-a-dia que a breve trecho estarão disponíveis para o público.

Palavras-chave: Configurador, Língua gestual, Tradutor, Unity, VirtualSign.

Abstract

One of the modern society's main concerns is promoting equal opportunities to everyone and social inclusion is a key topic in the agenda of the European Higher Education. Despite the efforts being made there is still not enough support for the deaf community. The technology has been growing very fast, with this some new applications start to appear, but the Portuguese sign language area is still lacking.

This thesis main objective is the creation of bidirectional translator of Portuguese sign language. To be capable of making this translator it was necessary to create two different applications with the capacity of translating gesture into text and text into gesture.

The gesture to text translator needs to have two different devices besides the computer, this two devices are a pair of gloves called 5DT gloves that contains 14 different sensors to be capable of recognizing the configurations made by the hand of the user. The second device is the Kinect that is a camera with sensors that has the capacity of recognizing movements made by the user.

The text to gesture translator uses one avatar 3D that has been created to reproduce gestures that represents the transcribed text. To perform the gestures the avatar 3D uses an animation parameterization system to make the correct gestures.

Translating sign language requires a vast set of parameters that need to be taken into consideration such as hand configuration, arms movement and facial expression. Those characteristics are the components of the translation moments.

So, to store all the information required for the translation of words to signs, considering the large number of existing words, the creation of the VirtualSign Studio (VSS) was necessary. The VSS application allows the users to create gestures that represent words.

All this development has been possible after an extensive study about sign language and after a study made about the state of art of applications that use sign language.

This dissertation was realized on the Instituto Superior de Engenharia do Porto in the TMDEI discipline.

This project goal is to obtain a major social inclusion of the deaf community in society, making the communication between deaf people and non-deaf much easier.

Keywords: Configurator, Sign language,Translator , Unity, VirtualSign

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Acronyms and Symbols

List of acronyms

3D	3 dimensional
BC	Boost cascade
GILT	Games interaction and learning technologies
ISEP	*Instituto superior de engenharia do Porto*
KNN	K-nearest neighbors
NN	Neural networks
NB	Normal Bayes
PSL	Portuguese sign language
RT	Random Trees
SVM	Support vector machine
VSS	VirtualSign Studio

List of symbols

π	Pi

1 Introduction

This project scope fits in the Dissertation for obtaining the Master's Degree, in the field of graphic systems and multimedia of Instítuto Superior de Engenharia do Porto “ISEP”.

The objective of this project is to create a bidirectional translator of Portuguese sign language (PSL), with this system it will be possible to help deaf people communicating with non-deaf people, helping them to be more socially integrated.

Like many other things in life, language is something that all the people in world start to learn in early stages of their life without even noticing that it is happening. Every species in the world learn to communicate without anyone teaching them to do that, every single species needs to learn that to survive. Some people need to learn to communicate differently than the others because of some problems that can happen in the beginning of their life or after a period of time. This project aims to help people that can’t listen or talk like the others. Deaf people are the reason this project came to exist.

In Portugal, there are 30 thousand deaf people that talk using Portuguese sign language but the number of people with hearing problems is 120 thousand (surdos, 2011).

The sign language is utilized by the deaf community to communicate between them and with all the people, but like Portuguese language isn’t recognized by everybody, sign language isn’t recognized by most of the people. In order to help the communication between deaf and non-deaf people a bidirectional sign language translator was created.

This translator pretends to create a bridge, that will make possible to translate text into gestures, because people that use sign language utilize a different grammatical system than Portuguese language and to help them to understand better what non-deaf people is trying to tell them. This is one side of the bridge and the other side is the translation of gestures into text translator. With these two translators, it became possible to create a fluid conversation between deaf and non-deaf.

The description of the whole process that was made to create this bidirectional translator is documented in this dissertation.

1.1 Problem

In these days there is a noticeable evolution (Dosi & Nelson, 2013) of the process of social inclusion (Atkinson, 2009) and the reduction of physical barriers, there are yet several problems within the deaf community concerning communication. This project aims for that problem to be reduced.

If a deaf person goes to a police station it will be complicated to communicate with the police officer and it's possible to see that in schools too, if the teacher wants to communicate with a deaf student. Deaf people have some problems reading because the rules of sign language. This is a problem that must be solved.

1.2 Goals

The main goal of this project is to help the communication between all the persons in the world, beginning with Portugal with a bidirectional translator of Portuguese sign language.

With the recent development of new technologies, the recognition of data through sensors that can tell us the movements made by a person are improved and there are new possibilities to create the translator. Now with the help of a Kinect device that can transform movements into data the translation process is easier. The Kinect is easily obtained by buying a console known as Xbox 360 (X-box, 2005), but this device has a problem that it can't recognize little movements made by the hands and the fingers of the person. Because of that problems 5DT gloves that have 14 sensors to follow precisely the movements of the hand and fingers were included in the project.

Utilizing these two devices it became possible to transform gestures into text and with that, one part of the problem had a possible solution.

It´s known that 10 thousand words exists in Portuguese sign language, this words are dynamic and they utilize movements, hand configurations and facial expressions, but the alphabet is mostly static only using configurations to be created.

With this knowledge it was decided to first try to recognize only letters, and if the results were good then advance to recognizing full words.

The second problem is to translate text into gestures. The objective is to create an avatar 3D with the possibility to reproduce gestures of sign language.

To create this possibility, the avatar, needed to be animated with all the gestures utilized in sign language and after that creating a form to make an association between the animations and the words.

In order to create all this points that were presented before it was necessary an enormous study of sign language to understand how the language evolved and all the grammatical and semantic elements that the language contain.

These are the main objectives to fulfil in this project in order to facilitate access and interaction of the deaf and hearing impaired to digital content, creating conditions to enhance their inclusion in the digital society.

1.3 Strengths and weaknesses

This project has some strengths and some weaknesses and the main objective is to create strategies to nullify those weaknesses. First the evolution of technologies will be used to take the most advantages about this innovator concept.

Secondly developing good strategies of marketing will be needed to attract more users to the translator.

One of the approaches is to sell this product to city halls and enterprises with public attendance, and the enterprises who use the product will acquire more benefits because they have a better attendance with improved social inclusion.

Finally, this product can be sold to schools, giving them benefits on learning and communicating with deaf people.

1.4 Approach

To resolve the problem presented a bidirectional translator of Portuguese sign language was made. This problem was divided on two modules, one of them is a translator capable of translating gesture to text and the second one translates text to gesture.

To be capable of that, the first assignment was to learn about the state of the art and gain some knowledge about Portuguese sign language. Starting with that it was good to think about some possible implementations for this project.

The second assignment was the creation of an application structure, use-case diagrams and class diagrams of all modules.

The third assignment was making an avatar capable of translating the text with gestures. This gestures are animations made frame by frame to translate the word recognized by the translator, in the same assignment a program capable of translate gestures into text was created. After that an interface that can show all of text to be translated for the avatar was created and is capable of showing the text recognized for the gestures realized.

The fifth assignment was testing various algorithms to check which ones have a better performance.

All these assignments have been evaluated using QEF (Quantitative Evaluation Framework) (Escudeiro & Bidarra, 2007). After the conclusion some questionnaires were made about the use of this translator.

1.5 Contribution

The contribution that it is pretended to create is to help all the deaf communities around the world to communicate easily with everyone. Of this project it was returned this contributions:

1. Recognition of movement signals emitted by the Kinect.
2. Recognition of the data emitted by the sensors entrenched in the 5DT gloves.
3. Comparison between classifiers implemented to give the percentage of acceptance of the gestures recognized.
4. A translator of gestures to text with the possibility to translate static gestures like the alphabet and dynamic gestures like words and phrases, but for this being possible the program need to be train to became possible to recognize the gestures.
5. A configurator of sign language, capable of create any word of Portuguese sign language that will be used by deaf people and experts in sign language.
6. A dictionary of sign language made through the configurator.
7. A translator between text and gestures, that will use the dictionary to be capable of translate any text transcribed or any text made.

1.6 Overview of the Dissertation

The dissertation document is divided in 8 chapters that contain all the developments made during the project.

In the first chapter it is possible to find the introduction to the project, this chapter contain elements like goals, strengths, weaknesses and even an approach.

The second chapter is constituted by the context, which includes the business concept, restrictions and value analysis.

The third chapter is constituted by the state of art, the technologies that have been used in this project and for some approaches and solutions evaluation.

In the fourth chapter is possible to find the requirements specifications.

The fifth is one of the most important elements that make the bridge between the theories and the development states made, is constituted by elements like architecture, use-cases, data-base and the classes diagrams of the application that have been done.

In the sixth chapter is talked about all the development made to create all the applications.

The seventh chapter talk about the evaluation methods that have been used. For the last chapter is the conclusions and the future work necessary.

2 Context

2.1 Business concept

This project has high probabilities to become successful on the Portuguese market. The application can be sold to various enterprises, if that enterprises have public attendance with this technology they can provide higher quality of attendance to all kinds of people. Thanks to the friendly user interface that allows any user to add words there's a considerable cost reduction on maintenance of the product. Yet it can be sold to city halls, police stations and every place that as attendance to the public.

Seeing all this it is possible to assume that the chance of making this business successful is high. Since this model is a component of a package the marketing and distribution will be handled by VirtualSign.

2.2 Process and actors

This product has been developed in games interaction and learning technologies (GILT) beneath the coordination of Paula Escudeiro. The evaluation questionnaires it was made by some deaf public anonymously. The development of the translators is in the responsibility of Jorge Lopes.

Jorge Lopes is also the creator of this document and the creator of this dissertation document.

2.3 Existing restrictions

This product has some restrictions, the first one is that the module gesture to text depend a lot of hardware like a pair of sensor gloves and the camera to recognize the movements made by the user. Another restriction is that the module gesture to text is not portable, that module needs to stay fixed due to the used hardware.

The module gesture to text can only be utilized in windows. The module gesture to text has another restriction, this restriction exists due to be necessary to train the module before using it. That train will improve the percentage of accuracy but takes some time to make.

2.4 Value analysis

2.4.1 SWOT

- Strengths
    - Innovation
    - Concept
    - Social inclusion
    - Module text to gestures is portable
    - Module text to gestures multi-platform

- Weaknesses
    - High costs
    - Module gesture to text not portable
    - Module gesture to text Single platform
    - Performance may vary on users

- Opportunities
    - New technology
    - Public attendance
    - No completion on the market yet
    - Possible to use on schools to help the communication with deaf people
    - Can be used to help learn sign language

- Threats
    - Sign language interpreters
    - Niche market
    - Deaf community may not accept the translator

In the swot analyses (Hill & Westbrook, 1997) about the project it's possible to see some strengths and opportunities. After that conclusion, if some strategies are created this product may have good quote of the market.

The project it will be disseminated thus resolving some threats as the dissemination will show how good it is and showing that the product won't take the jobs of the interpreters and proving that is only a complement to the deaf community use on its day.

This is some strategies that can be used to not put the interpreters against this, because if that happens it will be an issue that may result in market loss.

2.4.2 Canvas

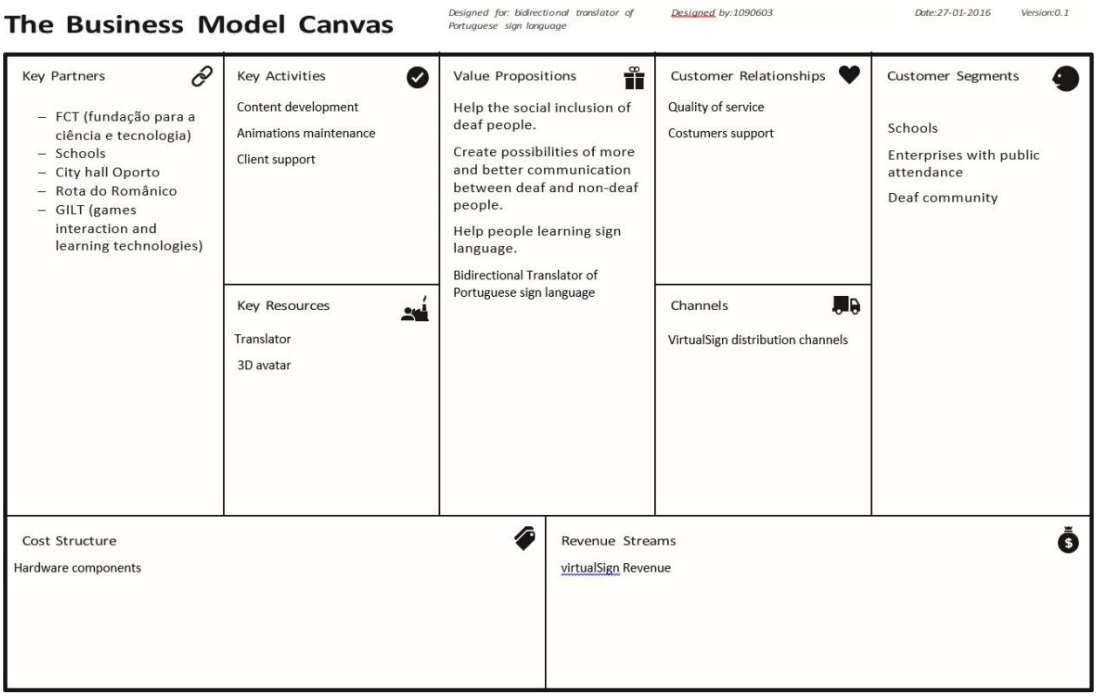

Figure 1 - canvas

With the canvas (Muhtaroğlu, et al., 2013) it's possible to see what the project needs to grow and what will be created to make it grow. With the help of the key partners it's possible to develop the project with good quality.

The value propositions show what is pretended to be made in this project. With the social inclusion in the front hand the enterprises can upgrade their public attendance and make the project recognized.

3 Background on deaf translators

This point will be presented points like State of art of the sign language, programs and applications with sign language, the Kinect, the specifications of the Kinect, the technologies used to make this application, approaches and solutions evaluations.

3.1 State of art

3.1.1 Sign language

Sign language is a language like any other and is a natural language that develops naturally like oral languages.

It is believed by some people that sign language (Stokoe, 2005) is universal, but that is not true. Like the other languages in this world are not universal. The first sign language to exist was the French sign language.

Sign language is complex like any other, the difference is that the sign language is transmitted through more channels than oral languages.

Sign language (Sandler & Lillo-Martin, 2006) can be divided into two major elements, like non manual characteristics and manual characteristics. The manual characteristics are the configurations of the hand, the rotation present in the wrist of the person, the movement of the hand and the point of articulation. The non-manual characteristics such as the facial expressions and the posture of the body.

With this six elements configuration of hand, rotation of the wrist, the movement, the articulation point, the facial expressions and the body posture, it is possible to realize any gesture used in sign language.

Like Oliver Sacks said one day “sign language is the equal of speech, lending itself equally to the rigorous and the poetic – to philosophical analysis or to making love” (Sacks, 1989). After reading the quote of Oliver Sacks and knowing something about the sign language, it is becomes easy to understand what he wants to pass to everyone.

3.1.1.1 Portuguese sign language

The first school that was created in Portugal it was in Casa Pia of Lisbon (surdos, 2011). The Portuguese sign language was created through Sweden sign language, because the first teacher in Portugal was Sweden and brought with him the alphabet.

Trough the time Portuguese sign language evolved and gain 57 hand configurations, with those configurations and the other five elements is possible to translate all the Portuguese words. The dictionary of sign language edited by Porto Editora was created by Ana Bela Baltazar (Baltazar, 2010) and the dictionary is constituted by 10000 thousand words.

The alphabet of PSL is for the most part static gestures by the dominant hand of the person, but a smaller part of the alphabet is a dynamic gesture. The dynamic letters that can be found on the alphabet are “D”, “K”, “Q” and “Z”.

Figure 2 – Alphabet LGP

In LGP in the case of the word not being found in the dictionary, the word is then translated letter by letter and the own names are translated letter by letter too.

3.1.1.2 Aspects of PSL when converted to text

Communication using Portuguese Sign Language (Bidarra, 2015) involves applying different configurations and orientations of hands, arm movements, body position and facial expressions. The translation of PSL to written text requires the analysis of all these elements together, in order to achieve a reliable outcome. Depending on the person communicating, and their experience in LGP, the performed gestures may have a longer or shorter duration and have significant variations when compared to the standard gestures. For this reasons, the automatic translation of PSL to text is not a trivial task. In order to approach this problem, we divided the recognition process into several interrelated steps:

- Recognize configurations of the hands;

- Calculate orientation of the hands;
- Estimate body position;
- Gather arms motion;

3.1.1.3 Aspects of Portuguese when converted to PSL

There are some elements of the Portuguese language (Norberto & Lopes, 2015) that disappear when they are converted into PSL and there are others that become even more relevant.

While translating sentences such as “O Pedro joga a bola”, the articles such as “o” and “a” are not translated therefore the translated text will be “Pedro joga bola”. Also there are aspects that improve the translation such as knowing beforehand which text input was made, therefor it’s easier to translate it as a whole sentence or word by word. As for proper nouns the translation will be done letter by letter as names do not have a single gesture for it.

In PSL the gender distinction occurs mostly when the topic is a feminine being. The woman gesture is used as a prefix. The element order in a PSL sentence use a specific structure which may differ from the normal Portuguese language.

There is no agreement as for which should be the predominant order for sentences, it could be either ‘subject-object-verb’ (S-O-V), or ‘object-subject-verb’ (O-S-V) (Correia, 2012).

After the research about sign language, a research about a program called face-shift will be made. That program is known for using the Kinect to reproduce facial expressions on an avatar.

Figure 3 - face Shift

3.1.2 Programs and games with sign language

The application CopyCat (CopyCat, s.d.) It’s part of a similar project which consists of a game where gestures are needed in order to progress in the level. The movement analysis is done by gloves with sensors. However, the researchers from CopyCat already released a video and intend to use Kinect as a sign detection tool.

Prodeaf (prodeaf, 2016) is a software capable of translate text and voice in Portuguese language into Libras (Brazilian sign language) with the objective to make possible the communication between deaf and non-deaf people. It is an application in the same area of the project being created for this dissertation, but this project is applied to Brazilian sign language.

In the University of Beijing (University, 2013) they have created a project of recognition utilizing the hardware known as Kinect, with the help of the Kinect they can recognize some gestures and translate them in sign language.

Show leap (leap, 2014) is a software that is trying to achieve a possible translation between gestures and text with the help of leap motion (LeapMotion, s.d.) and they use Myo (Myo, s.d.) as well. Leap motion is used to get the movements and the configuration of the hand and Myo is used to get the movements made by the arm with the help of electromyography sensors that detect electrical signals. With this architecture they are trying to achieve the translation between gestures and text.

Hand talk (HandTalk, 2012) is an android application, that transform text into gestures with the help of an avatar 3D. It translate the text into Libras (Brazilian sign language).

Motionsavvy (motionsavvy, s.d.) is a translator between gestures and text that also use the leap motion, they made a tablet that include the leap motion and a specialized camera, with that they translate the gestures into text, they also can translate voice into text. They also have a system that lets a person create is signs to be recognized by the system.

SignAloud (SignAloud, 2016) is a project made by two students that translates gestures into spoken English. This gloves are like the 5dt gloves they have sensors in each fingers and a gyroscopic sensor to recognize the movements and the configurations made by the person.

Some projects in this area already exist, but none of them uses Portuguese sign language, they use the sign language from their country.

In this project all the animations are created manually, but it is already possible to create animations through sensors or 3D scanning, to create the animations signals sent through the sensors are used. But even using motion capture the movement that it is needed to be recognized is very detailed and this application does not have such precision.

3.1.3 Kinect

When the objective is tracking movements all persons think about cameras that can transform images in data and that is what it is needed to transform gestures in text. A device capable of such task already exist. In this particular case it was decided to test Kinect that is easy to obtain because is a device that get distributed by a console very known for being sold by Microsoft (Microsoft, 1975).

The Kinect (Kinect, 2010) is a device developed by Microsoft to use on the console X-Box 360, with this device became possible to develop some games and applications. This device can detect and track a person body.

Kinect is used for various applications to recognize the movements made by its users. One of the best application that is using Kinect and that match this project is the Kinect sign language translator (translator, 2013) in this application they are trying to create the possibility to recognize gestures and transform them in text and also making a 3D avatar reproduce the same gesture that the person is doing. This project is very similar to our project but it has a big difference that our project is also trying to translate text to gesture.

Kinect is also used to create easy ways to interact with only gesture like the GestSure (GestSure, s.d.) in this project they are using Kinect to became possible that surgeons can control the screens around them because they can´t have a keyboard or a mouse in that room.

Fitnect (Fitnect, 2013) is an application that use Kinect to track the body of the clients, for the clients can try out the clothes that are sold in the shop. Using this application, the client does not need to take of their clothes to try a new one and that makes it easy to try new clothes that sometimes is a struggle.

These applications used the Kinect device to detect the human body, but Kinect is also used to play games. There are various games that can use Kinect making the player move in front of the camera to play the game. This type of games are very fun to play with other people.

Games like Just Dance 4 (justDance4, 2012) that uses Kinect to evaluate the player ability to dance and with that evaluation it gives a score for the dance moves.

So the Kinect has been used for trying to resolve various types of problems and to create some fun games.

3.1.4 Specifications Kinect

Kinect is a software technology developed by the Microsoft, the camera of the long range technology it was developed by the enterprise PrimeSense (Primesense, 2012). This camera has the capability of get the information of a scene 3D through a continued infrared light, this system is denominated by light coding.

The Kinect sensor is a box with 25x23x3 cm that connect to a motorized pivot. The dispositive have a camera RGB, a camera monochromatic and an infrared emitter. They use all this element to monitored pattern of reflected points by an object, allowing to get the time of a reflected light and to calculate depth.

Kinect a have field vision of 57 degrees on horizontal, 47 degrees in vertical and 27 degrees of movement in the pivot.

Figure 4 – Kinect

Kinect return a tri-dimensional description and a conventional RGB vision of what is being captured. The resolution of the RGB camera is 640x480 pixels and the depth camera is 320x240 pixels. The cameras capture the data at 30 fps.

One of the problems that Kinect has is that the camera can see the full 3D object. The camera can see the back of the objects or an object can be behind other, but it is possible to resolve this problem by using various Kinect systems.

The Kinect uses a normal USB device but needs to be connect to an adaptor to receive the full charge to become possible to use.

Using the Kinect framework in the pc, it is received a video feed and a data flow that represents the 3D objects recognized by the camera.

Other problems that exist in Kinect is that the expression facial detect is not the sufficient to use in the sign language, that problem surges to in the recognition of the configuration made by the hand. To resolve that problem, a pair of gloves was used.

3.1.5 5DT gloves

The 5dt gloves (Gloves, s.d.) have 14 sensors, these sensors work through pressure. The data that can be obtained by the gloves is presented from values that go from 0 to 1. They only contain 14 sensors but is possible to get 16 values. With this gloves it possible to have a great recognition of the configurations made by the person who is using the gloves. With 14 sensors it's possible to recognize the differences between gestures very similar like it's the ones represented in the figure 5.

Figure 5 - gestures

The gloves are made of lycra and for that reason it is easy to put them on. The gloves have a system that allows retrieving the data by wireless, with data it resolves some problems of using a system that have cables around you.

The worst problem that the gloves have is the price. The price for the glove is nearly 5 thousand dollars and for that reason isn't affordable for everyone.

Figure 6 – 5DT Gloves

3.1.6 Algorithms

An algorithm can be defined by a finite sequence of sequential paths to resolve a problem (FERRARI & CECHINEL, 2008).

When an algorithm is made it is created with a pattern that needs to be followed to get a result to the problem. One algorithm is not the solution of a problem, if that was the case each problem would have a single algorithm attached. However an algorithm is the path to a satisfactory solution for a problem.

Types of algorithms:

1. Classification algorithms
2. Regression algorithms
3. Segmentation algorithms
4. Association algorithms
5. Sequences analyses algorithms

In this project the classification algorithms will be used to make the comparison of vectors to obtain the closest match to the gesture made and also the standard deviation and accuracy of the results obtained by the various algorithms used.

With the results the best classification algorithms to use in this module was chosen.

3.2 Technologies

3.2.1 Unity 3D

Unity (Unity, 2005) is game engine developed by Unity Technologies. Unity is capable of exporting for multiple platforms. Currently supported platforms are: WebGL, Windows, OS X, Android, BlackBerry, iOS, Linux, Nintendo 3DS, PlayStation 3, PlayStation 4, PlayStation Vita, Wii, Wii U, Windows Phone, Windows, Xbox 360, and Xbox One. Unity also provides its users with an asset store that contains several different assets either paid or free. Unity supports Nvidia's PhysX physics engine. Nintendo's Wii U uses unity as its default software development kit (SDK). Unity Technologies calls this bundling an "industry first" (TAKAHASHI, 2012).

Unity has been evolving all the way to arrive to this moment, after unity came out in 2005 they didn't stop to update the engine, every week is possible to get more features, the version utilized in this project is the 5.0, because the visual upgrades that they have done in the transition between the version 4.0 to the 5.0.

Unity became a popular (Polsinelli, 2013) in videogame development because is a pragmatic tool that is mostly free and they won´t charge any royalties to the developers and it is popular because it works as an IDE.

Unity uses a Monodevelop tool (Norton, 2013) to code editor but is possible to change the code editor. In this project the code editor used was Visual Studio, that has some tools to connect with the unity that help the users to make debug to the code that is impossible to do with the

Monodevelop. In terms of classes that are created in unity all of them are connected to the monobehaviour directly or indirectly, this classes makes the connections between all the features that it is possible to use in unity.

In unity it is possible to use the inspector so that each object used in the game or application can have its settings altered for instance by adding scripts, materials and animators etc. In inspector it is possible to change even the public variables that are used in the scripts and with that become easier to test the application that are being created.

3.2.2 Web-service

A web service (W3C, 2004) is a possible solution to connect various application, creating a way to communicate between each other.

With the use of web-services it became possible to make applications older to connect with new ones and make communication between applications with different type of codes.

Basically it can provide resources that are contained in other machine or application.

Web-service are components that create the possibility to transfer and receive data to the applications, to make that possible he transforms the code language in a universal language for all data became understandable to all.

To the enterprises web-services help to create agility and efficiency in the communication between all the applications are used.

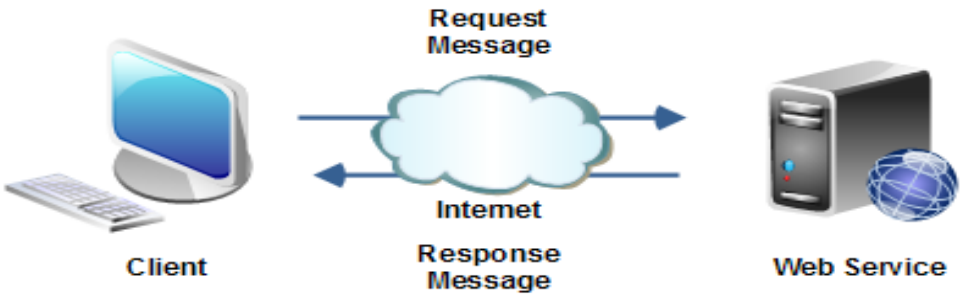

Figure 7 – web-service

3.2.3 Sockets

Socket (IBM, s.d.) is a mechanism of communication between machines, it is used to implement one model client/server that make possible to trade messages between processes of a server to another client.

In this moment is one of the most common technologies of communication between servers and clients.

Sockets are an abstraction of communication addresses through processes communicate with each other. To be capable of communicate it is utilized IP identification and the door that they can be made a connection.

Figure 8 - sockets

3.2.4 Maya Autodesk

Maya (Maya, 1998) is a tool for modeling 3D, animations, rigging objects, weight paint and even special effects, Maya was choose to use in this project because a formation that was done in Maya Autodesk with Ricardo Megre (Megre, 2011).

Maya is a program from the Autodesk foundation and is a paid program that costs around 1600 euros a year.

The first Maya program was launched in 1998 and now every year they launch a new version of Autodesk Maya.

Various known studios use Autodesk Maya to make the models and the animation to their games or even their movies, one of the movies that used Maya is a movie that most of the people known is Transformers and one of their creators is Mark Casey and he said "Autodesk Inferno and Autodesk Maya were absolutely the best tools for Transformers. Being able to import Maya animation into Inferno means we can leverage the animation work through the same file and with the same choreography in each shot. It is a very powerful, efficient, and streamlined way of working. That's where these tools really shine." (Casey, s.d.). One of the

game studios that used Maya is Naugthy Dog (Dog, 1994) that is the studio that create Uncharted, one of the popular exclusive games of Sony.

For eleven years Maya client's won Visual effects Oscar awards. One of that awards it was get for the movie King Kong (IMDB, 2006).

3.2.5 MySQL

MySQL (Mysql, 1995) is system to manage data-base. To communicate and manage those data-bases SQL language is used.

MySQL was launched for the first time in the year 1995 and now is one of the most data-base managers used in the industry, Even Nasa (NASA, s.d.) and the us army use MySQL to manage their data-bases.

Mysql have many advantages for the people that use them, like:

- Portability,
- Many compatibility's,
- Performance,
- Its free
- Easy to use.

3.3 Approaches and solutions evaluation

3.3.1 Measures

The measures that will be used for evaluation in this project is a percentage of precisions and user satisfaction. This is the most important thing to evaluate because the project need the users to be satisfied for them utilize the product and it needs to be very precise.

In this project the percentage of precisions can influence the success of the project, so because of that this measure needs to be used. The precision is also important because the main objective is to translate from a language to another, and if that translation have errors it will be prejudicial to all the users.

3.3.2 Hypotheses

Initially a research was made about an application called Lib-hand (Lib-Hand, 2011), this application is open-source. The application is known for create a hand very detailed, with this it will be possible to see how to create the hand of our avatar, the avatar needs to be very detailed on the hand, because sign language has many details locked on hand. In the Figure 9 it's possible to see how lib-hand works.

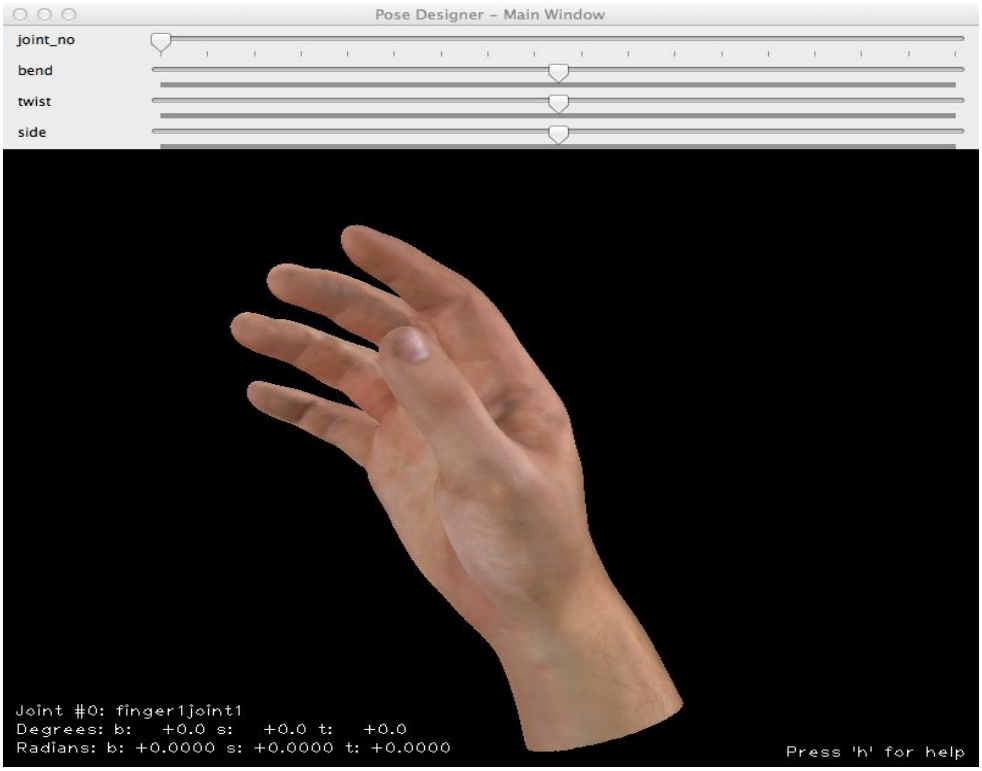

Figure 9 – lib-Hand

An intensive study was made about sign language, the objective of this research is too understand all the aspects about this language. This research is the most important of all.

3.3.3 Approaches

3.3.3.1 Gesture to Text

The hand configuration consists in the shape the hand assumes while performing gestures. In Portuguese Sign Language there are a total of 57 different configurations of hands, in the Figure 10 we can see some of the configurations.

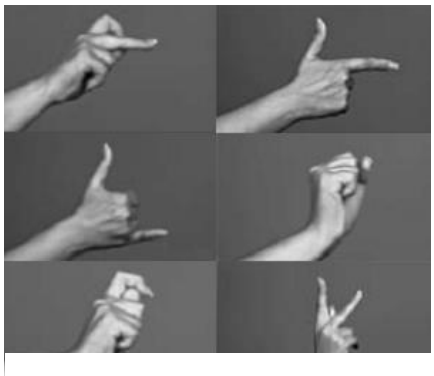

Figure 10- Sample of configurations

Note that the orientation of the hand is not taken into account in the recognition of the hand configuration. Concretely, in the Figure 11 we can observe the hand with two different orientations, but with the same configuration.

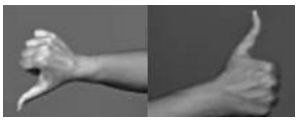

Figure 11- Two different orientations, but same configuration

As support for the classification of the hands configurations we will use 5DT gloves with 14 sensors each. The sensors indicate approximately the shape assumed by the hands by identifying the bending of the fingers and the spacing between them. Note that although the values obtained are relatively stable, physically similar hand configurations may induce into ambiguous results, mainly when gestures are performed by different people (hands of different sizes).

To ensure more reliable classification of the hands configurations we will analyze the performance of six machine learning algorithms, namely: Random Trees (RT), Boost Cascade (BC), Neural Networks (NN), K-Nearest Neighbors (KNN), Normal Bayes (NB) and Support Vector Machine (SVM). For all these algorithms, we will use a standard implementation available in the Open Source Computer Vision Library (OpenCV).

3.3.3.2 Text to gesture

To create a translation of text to gesture we have to validate properly the text. In order to create an efficient and high performance translation, the text will be treated sentence by sentence. Those sentences analyzed one by one and if there is gesture associated to that sentence it will be translated using that gesture, else if it doesn't have any gestures associated to the whole sentence, it will be divided by words and resorting to the database it will be translated if that word exists.

Also it is possible that the words do not have a direct translation such as proper nouns, therefor those words will be translated letter by letter.

A crucial part of this project is the animations which facilitate the translation of the texts. Those animations will be created resorting to the Autodesk Maya application.

The animations are made frame by frame and then interpolated in unity so the transaction between animations becomes soft and fluid, without creating a robotic look.

The animations are created by a certain number of frames. For each frame it's saved the position and rotation of all the avatar's body parts, then the connection between frames is automatically created, making the movement required to move the body from a point to the other.

Thus the animations are made with a higher consistency and are more realistic.

3.3.4 Methodology evaluation

The hypotheses will be compared with each other to recognize the various advantages.

In the case of the classifiers the tenfold cross validation will be used to understand which classifier is the best.

In the case of the text to gesture the evaluation will be made based on some questionaries' so percentage of accuracy and the acceptance of the deaf public can be seen.

With these evaluations it will be possible to see if the product is on the right path.

4 Requirements Specification

4.1 Functional requirements

Now the functional requirements necessary to develop this application will be addressed.

Primarily it was identified the elements necessary to develop all the given options to the user to translate, such as:

- Translate text into gestures with an avatar.
- Translate gestures into text.

In order to make those points operational it was defined some necessary elements to make them all functional, such as:

- The animation gestures to create an efficient translation of transcribed texts.
- Use of classifiers to recognize the better one.

Create a socket to make a connection between the two models.

4.2 Non-functional requirements

The non-functional requirements for the application were identified. To this project the choice of the requirements was very important, such as the performance and the application to be user friendly.

Performance:

The system performance can be defined for the time of the application response, this is one important point because the user wants to see the result of the translation fast and with the best quality possible.

This application it will be 3D and with that particularity the project will ask for some configurations on the machine that will be installed, without that the performance will be affected.

User-friendly application:

This will be a user-friendly application, being accessible for any kind of user, having a pleasant and easy perceptible graphic environment as well.

With that kind of graphic effects, the use of the application became easy with a faster and simple interaction. The harder element to be used is the translation from gestures to text because some extra hardware is needed like Kinect and that turns the utilization a little bit more complicated.

5 System design

5.1 Architecture

The Figure 12 shows the architecture proposed for translating text into gestures and gestures to text. In this diagram, is shown the two main modules, which carry out the steps needed in the translation process: text recognition, gesture sequence generation, gesture recognition and text sequence generation.

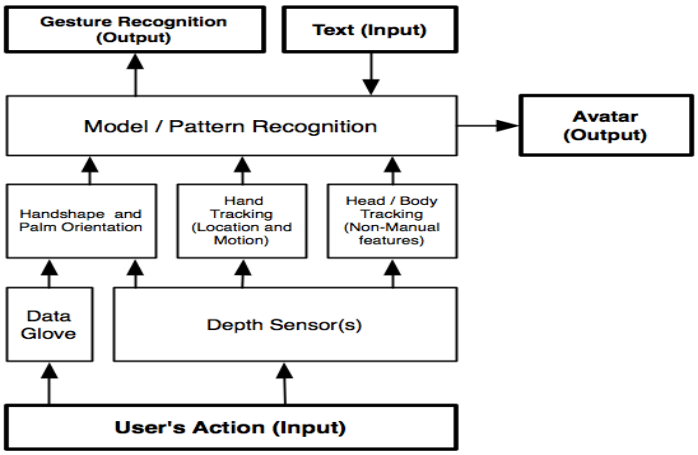

Figure 12 - architecture

The first module (text recognition) converts the written text into signals, which is represented by an animated character. The second module translates the gestures of sign language into text. In this process we used two devices: The Kinect for motion recognition, i.e., to recognize a word or set of words being dynamically represented by a user and the gloves for the recognition of static hand configurations, i.e., gestures that symbolize the alphabet of LGP.

5.2 Use-cases

5.2.1 Text to gesture

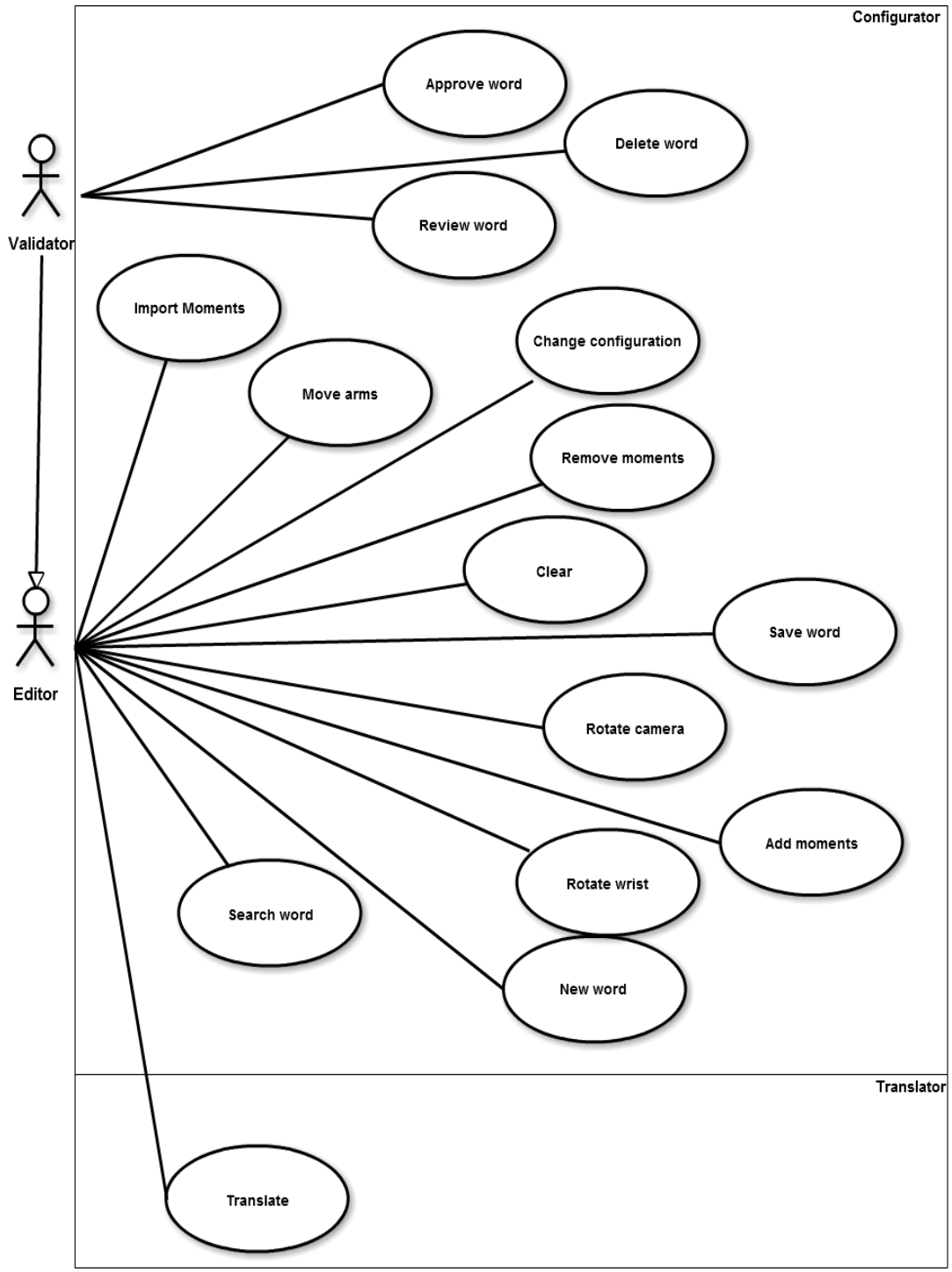

Figure 13 – use case text to gesture

5.2.1.1 Use-case Approve word

Table 1 – “Approve word”

Title	**Descriptions**
Name	Approve word
Summary	The validator approves the word
Actor	Validator
System	Configurator

The “Approve word” use case allows the validator approve a word created by the editors or the validators. After the word being accept the word can no longer be created again. The Validator needs to enter into the configurator and change to the validator menu, after that he needs to search the words he wants to approve and then click on the approve word button.

Table 2 – “Approve word” flow

Flow	**Descriptions**
Main Flow	1- Enter in configurator system, 2- Change to the validator menu, 3- Search for the word to validate, 4- Click in button approve word, 5- Success message displayed by the system.
Alternative Flow	1- Enter in configurator system, 2- Change to the validator menu, 3- Click in button approve word, 4- Failure message displayed by the system.

5.2.1.2 Use-case delete word

Table 3 – “Delete word”

Title	**Descriptions**
Name	Delete word
Summary	The validator Delete the word
Actor	Validator
System	Configurator

The “Delete word” use case allows the validator delete a word created. After the word being deleted the word can be created again.

Table 4 – “Approve word” flow

Flow	**Descriptions**
Main Flow	1- Enter in configurator system, 2- Change to the validator menu, 3- Search for the word to validate, 4- Click in button delete word, 5- Success message displayed by the system
Alternative Flow	1- Enter in configurator system, 2- Change to the validator menu, 3- Click in button delete word, 4- Failure message displayed by the system

5.2.1.3 Use-case review word

Table 5 – “Review word”

Title	**Descriptions**
Name	Review word
Summary	The validator Delete the word
Actor	Validator
System	Configurator

The “Review word” use case allows the validator to put a word in a state of review. That word will pass to an intermediate state, that intermediate state is for the validator recognize that the word is almost done but need a little change to be perfect. After the word being review the word can be altered and saved again.

Table 6 – “Review word” flow

Flow	**Descriptions**
Main Flow	1- Enter in configurator system, 2- Change to the validator menu, 3- Search for words to be validate but the word is not perfect, 4- Click in button review word, 5- Success message displayed by the system
Alternative Flow	1- Enter in configurator system, 2- Change to the validator menu, 3- Click in button review word, 4- Failure message displayed by the system

5.2.1.4 Use-case import moments

Table 7 – “Import moments”

Title	**Descriptions**
Name	Import moments
Summary	The user import moments presented in other words to being able to utilize work already done
Actor	Validator, Editor
System	Configurator

The “Import moments” use case allows the user to import moments from other word to be used in the current word or if the user wants to adjust the moments of that word. It is an easy way to reutilize work already done by all users.

Table 8 – “Import moments” flow

Flow	**Descriptions**
Main Flow	1- Enter in configurator system, 2- Click in the search button, 3- Input the text to search, 4- Choose the word, 5- Click button import, 6- Word imported to the moments

5.2.1.5 Use-case move arms

Table 9 – “Move arms”

Title	**Descriptions**
Name	Move arms
Summary	The user click over the Avatar wrist and drag the arm to move him to the right position
Actor	Validator, Editor
System	Configurator

The “Move arms” use case allows the user to move arms to the place that he need to create the word.

Table 10 – “Move arms” flow

Flow	**Descriptions**
Main Flow	1- Enter in configurator system, 2- Click in the avatar wrist, 3- Drag the arm.

5.2.1.6 Use-case change configuration

Table 11 – “Change configuration”

Title	**Descriptions**
Name	Change configuration
Summary	The user click over configuration combo box and choose the configuration the is wanted.
Actor	Validator, Editor
System	Configurator

The “Change configuration” use case allows the user to change the configuration that the avatar uses in that moment of the word that is being developed.

Table 12 – “Change configuration” flow

Flow	**Descriptions**
Main Flow	1- Enter in configurator system, 2- Click in the configuration combo box, 3- Choose the configuration, 4- The avatar performs the configuration

5.2.1.7 Use-case remove moments

Table 13 – “Remove moments”

Title	**Descriptions**
Name	Remove moments
Summary	The user click over the minus symbol to remove the moment
Actor	Validator, Editor
System	Configurator

The “remove moment” use case allows the user to delete a moment that he don’t need to complete the word configuration.

Table 14 – “Remove moments” flow

Flow	**Descriptions**
Main Flow	1- Enter in configurator system, 2- Click in minus symbol, 3- Moment is deleted.

5.2.1.8 Use-case clear

Table 15 – “Clear”

Title	**Descriptions**
Name	Clear
Summary	The user click over the recycle bin to eliminate all the data.
Actor	Validator, Editor
System	Configurator

The “clear” use case allows the user to delete all the data contained in all the interface inclusive the data performed by the avatar. All the data returns to the default position.

Table 16 – “Clear” flow

Flow	**Descriptions**
Main Flow	1- Enter in configurator system, 2- Click in recycle bin, 3- All data removed.

5.2.1.9 Use-case save word

Table 17 – “save word”

Title	**Descriptions**
Name	save word
Summary	The user click the button save to save the word that he have make.
Actor	Validator, Editor
System	Configurator

The “save word” use case allows the user to save the word that he terminated, this word will be saved in the local data-base and in the online data-base.

Table 18 – “save word” flow

Flow	**Descriptions**
Main Flow	1- Enter in configurator system, 2- Create a word, 3- Give a name to the word 4- Click in the button save word, 5- Success Message will be displayed.
Alternative Flow	1- Enter in configurator system, 2- Create a word, 3- Click in the button save word, 4- Failure Message will be displayed saying to input the word name.

5.2.1.10 Use-case new word

Table 19 – “new word”

Title	**Descriptions**
Name	new word
Summary	The user click the button new word to start the configuration.
Actor	Validator, Editor
System	Configurator

The “new word” use case allows the user to begin the creation of a new word, making this will put every data in default for being easy to create a new group of moments to create a word.

Table 20 – “new word” flow

Flow	**Descriptions**
Main Flow	1. Enter in configurator system, 2. Click in button new word, 3. A confirmation message will be displayed by the system to ask the user if he confirms that he want a new word, 4. Click yes, 5. Star a new word
Alternative Flow	1. Enter in configurator system, 2. Click in button new word, 3. A confirmation message will be displayed by the system to ask the user if he confirms that he want a new word, 4. Click no, 5. Stay the way it was.

5.2.1.11 Use-case rotate camera

Table 21 – “Rotate camera”

Title	**Descriptions**
Name	Rotate camera
Summary	The user click over the camera slider to rotate the camera around the avatar
Actor	Validator, Editor
System	Configurator

The “rotate camera” use case allows the user to move the camera around the avatar to make possible to put the arm in the right position.

Table 22 – “Rotate camera” flow

Flow	**Descriptions**
Main Flow	1- Enter in configurator system, 2- Click in the camera slider, 3- Camera moved.

5.2.1.12 Use-case add moments

Table 23 – “Add moments”

Title	**Descriptions**
Name	Add moments
Summary	The user click over the plus symbol to add moments
Actor	Validator, Editor
System	Configurator

The “add moments” use case allows the user to add new moments for became possible to complete the word with success.

Table 24 – “add moments” flow

Flow	**Descriptions**
Main Flow	1- Enter in configurator system, 2- Click in plus symbol, 3- Moment is added.

5.2.1.13 Use-case rotate wrist

Table 25 – “Rotate wrist”

Title	**Descriptions**
Name	Rotate wrist
Summary	The user click on button of rotations and after that rotate the wrist
Actor	Validator, Editor
System	Configurator

The “rotate wrist” use case allows the user to rotate the avatar wrist. To access the rotation, the user needs to click over the button of the rotations and will be displayed in the screen spheres that allow the rotation.

Table 26 – “Rotate wrist” flow

Flow	**Descriptions**
Main Flow	1- Enter in configurator system, 2- Click on the button rotations, 3- Use spheres to rotate wrist.

5.2.1.14 Use-case search word

Table 27 – “search word”

Title	**Descriptions**
Name	Rotate wrist
Summary	The user use the search bar to find the words he want
Actor	Validator, Editor
System	Configurator

The “search word” use case allows to search for words that are already available in the data-base, this search words can be used to help the creation of the other words.

Table 28 – “Rotate wrist” flow

Flow	**Descriptions**
Main Flow	1- Enter in configurator system, 2- Fill the search bar, 3- Use the combo box to find the word.

5.2.1.15 Use-case Translate

Table 29 – “translate”

Title	**Descriptions**
Name	Translate
Summary	The user fill the text field and then click in the button to translate
Actor	Validator, Editor
System	Translator

The “Translate” use case allows the user to pick any text that he want or even type the text and then translate that text into sign language. The user can translate phrases, words and even letters.

Table 30 – “translate” flow

Flow	**Descriptions**
Main Flow	1. Enter in translator system, 2. Fill the textfield, 3. Click button translate.

5.2.2 Gesture to text

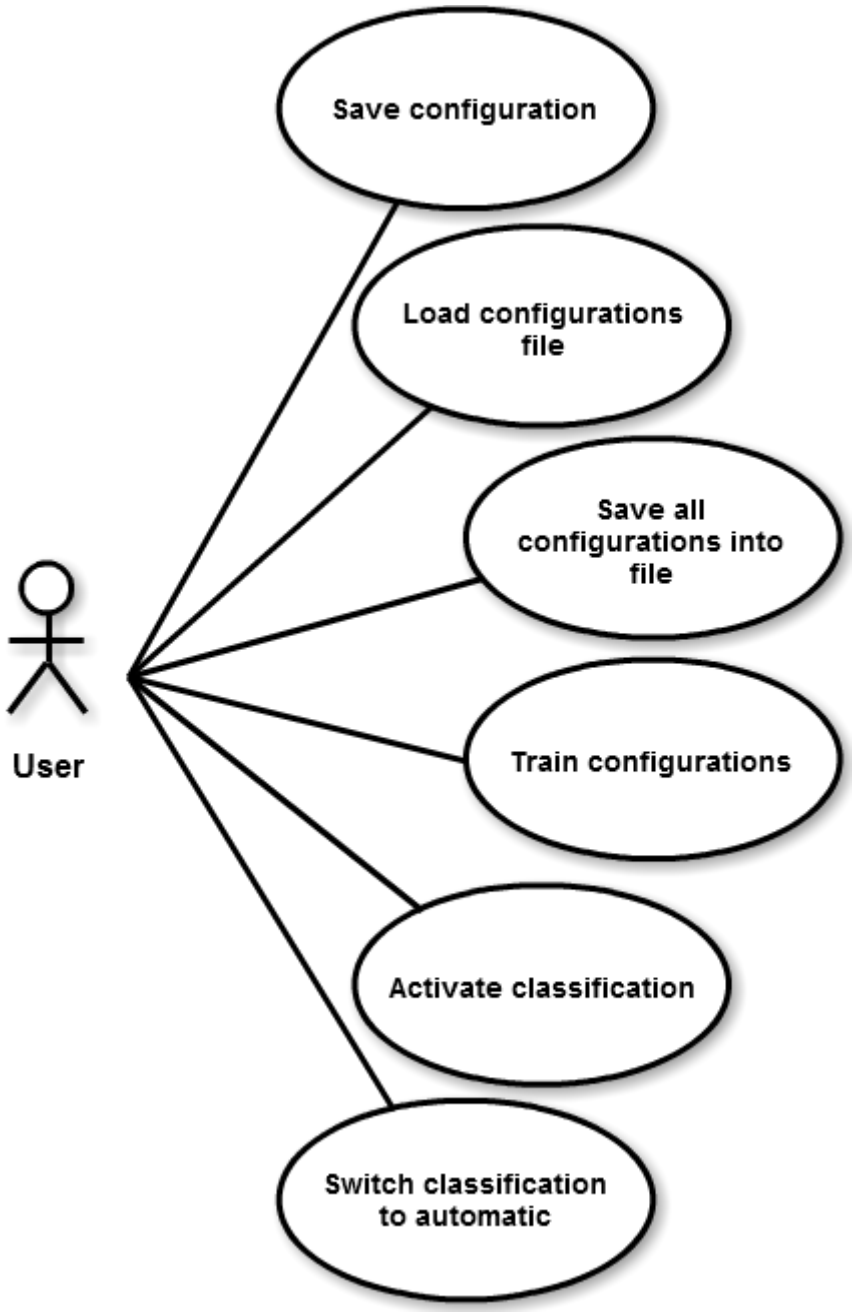

Figure 14 – use-case gesture to text

5.2.2.1 Use-case save configuration

Table 31 – “save configuration”

Title	**Descriptions**
Name	Save configuration
Summary	The user save the configuration that he is doing with the gloves.
Actor	User

The “save configurations” use case allows the user to make a configuration with the help of the gloves and then save the configuration on a data-set file.

Table 32 – “save configuration” flow

Flow	**Descriptions**
Main Flow	1. Enter in the system, 2. Change the configuration, 3. Click on enter to save the configuration.

5.2.2.2 Use-case Load configurations file

Table 33 – “Load configurations file”

Title	**Descriptions**
Name	Load configurations file
Summary	The user load the file into the system
Actor	User

The “Load configurations file” use case allows the user to import all the data contained on the configurations file into a system to became possible to continue the work done.

Table 34 – “Load configurations file” flow

Flow	Descriptions
Main Flow	1. Enter in the system, 2. Press “L” to load the file in the debug case.

5.2.2.3 Use-case save all configurations into file

Table 35 – “save all configurations into file”

Title	Descriptions
Name	save all configurations into file
Summary	The user save all the work into a file
Actor	User

The “save all configurations into file” use case allows the user to save all the data made in the system into a file.

Table 36 – “save all configurations into file” flow

Flow	Descriptions
Main Flow	1. Enter in the system, 2. Fill the data, 3. Click on “S” to save the data into file.

5.2.2.4 Use-case train configurations

Table 37 – “train configurations”

Title	Descriptions
Name	train configurations
Summary	The user train the configurations that exist in the system
Actor	User

The “train configurations” use case allows the user to train all the configurations present in the system. All the configuration need to be train at least 5 times each to create a complete data-set.

Table 38 – “train configurations” flow

Flow	**Descriptions**
Main Flow	1. Enter in the system, 2. Make configuration, 3. Press enter to save.

5.2.2.5 Use-case activate classification

Table 39 – “activate classification”

Title	**Descriptions**
Name	activate classification
Summary	The user active the classification to see the percentage of acceptance.
Actor	User

The “activate classification” use case allows to turn on the classification so became possible to access the percentage of acceptance for that configuration.

Table 40 – “activate classification” flow

Flow	**Descriptions**
Main Flow	1. Enter in the system, 2. Press “C” to activate.

5.2.2.6 Use-case switch classification to automatic

Table 41 – “switch classification to automatic”

Title	**Descriptions**
Name	switch classification to automatic
Summary	The user switch the classification to automatic
Actor	User

The “switch classification to automatic” use case allows the classification became automatic, every configuration that is showed have the acceptance percentage and the standard deviation of that configuration.

Table 42 – “switch classification to automatic” flow

Flow	**Descriptions**
Main Flow	1. Enter in the system, 2. Press “A” to activate.

5.3 Data-Base

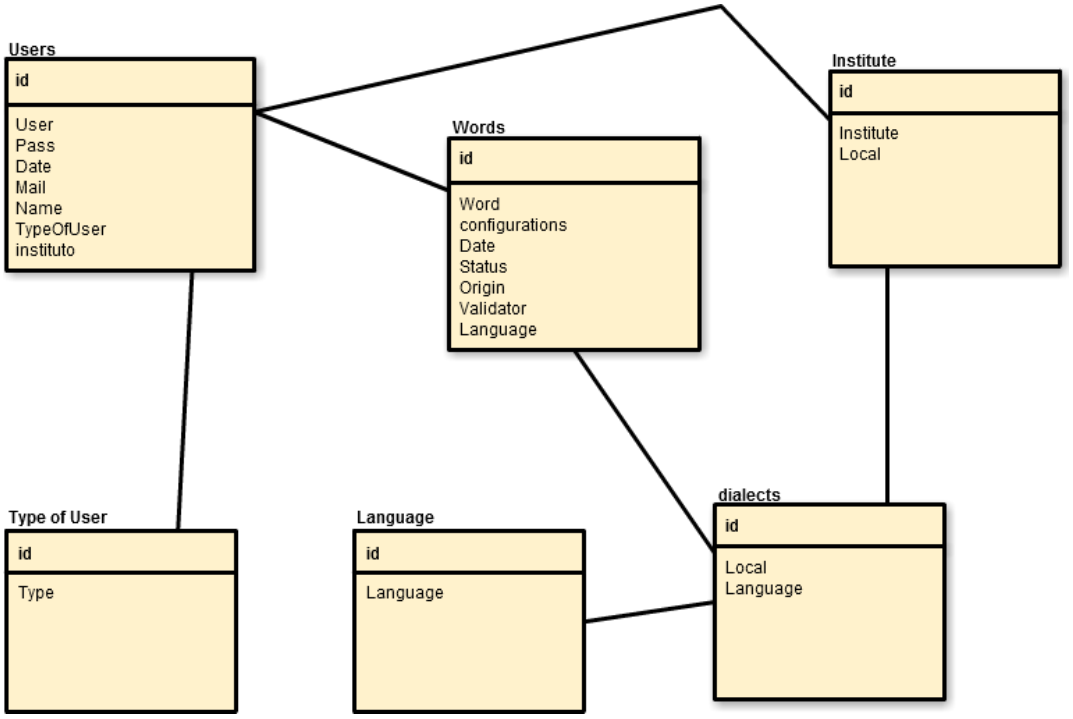

Figure 15 – Data-Base

The data-based used is constituted by 6 tables, with this 6 tables it is possible to manage all the data needed for the project.

Beginning with the “User” table, it has eight elements, the id that is the primary key of the table used to give a unique number to each user, the user and pass are the login data that is used to login in the application. Date, mail and name are only information from the user. The typeOfUser is used to know what type of restrictions the user will have using the application. The user known by editor can´t approve or eliminate words from the data-base but the user known as validator can do that. The institute element is to make analyses and statistics about what institute is more active in the creation of the dictionary and to know how many people for each local is working in the project.

The Type of user table has registered the various types that are allowed to use the application. This id in the table “Type of User” is connected directly to the “Users” table to the typeofuser field becoming a foreign key.

“Words” table is one of the main, because it contains all the information about the words that the application uses to translate all the text presented. The id is the primary key of this table. The camps known as word and configuration are the principal elements of the project with that type of data it is possible to create a relation between the words and the configurations used to make that word. The elements date and status are used to know the date of creation and if the word is approved, in review or to be approved. The origin and the validator is used to know

who created the word and who validated that word, these two elements have a connection with the “Users” table. The last element is used to know to what dialect that word belongs.

“Institute” table is used to record all the institutes using the program and the element Local is to create a relation between the dialects and the local they are used. With that data it is possible to use the local dialect when are being translate the text.

The table “dialects” is used to make the connection between the place and the language used in that country, that way it become possible to know how many dialects exist in a single country.

The last table is “language” that is used to save all the languages that is possible to translate with the project.

5.4 Class diagram text to gesture

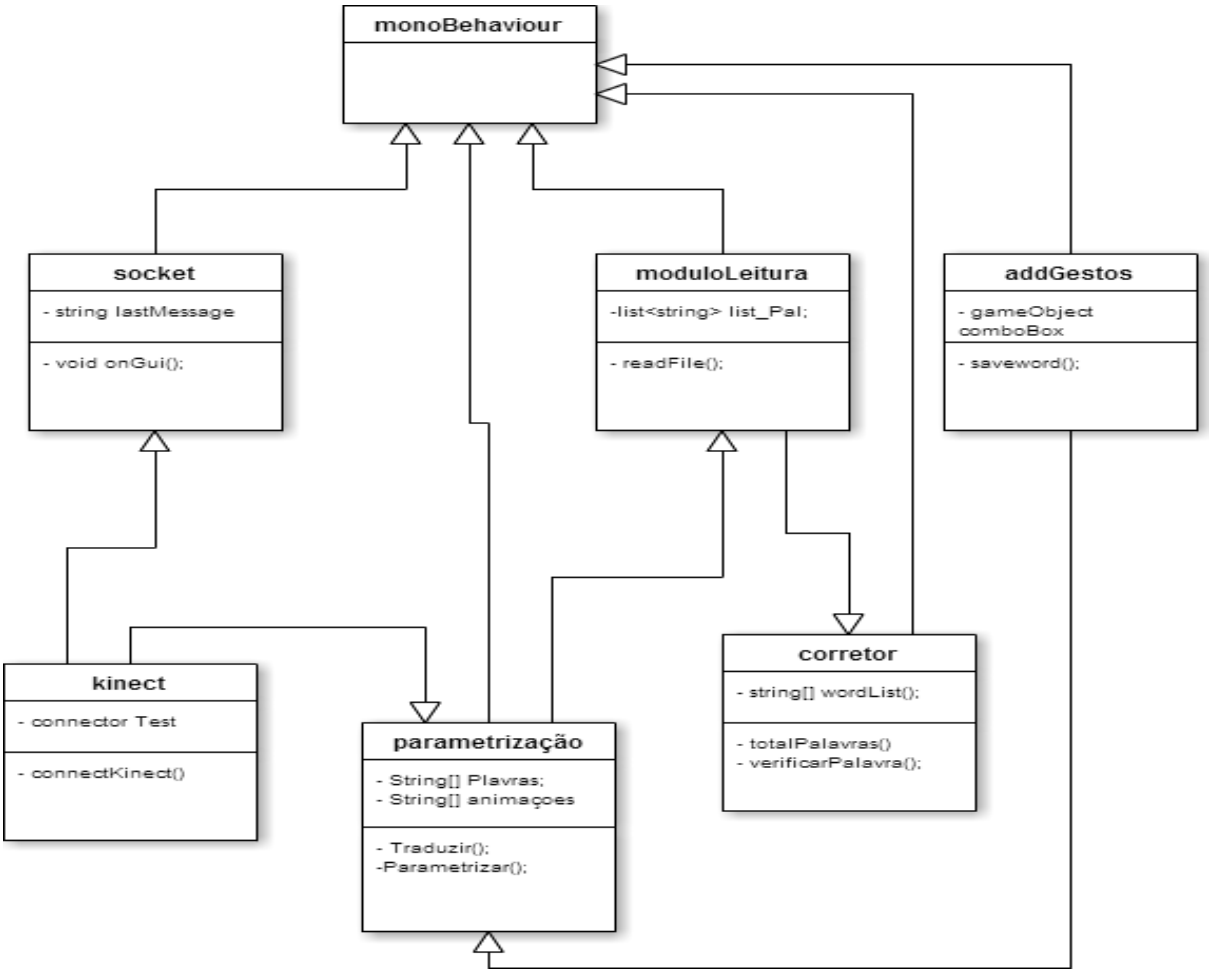

Figure 16 – class diagram text to gesture

In the Figure 16 it is possible to see all the classes implemented on the translator text to gesture. First because this project will be made on unity all the classes need to be connected to the monobehaviour, it is the main class on unity. The socket class is the connector between the translator gesture to text and text to gesture, Kinect is the class to treat all the messages between the two translators. The class parametrização is the class that will be able to make the translation and it needs to connect all the animations to make all the text translation to sign language. The addgestos class has the objective to add gestures to the database, filling the database easily. The class corrector and moduloLeitura are the classes that read the data base and help deaf people on writing regular texts, because the sign language is based on verbs and the deaf people have some trouble writing and reading.

5.5 Class diagram gesture to text

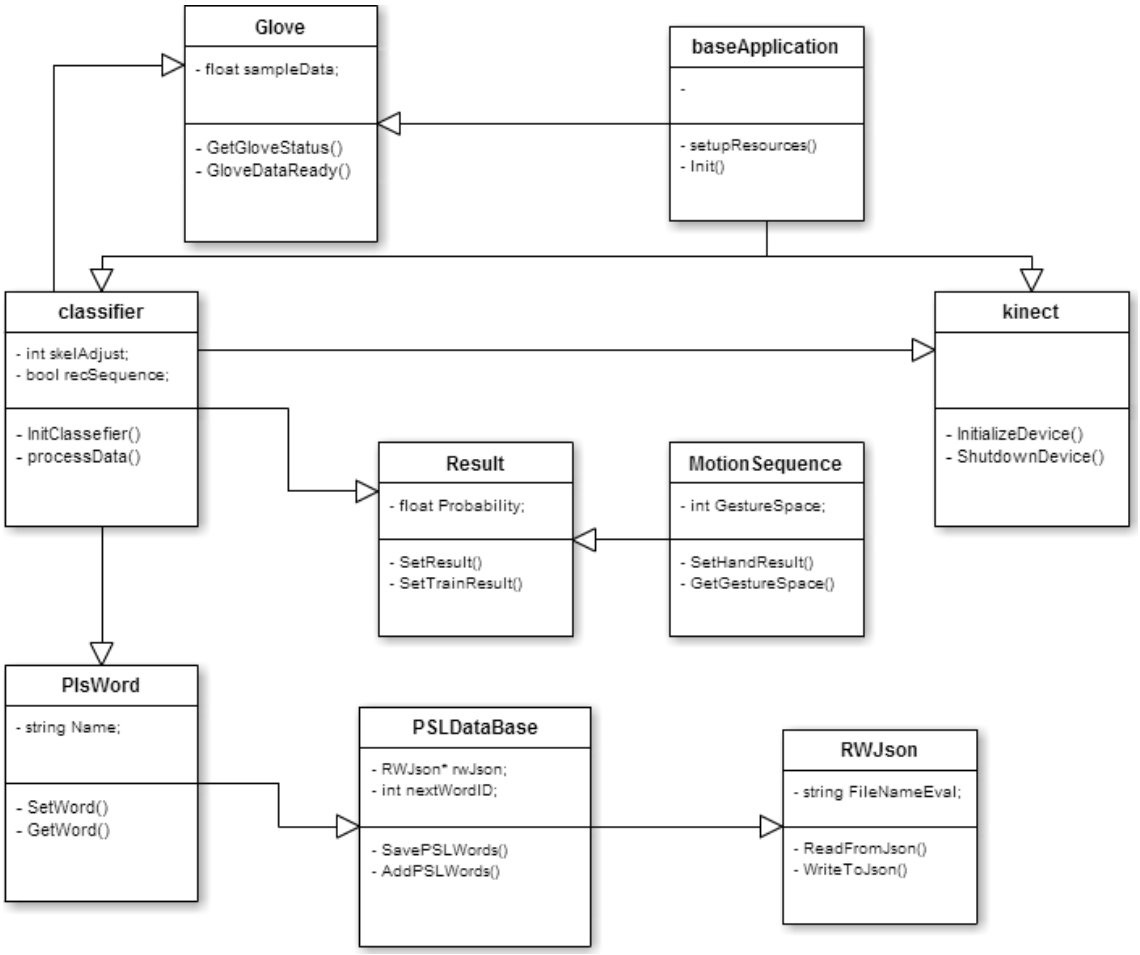

Figure 17 – class diagram gesture to text

In the Figure 17 it is possible to see the classes that will be used to translate gestures to text. First the class glove capable of getting the values sent by the gloves, with those values it is possible to compare and train the classifiers and then get what gesture was made. Baseapplication class is the class that will treat and make the connection with the others. Kinect is the class that makes the connection between the project, the image and the values retrieved by the Kinect.

Then the class classifier that will classify all the signals made and compares them with some classifiers like K-Nearest Neighbors or vector machines. Result is the class that will set the results obtained by the classifier and the motionsequence class. PlsWord is the class capable of getting the words already trained and replying to the classifier to make the correspondence between Animations.

5.6 Class Diagram configurator

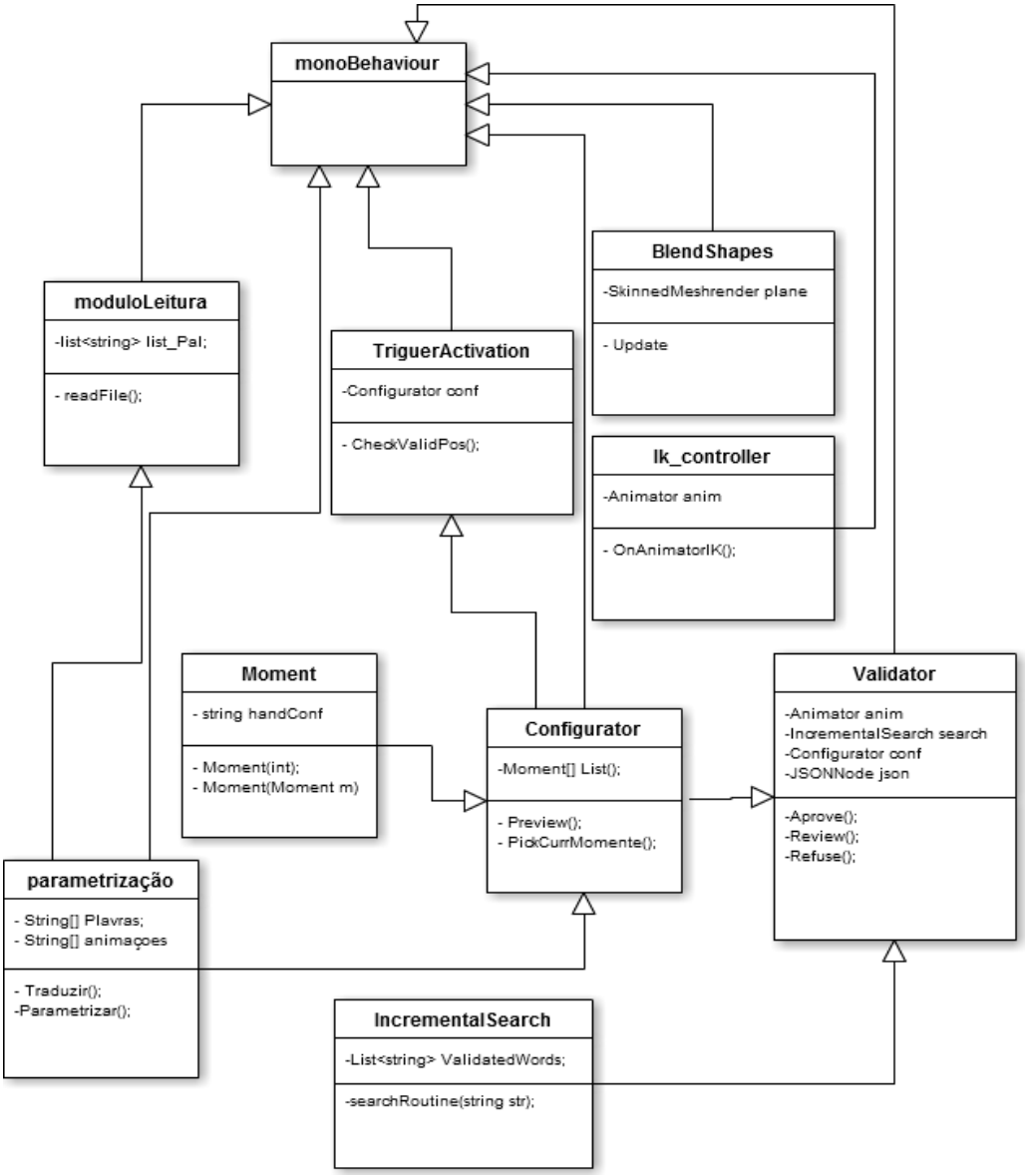

Figure 18 – Class diagram Configurator

Figure 18 shows the classes that make the configurator work. The configurator is used to create the dictionary of the sign language that is being worked on and it was constructed to be capable of creating words for every sign language in the world. The configurator was created in unity and because of that all the classes are connected directly or indirectly to the monobehaviour. The classes known has ik_controller, blendshapes and parametrização are used to create all the gestures and facial expressions needed to create a gesture, with this classes it became possible to move the arms of the avatar freely, to change the facial expressions and even to change the configuration of the hand. The class Moment is in charge to save all the information's necessary to create a word in sign language, it is called moment because one word can have many moments like the word "dia" first the word "dia" begin with the static moment with the

configuration D and then have a moment that takes the arm to the shoulder with the same configuration. The class validator is only used by a user validator and the class allows to approve, reject or even put a word on review. In order to do so a class was created that allows to search in the data-base for words that need to be approved for people and the class that makes the search possible is the incrementalSearch. IncrementalSearch class makes various requests to the data-base to be capable of showing all the words already in the data-base. The class known as configurator is the class that allows the user to change the moment that he is working on. The user is capable of making a preview of what is being made and is capable of cleaning all the elements presented on the interface.

6 Development

6.1 Avatar

The avatar 3D is one of the most important elements used in this project. The avatar is used to translate all the text into gestures.

To make the avatar capable of translate the text it had to get past various phases.

The first phase was the modeling and the program used to achieve that was Autodesk Maya. The avatar was created through box modeling (Ménesguen, et al., 2007). The model needed to have a big head because of the facial expressions. The facial expressions needed to be noticed and for that reason a big head was the best way to highlight the expressions.

Other thing that needed to be noticed was the configurations made by the avatar, so the same method was applied, the avatar hands are bigger.

The avatar needs to have other aspects into consideration, like the avatar needs to have a background that creates a contrast. That contrast is needed for all the gestures and the movements made to be recognized by the deaf people.

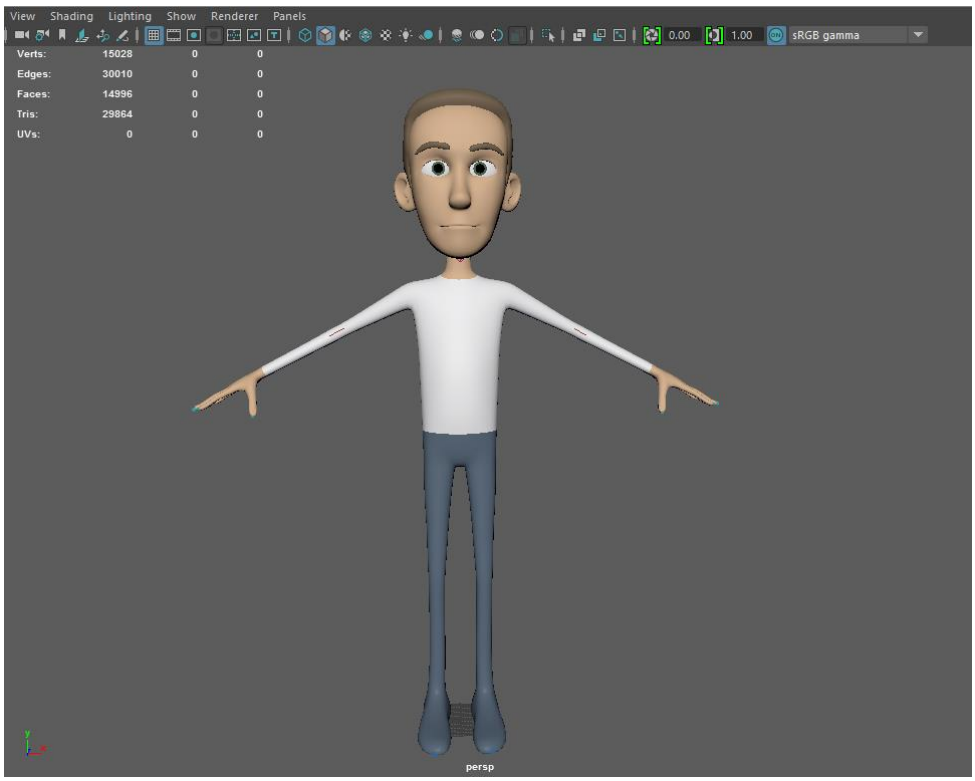

Figure 19 – Model Avatar

Figure 19 is the result of the avatar after all the aspects being included. The bigger head and the hands became the focus of the avatar, that focus is needed because the gestures with the facial expression is necessary for the translation.

After the model was completed, it was time to advance to the rigging. This rig is so that the model is capable of moving.

The rig was created so the avatar moves like a human, but in terms of the hands and the face this rig is very complex.

In each finger it is possible to find 3 bones, these bones are used so that the avatar has the same proportion than a human being. The avatar hand complements the fingers with one more bone to connect all the others and to change the direction of the configurations.

In the face of the avatar is possible to find various bones linked to the skin of the avatar. This bones are created to make the avatar capable of doing facial expressions. The bones can change various points of the face, for the lips the avatar has 4 bones to move the lips around and the mouth has one other bone just to open the mouth. In each eyebrow it is possible to find 3 bones and the cheeks have one for each.

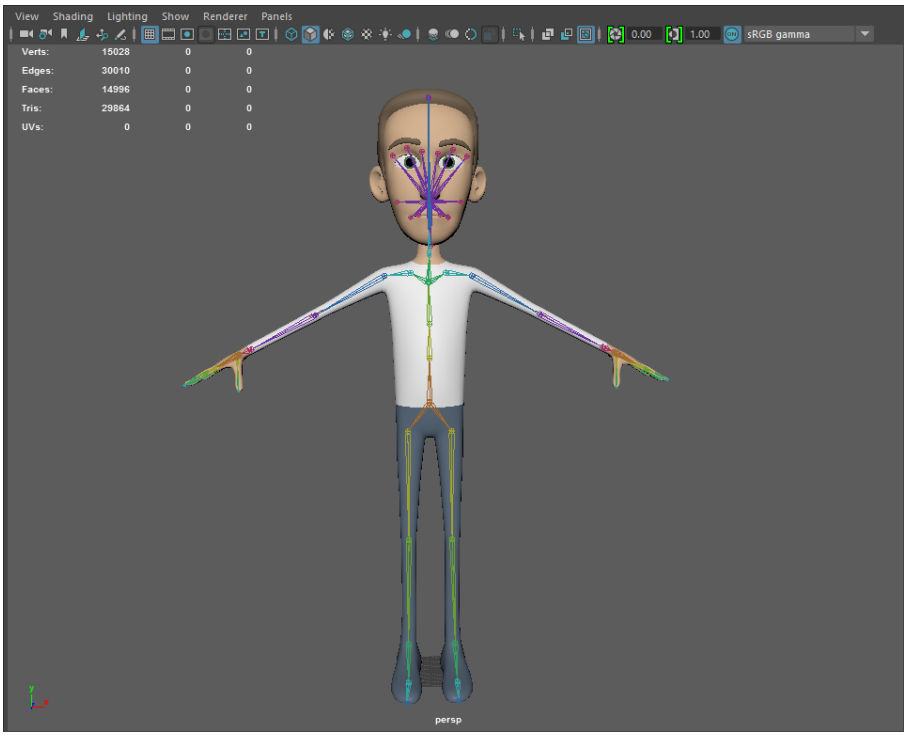

Figure 20 – Rig avatar

In the Figure 20 it is possible to see what the result was after the rig. So the third and last step to do was the weight paint.

Weight paint is a method to tell the bones what part of the avatar it will move. To do that the user needs to go to each bone created and paint the places that we want the bone move. Each bone can have an influence between 0 and 100. When the weight paint was being made it was needed to verify if all the movements were correct, because some vertices were not affected by the weight paint and needed to be painted again.

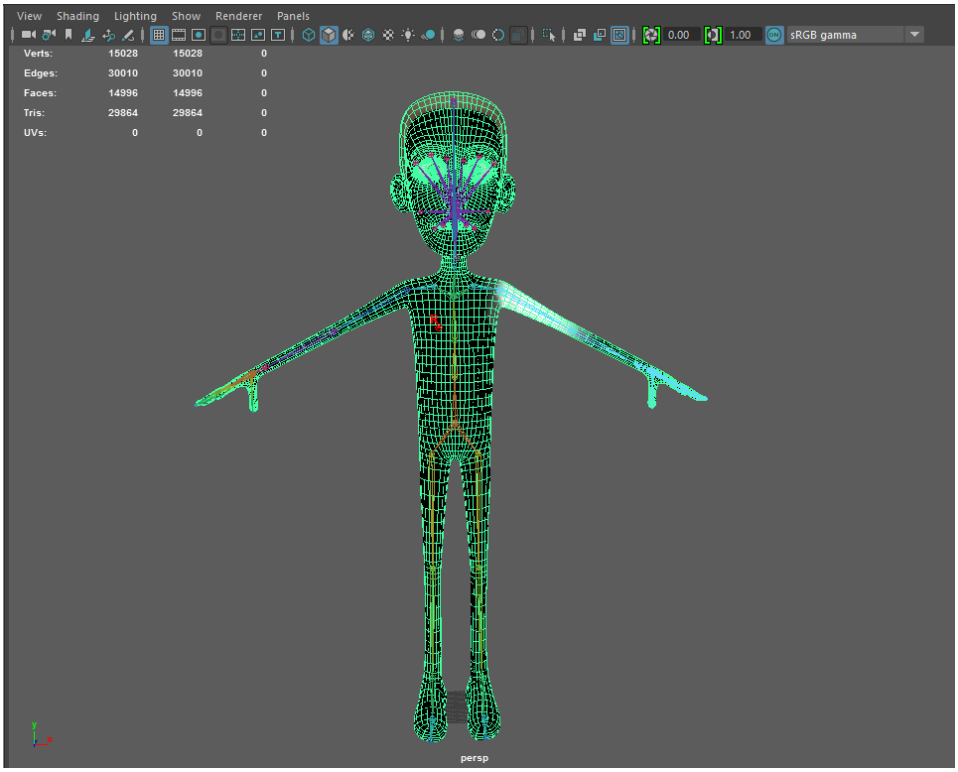

Figure 21 – Weight paint

In the Figure 21 it is possible to see how the weight paint is made, if the colour is black that point won't be moved when that bone is moved, the white part is the part affected by the bone.

With this parts finished, the avatar was prepared for all the gestures. With this points made the avatar can move like a human, but the avatar instead of being humanized even more it was decided that the avatar needed to be more like a cartoon. The way that the avatar was made was based on aspects decided by specialist of sign language, because of that the avatar is made to respect the most important points of the sign language.

6.2 Translator

6.2.1 Text to Gesture

The text to gesture translator has the possibility to get the text written in the text field and translate that text trough an avatar 3D. Initially all the words had one completed animation. In this first approach the creation every verb that exist in the LGP was attempted and the words that were not found would be translated letter by letter. The translation letter by letter occurs when a new word is found and that word still doesn't have a gesture for it or in the case of being a name, like the name "Jorge" is translated letter by letter. The deaf community to resolve the name translation they create gesture to represent the person, with that they don´t need to translate letter by letter and the conversation flows faster.

To translate the gesture like a human all the transitions needed to be done with the cross fade queued, the cross fade is a function that the unity has to animate the objects this function gets the time of the animations and makes a connection with the next one based in the time chosen for that effect. The time picked in the function will be the time that will make the connection between one gesture and another, finally, the function receives the info to know if the gestures need to go to the end to make the connection or if the gesture can change in the middle of the animation.

```
for (int j = t; j < word.Length; j++) {
            letra = word[j];
            string y = "";
            if (word.Length == j + 1)
            {
                y = "parado";
            }
            else {
                letra2 = word[j + 1];
                y = letra2.ToString();
                y = y.ToLowerInvariant();
            }
            x=letra.ToString();
            x = x.ToLowerInvariant();
            animation.CrossFadeQueued(x, 0.2f, QueueMode.CompleteOthers);
        }
```

Code 1 - CrossFade

In the Code 1 it is possible to see in the last line of code the cross fade queue function and how it is possible to use the function. The rest of the code is used to translate words not recognized letter by letter.

With that approach it was possible to get some good results but when the translator became able to translate around 600 words, the translator reached 1gb of space in the disk and each word animation took too much space, because of those problems the program needed to be changed.

It was then possible to see that this approach would not solve everything. Knowing this a second approach became necessary and this approach is the parametrization of animations. With the parametrization of the animations, it was possible to only create gestures for the hand, gestures for the arms and with that join the animations to get the word translation.

To implement this second approach, it was necessary to make 57 animations that represented all the configurations used in LGP, these animations only include the hand. In the animations only the fingers and the hand have key frames, this key frames influence the initial position of the hand and the final position. The arm has a limited number of possible movements, doing all those movements and transforming them into animations with the combination of the movements and the configuration, it will be possible to achieve the 10000 words without the application becoming super-sized.

To apply this method in unity, it was necessary to make some alterations. In unity it became necessary to create various masks. Six masks were needed, each arm gets one mask, each hand gets one too, the head takes one masks to become capable of receiving the blend shapes that represent the facial expression and the rest of the body uses only one. With this masks it is possible to tell unity that the animations that use a mask only move the points permitted by the mask.

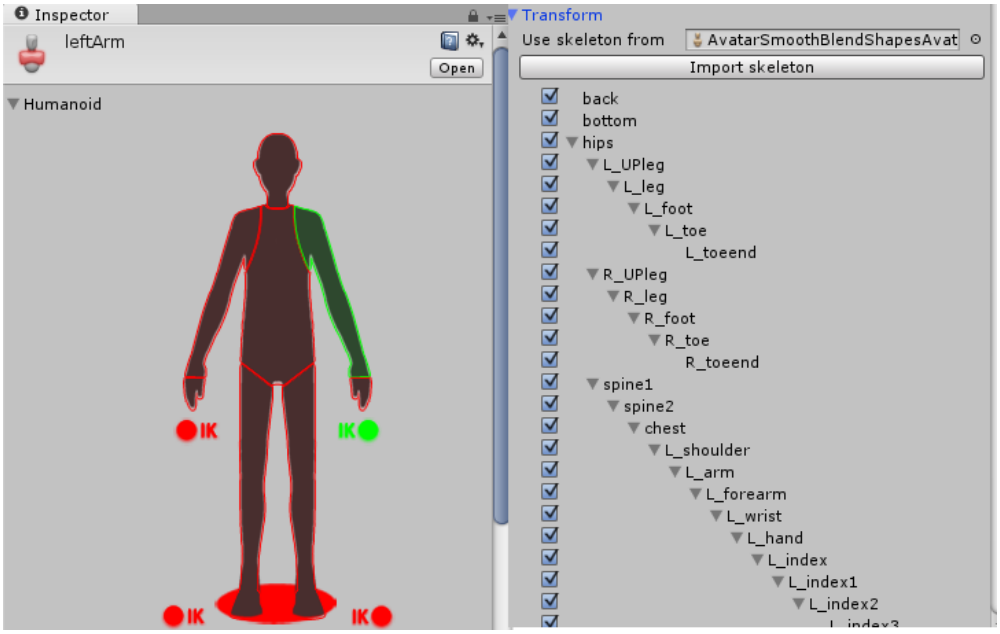

Figure 22 - masks

In the Figure 22 is shown how it is possible to create the masks. The mask can be done by using the options given by the human body or it is possible to import the rig of the avatar that is being used and choose the bones that will be affected by the mask. Like it was said before with the combination of this 6 masks and the animations of the arms and the configurations made by the hands it became possible to get the 10000 words.

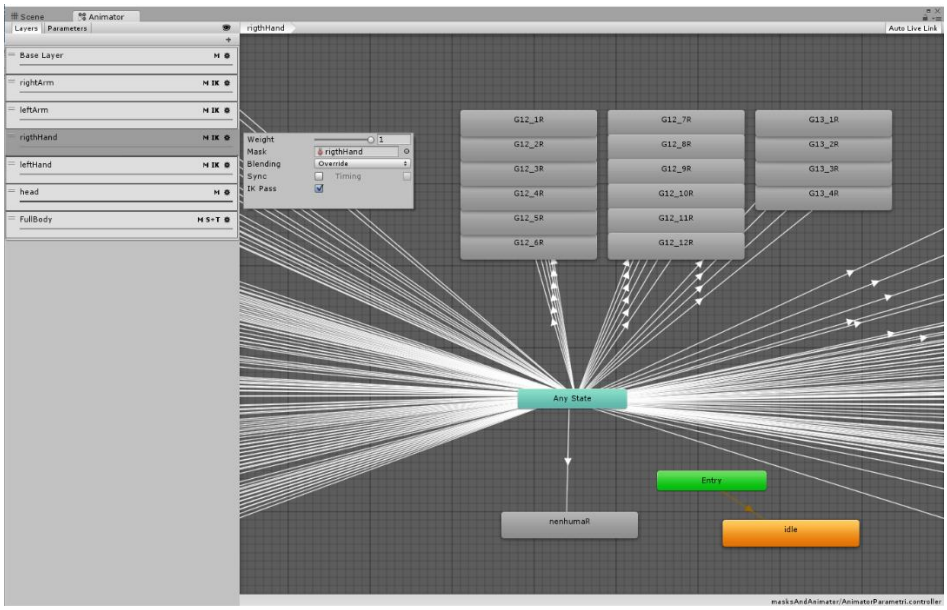

Figure 23 - Animator

The Figure 23 represents the animator that the avatar uses to make all the animations and gestures necessary to translate the text. This animator was divided into 7 layers, each layer takes one of the masks but the “full body” and the “base layer” take the same mask. The animator is used to put all the animations that are used by the avatar. All the information needed to resolve the animations are found in the nodes created in the animator. All of these animations need to be connected to the idle state node, using that the cross fade between the animations becomes more accurate.

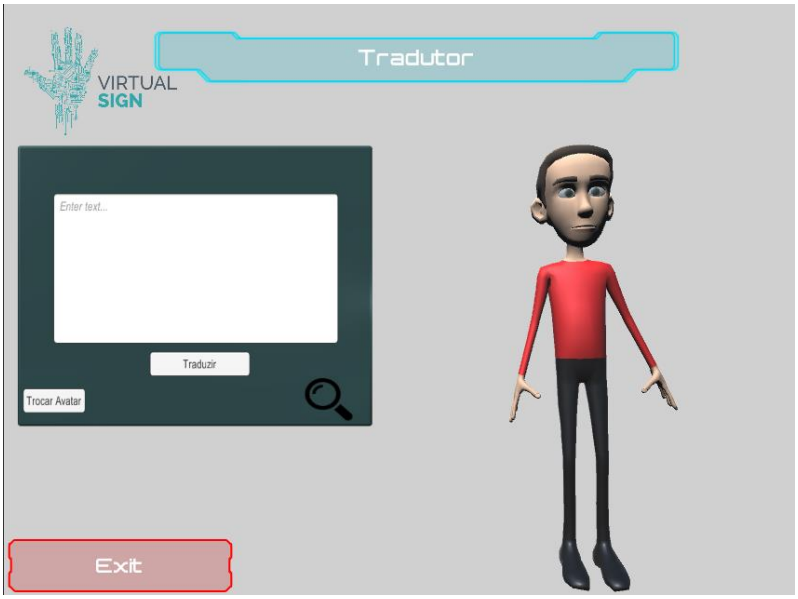

Figure 24 – text to gesture translator

Figure 24 shows the final aspect of the translator text to gesture. To be capable of translate, it needs to translate a text on the text field and then click on the button “traduzir”. It is possible

to see in the Figure 24 there is a button called “trocar avatar” if the user clicks on that button the avatar will be changed. There are 6 different avatars capable of translating LGP. What the user needs to do in this translator is very simple so it is easy to the user to adapt to the way he needs to work with this product.

To translate all the text, the application, begin by reading all text transcribed, after that the app divides all the text into phrases. After the phrases get divided it is picked the first one and the application try´s to find a direct translation for that phrase in the data-base, if that phrase doesn’t exist the application starts to reduce the phrase taking the last word of the phrase until finding a possible translation. After that the rest of the phrase that was not translated goes through the system again, for example:

Table 43 – translation example

Phrase	**Have a direct translation**	**Word reduce**
“eu gosto de jogar a bola”	no	bola
“eu gosto de jogar”	no	jogar
“eu gosto”	yes	None
“jogar a bola”	yes	none

With the table 43 is easier to understand how the translation is done. Like it is possible to see in the table 43 some words get erased, those words aren´t translated because the syntax used by LGP does not use them. Because of that when the application is trying to translate a syntax analyses is done too, for the translation to be correct.

```
foreach (string f in frase)
        {
            jaTraduzido = 0;
            string[] pala = f.Split(delimiters2,
StringSplitOptions.RemoveEmptyEntries);
            for (int i = pala.Length; i > jaTraduzido; i--)
            {
                fraseAverificar = "";
                for (int j = jaTraduzido; j < i; j++)
                {
                    if ((j + 1) == i)
                    {
                        fraseAverificar += pala[j];
                    }
                    else
                        fraseAverificar += pala[j] + " ";
                }
                    testeSeexiste = verificar_ani_file(fraseAverificar);
                    if (testeSeexiste == "")
                    {
```

```
                        if (fraseAverificar.Split(delimiters2,
StringSplitOptions.RemoveEmptyEntries).Length == 1)
                        {
                            jaTraduzido = i;
                            i = pala.Length + 1;
                            if(!(fraseAverificar.Length==1))
                            yield return
StartCoroutine(traduzLetraALetra(fraseAverificar));
                        }
                    }
                    else
                    {
                        if (testeSeexiste != "")
                        {
                            jaTraduzido = i;
                            i = pala.Length + 1;
                            if (!(fraseAverificar.Length == 1))
                            yield return
StartCoroutine(traduzirEmLgpDirecto(testeSeexiste));
                        }
                    }
```

Code 2 – Phrase analysis

The code 2 represents the way that the phrases are treated, like it was described above.

Each word has various moments that contain a hand configuration, an arm movement and a facial expression, with that when the avatar gets a word to translate, a search with that word is made to the data-base, the response has the values of the hand configuration first then the arm position and the expression facial, these 3 elements represent one moment and a word can have various moments. The avatar translates one moment at a time using all the 3 elements at the same time.

```
        if (BlendShapes.targetBlend != Int32.Parse(m.FacialExpression))
                    clickFacialExpression(Int32.Parse(m.FacialExpression);
                    foreach (Transform t in transforms)
                        if (t.name == "Panel")
                        {
                            tempFace.Add(t.GetComponent<Image>());
                        }
                    foreach (Image i in facesExpre)
                    {
                        i.color = new Color(255, 255, 255);
                        tempFaceColor.Add(i);
                    }
                    if (m.HandConfL != CurrentLHandConf)
                    {
                        anim.CrossFade(m.HandConfL, 1f);
                        animatingL = true;
                    }
                    if (m.HandConfR != CurrentRHandConf)
                    {
                        anim.CrossFade(m.HandConfR, 1f);
                        animatingR = true;
                    }
                    sTime = Time.time;
```

```
                float RLength =
Vector3.Distance(IkLookatR.transform.position,
((Moment)momentos[currMoment]).PointFinalR);
                float LLength =
Vector3.Distance(IkLookatL.transform.position,
((Moment)momentos[currMoment]).PointFinalL);
                if (RLength > LLength)
                    jLength = RLength;
                else
                    jLength = LLength;
                CurrentLHandConf = m.HandConfL;
                CurrentRHandConf = m.HandConfR;
                //usar fracjorney

                AnimatorClipInfo[] myAnimatorClip =
anim.GetCurrentAnimatorClipInfo(0);
                float myTime = myAnimatorClip[0].clip.length;

                if (animatingR || animatingL)
                    yield return new
WaitForSeconds(anim.GetCurrentAnimatorStateInfo(3).length /
anim.GetCurrentAnimatorStateInfo(3).speed);

                while (fracJourney < 1f)
                {
                    yield return null;
                }
                yield return new WaitForSeconds(0.075f);
                currMoment++;
```

Code 3 - Parametrization

The Code 3 represents how the avatar processes the moments that represent the word that needs to be translated. This is one of the most important codes of this project. In the Code 3 it is possible to find the variables RLength and LLength that are compared to find which of them has a higher distance to reach the final position, the one that has more distance is used to know the time that will be used to make the arms move. This is the way to make the two movements being finalized at the same time.

Using this system all the avatars became capable of translating all the text.

6.2.2 Gesture to text

The gesture to text translator combines the data received through the Kinect and the data received through the 5DT gloves to translate the gestures made in written Portuguese.

In the beginning an application that permits to only use the 5DT gloves to train the configurations of the hand and to classify the configuration made by the user was created. The application has two modes the training one and the classification one. This approach was aimed to recognize static configurations of the hand, most of those configurations represent the alphabet and the numbers. In the PSL there is 57 configurations, but only 42 really exist because there are 15 that only change the orientation of the palm.

To obtain the configuration made by the user the data is passed through classification. The classification is made from labelled samples, then the program classifies the new samples in real time. Each glove has 14 sensors that are allocated on the fingers so it is possible to get all the joints of the fingers. It is only saved one sample to represent the configuration, this sample is chosen when the hand stays stable for a defined time. After the sample is obtained the data is passed thought the classification. It is used six different algorithms to classify the data. The six were used to make various tests to see what will be used after the evaluation of the precision and accuracy of each other. To make the tests a data-set with 40 samples of each hand was used. The results that have been achieved are presented in the table. The classifiers used are the Random trees (RT) (Le Gall, 2005), Boost cascade (BC) (Viola & Jones, 2001), neural networks (NN) (Haykin & Network, 2004), k-nearest neighbours (KNN) (Cover & Hart, 1967), naive bayes (NB) (Rish, 2001) and support vector machine (SVM) (Christmann & Steinwart, 2008). After the results it was chosen to use the SVM, the results that permits to choose the SVM will be presented in the evaluation point.

Figure 25 – hand configurator application

The Figure 25 provides the interface made for the train and the creation of data-set program. The hand 3D model shows in real time the position of the hand, to do that the program reads the sensors position and after that provides the virtual hand with that data. The image that is shown in the top right corner is the configuration that the user needs to do, to save the configuration train the user needs to press “enter” and the data that represents the configuration is saved. After all the train has being done the user presses “S” and all the data that has been save is stored in file, that file is the data-set. The data-set is used to train the

classifier, after that the classifier is ready to make a classification of the gestures made by the user. It is possible to see in the bottom right corner of the Figure 25 what is the mode that is being used at the moment, the user is using the classify mode with the SVM algorithm and for that position of hand the program said that it was the G10_4 configuration with 100 percentage of confidence.

```
void ConfDescriptor::GetBestMatches(CvMat *votes, Result* pResult, int
norm){
 pResult->ClearResult();
 int *labels = pResult->GetLabels();
 float *probs = pResult->GetProbabilities();
 int type = CV_MAT_TYPE(votes->type);

 for(int i=0, j; i<CLASSES; i++){
        float vote = (type == CV_32S)? votes->data.i[i] : (type == CV_32F)?
votes->data.fl[i] : -1;
        if(vote > probs[(j = 2)]){
               if(vote > probs[1]){
                      probs[2] = probs[1];
                      labels[2] = labels[(j = 1)];

                      if(vote > probs[0]){

                             probs[1] = probs[0];
                             labels[1] = labels[(j = 0)];
                      }
               }
               probs[j] = vote;
               labels[j] = i;
        }
 }
```

Code 4 – Best matches

The code 4 is used to get the configuration done by the user, after that the data is compared by the classifier and the best 3 results are saved, but if the percentage of acceptance in one of the labels is 100 that is the only one saved. This approach only uses the best one but the application that use the Kinect saves the 3 best results every time.

The hands provided on the bottom are displayed in green when the hand is stable, with yellow when the hand is moving and with red if the glove is not connected. That way the user knows if it is the moment to save the configuration or in the mode of training.

This approach creates the possibility to achieve the data-set and train the classifiers with all the configurations used in sign language.

The second program makes the connection between the gloves and the Kinect, with this two together it is possible to translate gesture into text. The data gloves provide the configuration of hands and the Kinect provides the movements and the orientation of the hands.

This part of the project has some challenges such as the ability to distinguish words and also the ability to understand the beginning and the end of each word during the gestures that are made by the user. Every user has different times for doing the gestures, the movements are different, for instance they can be taller. Because of these problems the program needs to have flexible metrics to achieve the identity of the gestures. To make a gesture the user makes a sequence of configurations using the main hand and the support hand, the movement and the orientation of both hands. When the user starts the gesture he adopts a configuration with the main hand and the end of a gesture is when the user terminates the gesture or changes the configuration. When the user changes the configuration it creates a problem. The change can either be the progress of the gesture or it can be the beginning of the other gesture.

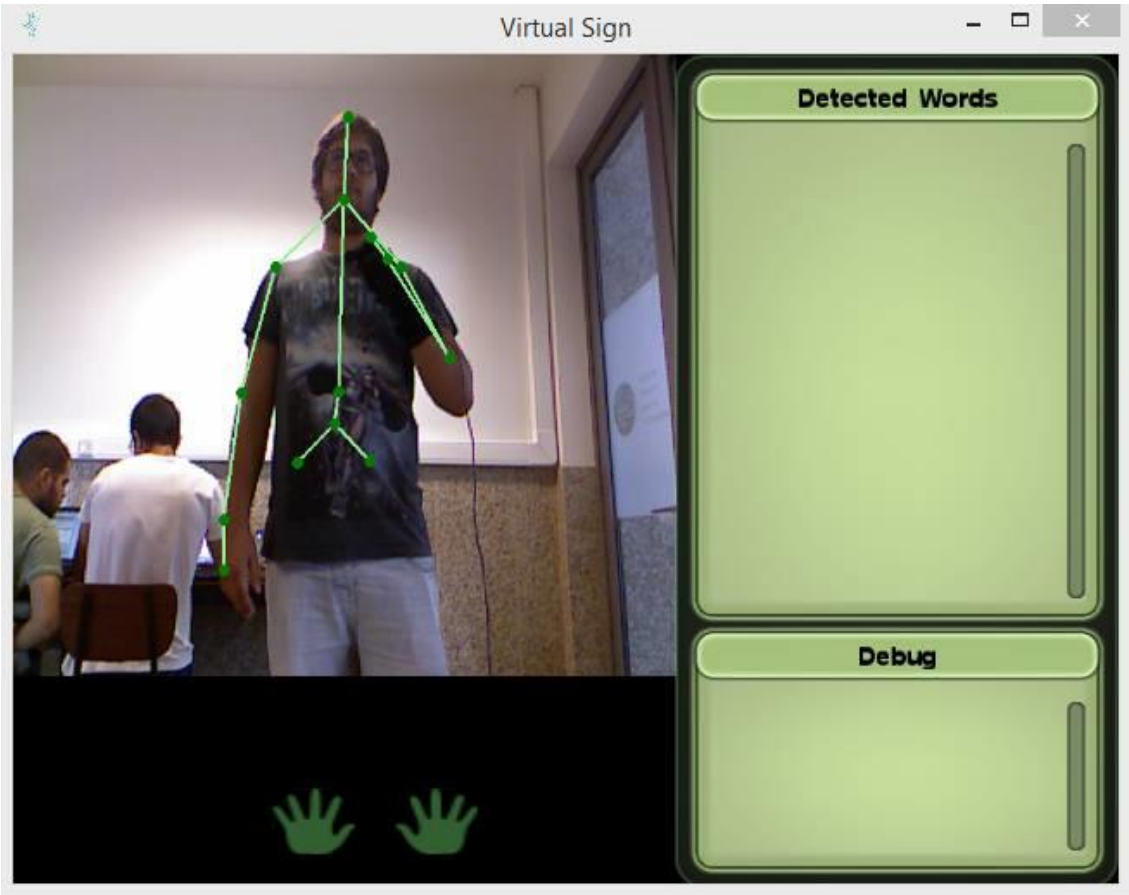

Figure 26 – framework

The Figure 26 shows the interface included in this version that processes the movements with the Kinect and the configuration with the gloves. In the right part of the screen the words are shown and the debug box provides the top 3 configurations detected. The program is made to store the 3 configurations with most probability and this probability is used to increase the classification accuracy. All of these elements are built to be used in the classification model for the word recognition.

This approach needs to treat the intermediate configurations that we call fake configurations that only create noise, these configurations happen when the user is changing the configuration. The intermediate gestures have a shorter stable time and that is used too determinate if the configuration is valid or only noise. To resolve this problem, the configuration to be read needs to be steady for a described time, the configurations bellow that time are discarded. To equalize the frequency of samples between the Kinect and the gloves, the frequency has been reduced in the gloves to 30 samples per second. In the Figure 26 it is possible to see the skeleton in green, each point provides the position in space (X, Y, Z). In this skeleton only used 6 points (hands, elbows, hip and head) are used because the other ones don´t include much in the sign language.

```
void NuiSkeletonStream::DrawSkeleton(uint8* pDest) {
 if(!mSkeletonReady){ return; }
 // Torso
 DrawBone(pDest, skeletonData, NUI_SKELETON_POSITION_HEAD,
NUI_SKELETON_POSITION_SHOULDER_CENTER);
 DrawBone(pDest, skeletonData, NUI_SKELETON_POSITION_SHOULDER_CENTER,
NUI_SKELETON_POSITION_SHOULDER_LEFT);
 DrawBone(pDest, skeletonData, NUI_SKELETON_POSITION_SHOULDER_CENTER,
NUI_SKELETON_POSITION_SHOULDER_RIGHT);
 DrawBone(pDest, skeletonData, NUI_SKELETON_POSITION_SHOULDER_CENTER,
NUI_SKELETON_POSITION_SPINE);
 DrawBone(pDest, skeletonData, NUI_SKELETON_POSITION_SPINE,
NUI_SKELETON_POSITION_HIP_CENTER);
 DrawBone(pDest, skeletonData, NUI_SKELETON_POSITION_HIP_CENTER,
NUI_SKELETON_POSITION_HIP_LEFT);
 DrawBone(pDest, skeletonData, NUI_SKELETON_POSITION_HIP_CENTER,
NUI_SKELETON_POSITION_HIP_RIGHT);

 // Left arm
 DrawBone(pDest, skeletonData, NUI_SKELETON_POSITION_SHOULDER_LEFT,
NUI_SKELETON_POSITION_ELBOW_LEFT);
 DrawBone(pDest, skeletonData, NUI_SKELETON_POSITION_ELBOW_LEFT,
NUI_SKELETON_POSITION_WRIST_LEFT);
 DrawBone(pDest, skeletonData, NUI_SKELETON_POSITION_WRIST_LEFT,
NUI_SKELETON_POSITION_HAND_LEFT);

 // Right arm
 DrawBone(pDest, skeletonData, NUI_SKELETON_POSITION_SHOULDER_RIGHT,
NUI_SKELETON_POSITION_ELBOW_RIGHT);
 DrawBone(pDest, skeletonData, NUI_SKELETON_POSITION_ELBOW_RIGHT,
NUI_SKELETON_POSITION_WRIST_RIGHT);
 DrawBone(pDest, skeletonData, NUI_SKELETON_POSITION_WRIST_RIGHT,
NUI_SKELETON_POSITION_HAND_RIGHT);

 // Draw joints
 for (int j = 0; j < 12; j++) { //NUI_SKELETON_POSITION_COUNT; j++){
       DrawJoint(pDest, skeletonData, (NUI_SKELETON_POSITION_INDEX)j);
 }
 DrawJoint(pDest, skeletonData, NUI_SKELETON_POSITION_HIP_LEFT);
 DrawJoint(pDest, skeletonData, NUI_SKELETON_POSITION_HIP_RIGHT);
}
```

Code 5 – Draw skeleton

The code 5 is used to draw the skeleton in the position of the user.

The recognition of a gesture only starts if the dominant hand goes above of the hip. One of the major problems is to identify the time that takes to do a gesture, to resolve this problem, only the information of the motion with a significant movement has been made is saved. With this the movement only is saved when the position of the dominant hand or the both hands is greater than a threshold created. When a movement have been detected by the program it is saved in a vector that contains the normalized coordinates of the hands and the angle of the orientation. To normalize the coordinates a subtraction is made between the hand position (Xm, Ym , Zm) and the vector that represents the central position(Xa, Ya, Za).

$$(x_n, y_n, z_n) = (x_m, y_m, z_m) - (x_a, y_a, z_a)$$

To be capable of getting the orientation made, the angular coefficient is defined to a straight line of the intersection of the hand and the elbow.

$$Angle = \tan^{-1}\left(\frac{y_a - y_c}{x_a - x_c}\right)$$

Each sequence has at least one configuration and may have a movement and a configuration made by the support hand. The construction of the sequence begins when the dominant hand goes above the hip and after that the sequence terminates when the hand goes bellow the hip. This sequence can have one or more atoms. After the sequence being created the program starts to classify the gesture, this is made comparing every gesture presented in the data-base (gesture that have been created previously) that have the same size of the gesture created by the user. Each element receives a weight of a third, these components are the dominant hand, the support hand and the movement. If the configuration matches it is given a value of acceptance that represents the probability obtained in the classification of the configuration but if the configuration gets no match it receives a null value. After that a comparison between the movements performed is made and to get that, a dynamic time warping algorithm (Müller, 2007) is used. The last step is normalizing all the atoms and comparing them with the other data presented in the data-base and the highest ranked corresponding gesture will probably represent the gesture performed by the user.

```
void Classifier::ProcessData(NUI_SKELETON_DATA skeleton){
 GESTURE_SPACE tSpace;
 if((skelAdjust = mMotionDescriptor->SkeletonPosition(skeleton)) ==
CENTER){
        if((tSpace = mMotionDescriptor->IsPerformingGesture(skeleton,
MAIN_HAND)) != NONE){
               Result *resultM = ProcessDataGlove(MAIN_HAND);
               if(resultM != nullptr){
                      if(mMotionSequence-
>size()){ UpdateAuxHandResult(nullptr, true); }
                     MotionSequence *mSequence = new MotionSequence();
                     mSequence->SetHandResult(resultM, MAIN_HAND);
                     mMotionSequence->push_back(mSequence);
                     configMHTime = clock();
```

```
                        updateTimeGloves[AUX_HAND] = 0;
                        oldHandsPosition = nullptr;
                        recSequence = true;
                }

                if(mMotionSequence->size()){

                        if(mMotionDescriptor->IsPerformingGesture(skeleton,
AUX_HAND) != NONE){ ProcessDataGlove(AUX_HAND); }
                        else if(isAuxHandUP){ UpdateAuxHandResult(nullptr,
false); }

                        MotionSequence *mSequence = mMotionSequence->back();
                        MVector *handsPosition = mMotionDescriptor-
>GetHandsPosition(skeleton);
                        mSequence->UpdateGestureSpace(tSpace);
                        if(oldHandsPosition == nullptr ||
RelevantMotion(oldHandsPosition, handsPosition)){
                                mSequence->AddMotionVector(handsPosition);
                                oldHandsPosition = handsPosition;
                        }
                }

        } else if(recSequence) {
                UpdateAuxHandResult(nullptr, true);
                mMatchedWords = mMotionMatcher->EvalMotionSequence(pslWord);
                classificationTime = clock();
                ResetMotionSequence();
        }
  } else if(recSequence) { ResetMotionSequence(); }
}
```

Code 6 - Classification

The code 6 presented is responsible for making the classification of the gestures made.

The classification of the hands configuration can use various algorithms but the SVM was chosen due to its performance. The classification of all components together only uses KNN algorithm to classify.

6.3 Configurator

The configurator appears with the creation of the parameterizing done in the translator text to gesture, this happen because the possibility of transforming all the animation into a combination of animations.

The configuration in the beginning only used combo boxes to describe the various moments that made a word. It was possible to find 5 combo box utilized for changing the left and the right hand configuration, the right and the left arm movement and the facial expression. With this first configurator it was very difficult to create a gesture, because the combo box had too many options and it was difficult to find what option the person wanted.

Figure 27 – first approach configurator

The configurator needs first the word that will be added to the data-base and then the user can choose all the points that create the gesture, if necessary more moments can be added, the user only needs to click on the plus button.

With this approach some problems were found, one of them is that it was difficult to get all the possible movements into animation and give them names to be understandable by all the users and the word only had the possibility to have 6 moments. Other problem is the movements made by the wrist, with the first approach it wasn't possible to change the position of the wrist.

When this problem has been found, it was made a search to find all the contact points in the body used by the LGP and the possible movements made by the wrist in the LGP.

After that a second approach became possible. In this approach it became possible to pick contact points and choose the distance of that element and the rotations of the wrist were included.

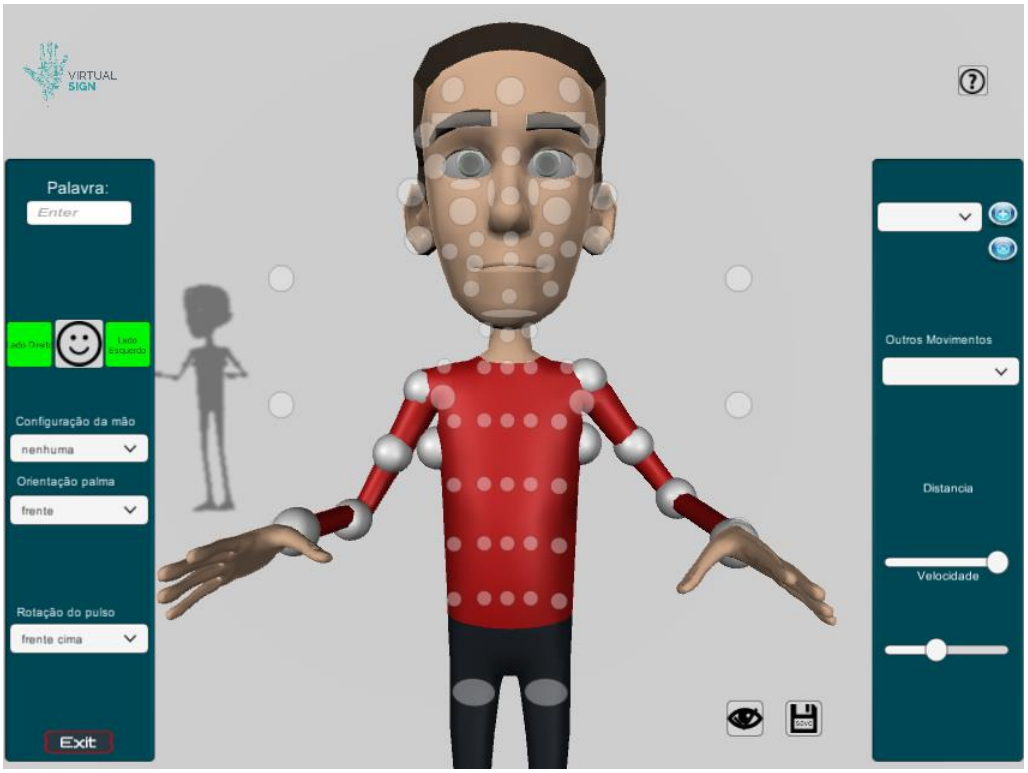

Figure 28 – second approach configurator

The second approach got a new interface to implement all the new features included. Like it is possible to see in the Figure 28 many new features have been integrated in the configurator. The first step to take like in the older version is to put the name of the word that will be created. This name will be saved in the data-base and will be connected to the moments necessary to make the gesture that represents that word. In this version the user is able to choose what hand will be changed. Clicking in the button “lado direito” or “lado esquerdo” the user changes the side that will be configured, after that the options of the combo box will only change the side picked. The points that are visible in front of the avatar in the Figure 28 are the contact points, clicking on them the avatar will move the arm to that position, using all the options chosen on the combo box presented in the lefts side of the screen. The spheres presented in the avatar is another types of contact points, because they are presented in locals that can be moved to other places as they the arm. Other thing that has appeared when this second try began was the speed of the movements made by the avatar, this was something that the deaf people ask to be presented, because every person has a different speed to gesticulate. The distance was another thing included in this version, the distance is very important because the gestures have different places where they are done, including the distance made this version close to the specs necessary to became possible to do all the gestures. With this second version it was still possible to find some problems, one of them is the interface that has too much buttons and isn’t very user friendly and it was possible to see that the configurator has many potential and new features that will help the users to configure new words. Based on these points, a third approach was started.

This third approach was based on turning the second one into a user friendly application and including more features that have the possibility of help the construction of all the gestures.

First a system that allow to connect the system to a data-base online was included, thus, creating a dictionary online that will be shared by all the users. With that system it was possible to include a possibility of creating users that have only permissions to create gesture and other that have permission to validate the words created by the editors. With this it became easier to fulfil all the data-base with the 10000 words that exist in the LGP.

The system of login is simple, the user only needs to login with the data that is given by the admins of the system.

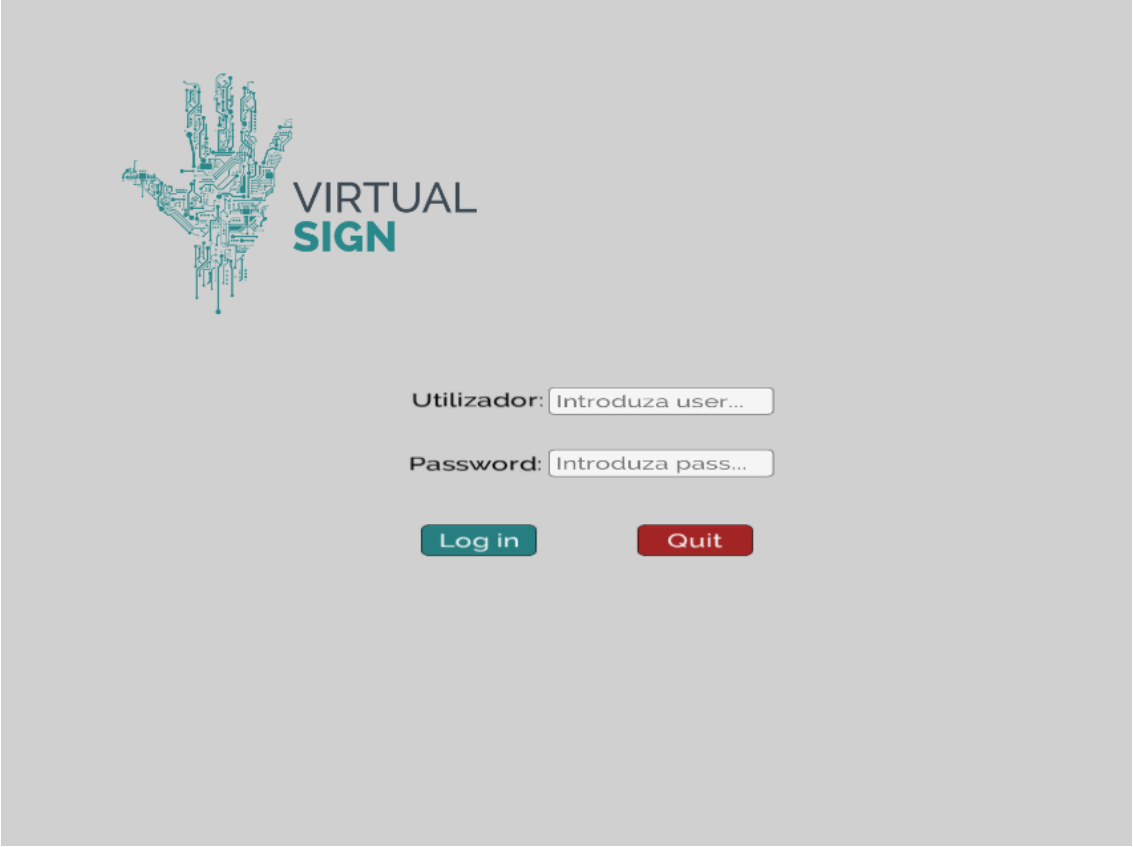

Figure 29 – login

Like is possible to see in the Figure 29, the user only needs to put the user and the password and the system will see that user exists in the data-base and what type of user he is. If the user is an editor he will only have access to the separator editor, like is showed in the Figure 30.

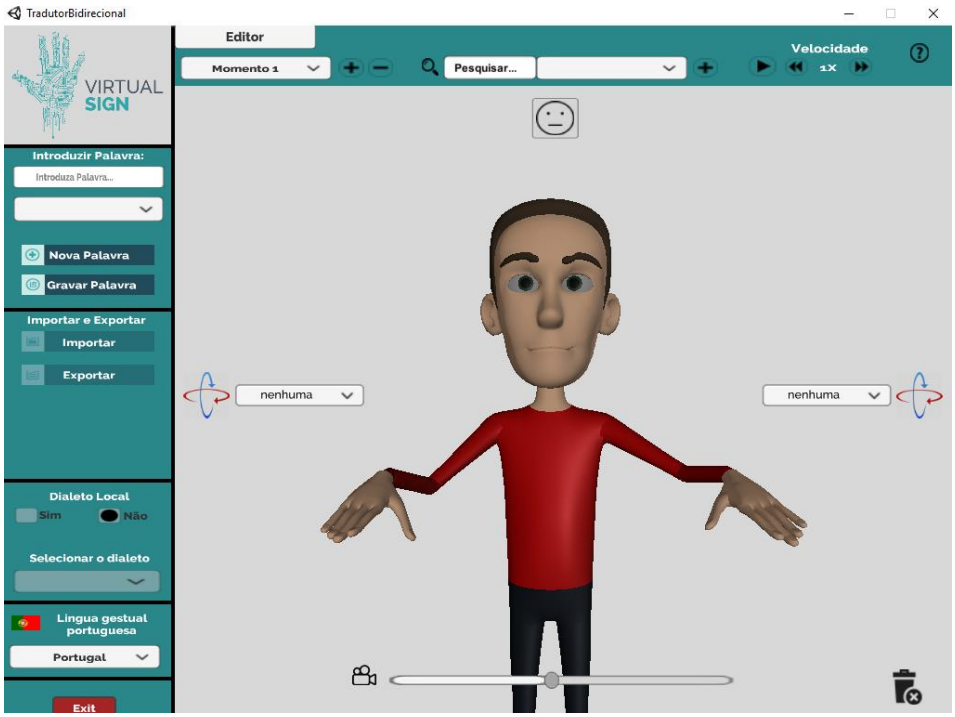

Figure 30 – editor tab

The user with the editor permissions is capable of creating words to be introduced in the database. In this new approach the user gains a possibility to import a word already made. With this the user became capable of reusing words to help to making new ones. The search made is incremental, if the user picks a letter “A” only words that start with “A” will be shown, if another letter is added the search will only present the words that begin with those two letters.

```
private void ThreadSearchString()
    {
        while (true)
        {
            if (!threadRepeat)
                Thread.Sleep(100);
            else
                {
                    resultsIDs.Clear();
                    int count = 0;
                    foreach (string word in ModuloLeitura.list_palavras)
                    {
                        if (word.StartsWith(str))
                            resultsIDs.Add(count);
                        count++;
                    }
                    threadRepeat = false;
                    searchEnded = true;
                 }
            }
        }
```

Code 7 - Search

The Code 7 represents how the incremental search is made. The user has two systems of importing words in this new model. The first one is the combo box presented under the text field “introduza palavra”, that combo box permits to import the words chosen by the user, but this import will clear all the moments that are being used by the avatar at that time. This import exists to permit the user see all the words already done and already validated. The second one can be found in the text field called “pesquisa”, the user inputs the word that he is searching then in the combo box presented next to the text field the word that he wants can be clicked and after that the user can click on the plus button to import the moments that represents the word and that moments are added to the moments that already being used. In this new version the user has the possibility of picking the arm of the avatar and moving the arm to the right place, with this new away of moving the avatar the user haw more freedom to make the gestures. This points have been included because using the contact points create some limitations to the gestures and permitting the user to move the arm freely takes away those limitations. With arm movement being free it was necessary to include the rotation of the camera to permit changing the distance used on the gesture. It was already included the possibility of adding new languages to the configurator. With this, the translator can become a translator to all the sign languages that exist around the world. Other new feature added it was the dialect and that was included because some words have differences between locals that have the same sign language, this way is possible to translate the text with the gesture that represents the word in that local.

In this new approach when the user clicks to save the word a connection to the data-base is created to put this word on the table Words, but this word is included with a state of word to being validate.

```
public void save()
    {
                foreach (Moment m in momentos)
                {

                    if (!first)
                    {
                        FinalAnimation += "||";
                    }
                    else
                    {
                        first = false;
                    }
                    if (m.HandConfR != "")
                        FinalAnimation += m.HandConfR + "&";
                    //pos right
                    FinalAnimation += vec3ToString(m.PointFinalR) + "&";
                    //rot right
                    FinalAnimation += QuaternionToString(m.RotationsR) +
"&";
                    if (m.HandConfL != "")
                        FinalAnimation += m.HandConfL + "&";
                    //pos Left
                    FinalAnimation += vec3ToString(m.PointFinalL) + "&";
```

```
                    //rot Left
                    FinalAnimation += QuaternionToString(m.RotationsL) +
"&";
                    if (m.FacialExpression != "")
                        FinalAnimation += m.FacialExpression;

                    if (FinalAnimation[FinalAnimation.Length - 1] == '&')
                    {
                        FinalAnimation =
FinalAnimation.Remove(FinalAnimation.Length - 1);
                    }
                }
                if (FinalAnimation[FinalAnimation.Length - 2] == '|')
                {
                    FinalAnimation =
FinalAnimation.Remove(FinalAnimation.Length - 2, 2);
                }
                if (Login.userJson != null)
                {
                    int stat = 0;
                    sendWordToRepository(palavra, FinalAnimation, data,
stat.ToString(), Login.userJson[0]["ID"].Value,
Login.userJson[0]["Name"].Value);
```

Code 8 - Save

The Code 8 represented is used to unify all the parameters in the parametrization in one string that will be used by the avatar to translate the text. This method is called when the user terminates the configuration of gesture that represents the word and then presses the button “save word”.

The second type of user is the validator, the user validator has permissions to validate a word, put a word on review or even eliminate a word. All the words created need to pass by a validator, this is done for all the words used to translate have the right gestures.

The validator has all the permissions that the user editor has plus the validate words, put a word on review and eliminate.

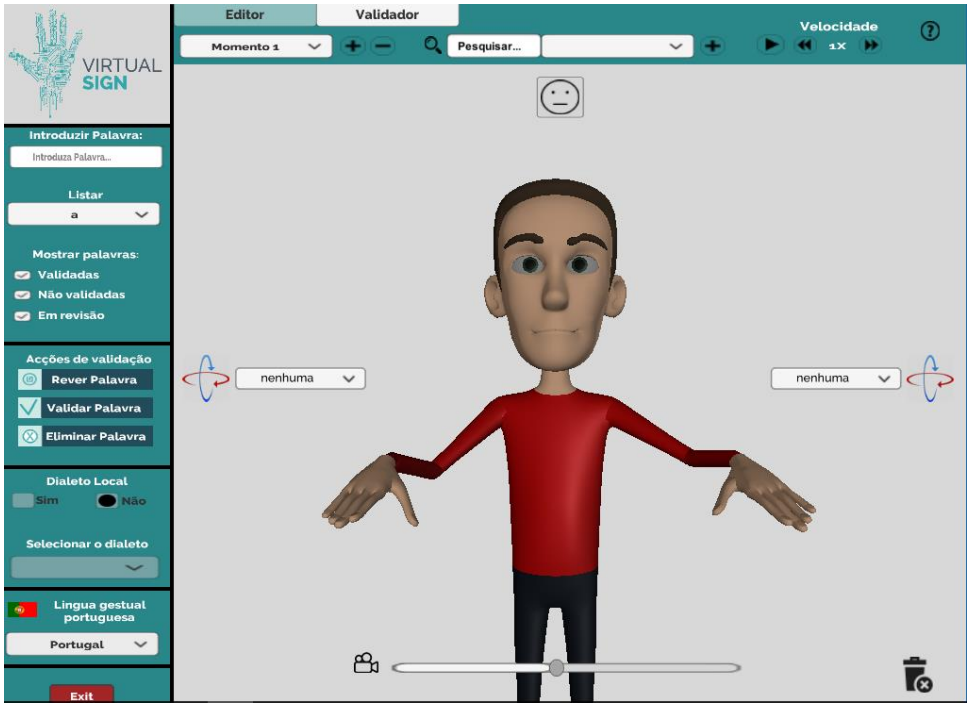

Figure 31 – validator

The Figure 31 shows the tab that only the validator has access. The validator has the possibility of validating words, the validator imports words that need to be validated and can then use the preview system to see if the word is correct, if the word is correct then the validator only needs to click in the button “validar palavra” and after that moment this word starts to be used to translate the texts.

```
NameValueCollection param = new NameValueCollection();
string url =
"http://193.136.60.223/virtualsign/pt/API.php?method=ValidateWord";
WebClient c = new WebClient();
try
{
byte[] responseArray = c.UploadValues(url, "POST", param);
cur++;
}
catch { Debug.Log("failed"); }
word.text = json[cur]["Word"];
```

Code 9 – Approve word

The Code 9 represents what is made to turn this word in an approved one. The application sends an HTTP request POST to the URL described on the string “url”.

If the word is not correct but only has some little things to be changed the user can correct them or put the word in review state for other person pick that word and fix it. The last possibility is to eliminate the word, if the validator thinks that word is not good enough he can

decide to eliminate the word. This are the options that the user validator has more than the editor user. Using the configurator, it is possible to fulfil the 10000 words fast.

7 Evaluation

7.1 QEF (Quantitative Evaluation Framework)

QEF is an evaluation system created by Paula Escudeiro. QEF is a framework that evaluates educational software, with 3 dimensions which are the functionality, the efficiency and the adaptability. Every dimension evaluates various factors and this factors are components that represent the system performance from a point of view. The system quality is defined in the three-dimensional Cartesian quality space represented in by the coordinates (1, 1, 1) and measured in percentage, relatively to a hypothetically ideal system.

q	D	q_i	Dimension	Q_i	W_{ij} (Factor Weight *j* in Dim *i*) [0,1]	Factor	rw_{jk} (requirement weight *k* in Factor *j*) {2, 4, 6, 8, 10}	Requirement	wf_k % requirement fulfillment *k*) [0,100]
84%	0,40	91,667	Functionality	86,11	0,43	Functional	10	FF01 - Avatar reproduction of LPG translation	100
							10	FF02 - Avatar have facial expressions	100
							10	FF03 - The application can connect with kinect	100
							10	FF04 - the application can translate gestures to text	100
							10	FF05 - The application have a posible to add new words	100
							10	FF06 - Avatar translates the incoming mensages of kinect	100
							10	FF07 - The application highlights misspellings	100
							10	FF08 - The application help in the syntax of the sentences	75
							10	FF09 - The application have train mode for the module gesture to text	0
				93,75	0,38	User Interaction	10	FUI01 - The application interface is intuitive	100
							10	FUI02 - the application menu shows all possibilities	100
							10	FUI03 - In the translator text to gesture is shown all the words	100
							10	FUI04 - In the translator gesture to text is shown the skelleton	100
							10	FUI05 - In kinect menu all the translated words are shown in the text box	100
							10	FUI06 - In kinect menu the person performing the gestures is visible	100
							10	FUI05 - In translator menu it is possible to change the avatar	100
							10	FUI06 - In translator menu the avatar is visible	50
				100	0,13	Content Quality	10	FCQ01 - All product information is well organized	100
							10	FCQ02 - The texts are well written and all the setences make perfect sense (annexed standards)	100
							10	FCQ03 - All the messages are easy to understand and human personified	100
							10	FCQ04 - All the contents are related to the product	100
		66,667	Adaptability	50	0,67	Versatility	10	AV01 - Different operative systems compatibility	50
							10	AV02 - Different mobile compatibility	50
				100	0,33	Maintenance	10	AM01 - Adding possibility of new features	100
		80	Efficiency	75	0,40	Strength	10	ES01 - Product has a good structure and allows users to access contents in an intuitive way to the main functions	100
							10	ES02 - Application user interface is quick and fast responsive	50
				100	0,40	Consistency	10	EC01 - Continuous operation	100
							10	EC02 - Outputs according to user inputs	100
				50	0,20	Integrity	10	EI01 - Contents related with product	50

Figure 32 – Quantitative Evaluation Framework

In the Figure 32 it's possible to see what has been evaluated during the process of creating this application. With these elements it was possible to know if the conclusion of the project it's near. The project has been evaluated in all the moments using the QEF, and with that particularity it was easy to see what elements needed more focus on development. In blue there is the functionality elements to be considered, in pink the elements that belong to the group of adaptability and the last one is the green, the group of efficiency.

The elements in blue are divided in three sub categories, functional, user interaction and content quality. These are the most important elements in terms of development, the pink ones are divided in versatility and maintenance. They are important because of those elements it is

possible to create more possibilities of distribution. The last ones are the elements in green and are divided in Strength, consistency and integrity.

With the QEF it was possible to recognize at any moment what elements needed to have more attention and provides an easy way to make a calendar of tasks to achieve the expected result.

Like it is possible to see in the Figure 32 the final quality percentage is 84%. Some of the most subjective factors or the QEF used surveys for measurement. The questionnaires will be presented in the next topic of this dissertation.

7.2 Questionnaires

Anonymous questionnaires were made to obtain information about the quality of translation of the translation between gesture to text and text to gesture. The text to gesture already have a good data-base that presented around 600 words and it was asked to some people in the area of sign language to see if the words are being created well.

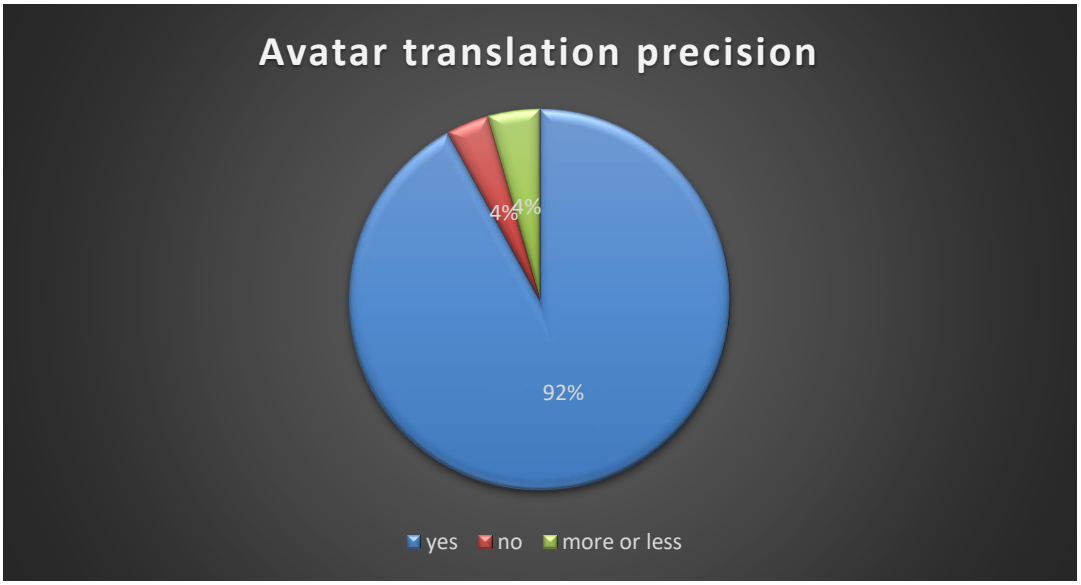

Figure 33 – Avatar translation precision

The Figure 33 presents the result obtained about the precision of the 600 gestures that have been analyzed by the specialist of PSL. In the same questionnaire it was asked to the specialist what they have liked what they have disliked and some suggestions about the text to gesture translator and that resulted in some good responses. The range of ages of the specialist that have made these questionnaires goes from 39 to 64.

After the questionnaire about the precision another one was made. This new questionnaire contains all the application features that have been made. The questions made are about the quality of the translator, if the interface is intuitive, if the application helps the communication with deaf people and etc. these questionnaires only had 10 responses which is not a large

number of replies but with the questionnaires made by the specialists and these questionnaires that have been responded by simple users the relevance of the results is increased.

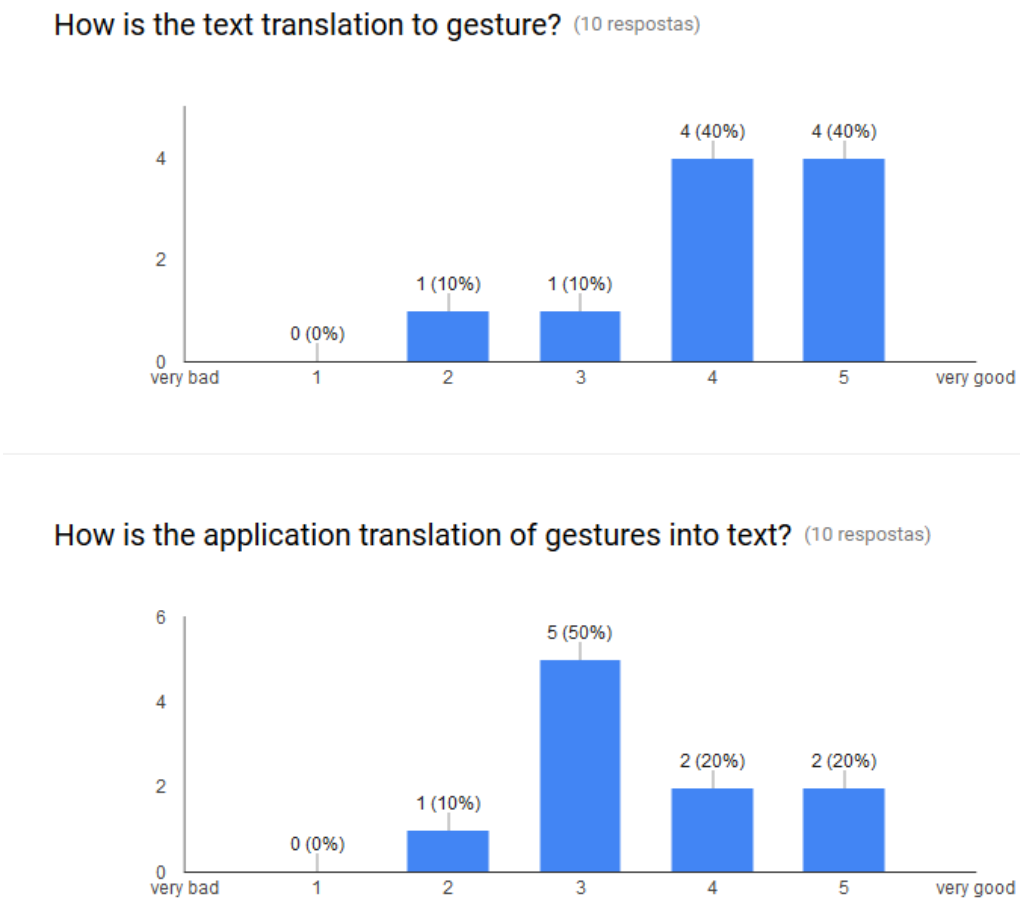

Figure 34 – quality of the application

With the results presented in the Figure 34 it is easy to understand that the gestures into text needs to improve a bit. The results obtained in the text to gesture shows some good results but in the 10 users one of them did not like the results obtained with the text to gesture translator.

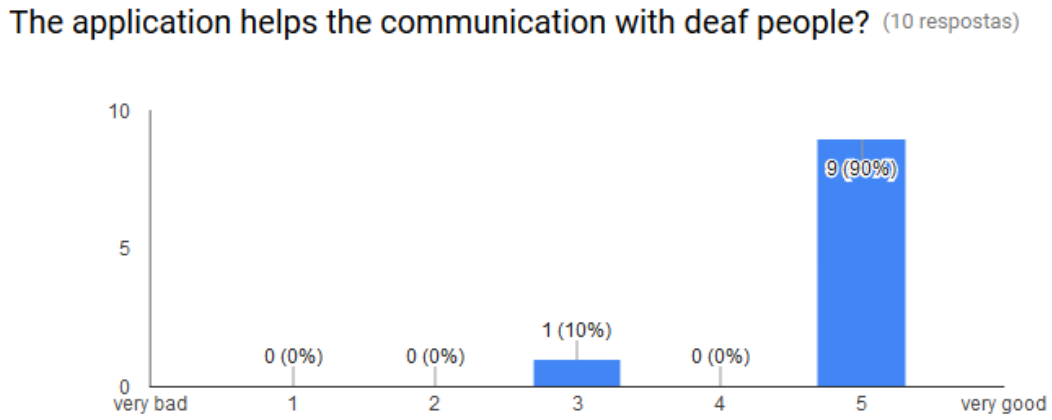

Figure 35 – communication

This Figure 35 shows one that the main objectives has been fulfilled as 90% of the people thinks that the application helps the communication and that is what we want to concede to the people.

Finally, in terms of informatics is known that the user interface and the application should be easy to use and in the Figure 36 is shown the results obtained about that point.

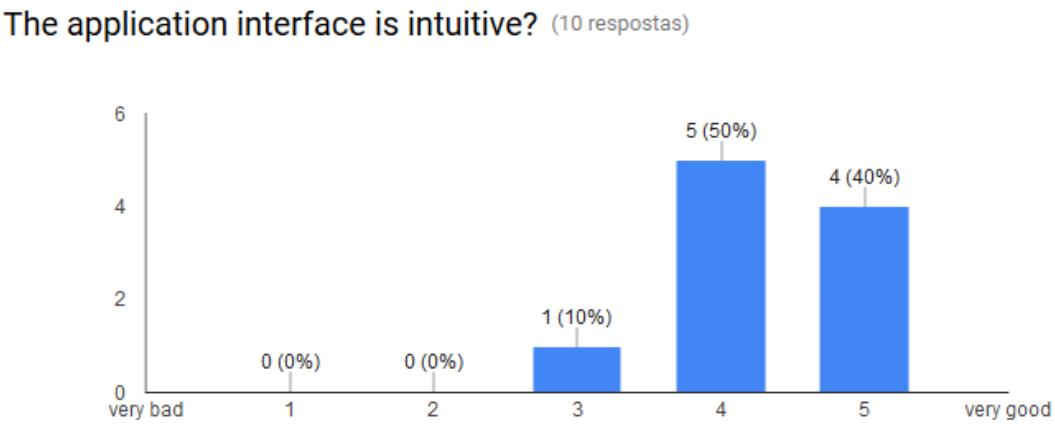

Figure 36 – intuitive system

With the results presented before, it is possible to say that the main objectives have been achieved. The results are the proof that the application is in the right path, it is possible to see too that the application has yet a margin of evolution.

7.3 Classification results

There were various tests to the classification system. Initially tests to choose the best classifier to use in the configuration classification were done. Before showing the table that represents the results it will be shown a sample of the data-set utilizes.

Table 44 – data-set sample

Sensor 1	Sensor 2	…	Sensor 14	label
0.182	0.489		0.947	0
0.472	0.214		0.754	1
0.213	0.382		0.349	2

The data-set is constituted by the values of the sensors and what label that values belongs to, there are 42 labels and each label has 10 samples. To get the results with less variance it was tested using 10-fold cross validation.

Table 45 – Results for the right glove

%	RT	BC	NN	KNN	NB	SVM
precision	98,8	86,1	97,2	98,0	98,0	98,1
accuracy	87,3	96,6	80,4	98,2	96,8	100,0

Table 46 – results for the left glove

%	RT	BC	NN	KNN	NB	SVM
precision	98,6	82,0	98,1	98,8	97,5	98,6
accuracy	85,5	95,4	78,1	97,3	97,1	100,0

With this results it was possible to choose what classifier was used. Like it was mentioned on the topic Gesture to text this results prove that SVM was the best classifier to be used.

The results obtained are very good but this results only use one data-set created by the same person. When it was tried to use a different users with the same data-set the problem begin to appear as the percentage using this system was very low.

Table 47 – first results using different data-sets

	Jorge	Marcelo	Pedro	Jorge Marcelo	Marcelo Pedro	Pedro jorge	Everyone
Jorge	**0.8047619**	0.2735714	0.2792857	0.5669048	0.2933333	0.5708333	0.4833333
Marcelo	0.3130952	**0.8640476**	0.2695238	0.6202381	0.5986905	0.3063095	0.5182540
Pedro	0.2480952	0.2966667	**0.7083333**	0.2886905	0.5302381	0.5034524	0.4476984
Jorge Marcelo	0.6980952	0.6752381	0.4045238	**0.7242857**	0.5691667	0.5805952	0.6321429
Marcelo Pedro	0.3595238	0.6250000	0.6573810	0.5182143	**0.6788095**	0.5340476	0.5886508
Pedro Jorge	0.6450000	0.3761905	0.6692857	0.5405952	0.5544048	**0.6954762**	0.6046032
Everyone	0.6597619	0.6642857	0.6688095	0.6975000	0.6994048	0.7069048	**0.7160317**

The table 47 represents the problems that has been mentioned above. With this problem it will be difficult to make this project reach the expected results when someone who has not trained the configurators is using the system. To resolve this problem, the decision was to create groups of similar configurations, dividing the 42 configurations into 13 distinct groups. Creating a system that first start for get the group that the configuration belongs and after that trying to classify hierarchically. After being applied this system it was used again a 10-fold cross validation to get the results.

Table 48 – results with the train data-set Jorge comparing with others test data-sets

		Marcelo	Pedro	Jorge
	Groups	**Accuracy**		
Jorge	**1**	1	1	1
	2	1	1	1
	3	0,975	0,975	0,975
	4	1	1	1
	5	1	1	1
	6	1	1	1
	7	1	1	1
	8	1	1	1
	9	1	1	1
	10	1	0,9333	1
	11	1	0,98	1
	12	1	1	1
	13	1	1	1

Table 49 - results with all the train data-set comparing with others test data-sets

		Marcelo	Pedro	Jorge
	Groups	**Accuracy**		
Everyone	**1**	1	1	1
	2	1	1	1
	3	1	0,975	0,975
	4	1	1	1
	5	1	1	1
	6	1	1	1
	7	1	1	1
	8	1	1	1
	9	0,975	1	1
	10	1	1	1
	11	1	1	1
	12	1	1	1
	13	1	1	1

This results are much more satisfying, with this system all the configurations got a very good result even if the user utilizes a data-set by another person.

Then it was started to be made some tests to the gestures including movements to understand if the thresholds applied in the code help to get good results. The objective in this tests is to predict correctly the gestures made by the user.

This evaluation counts with 15 words, these 15 words have 2260 samples, but only 750 samples were used to train the SVM. Each one of the 15 words has 50 examples, it was used the same number for all of them to ensure a uniform distribution of the classes. This gestures has been obtained by different users. To make this recall and precision were used in relation to each class. The recall is a measure to select all the instances of a particular class and the precision is the percentage of correct predictions to a particular class. The classes (words) used are “Olá”(1), “Adeus”(2), “Sorrir”(3), “Segredo”(4), “Floresta”(5), “Sol”(6), “Flor”(7), “Aluno”(8), “Escola”(9), “Casa”(10), “Aulas”(11), “Desenho”(12), “Amigo”(13), “Pais”(14) and “Desporto”(15).

Table 50 – Recall and precision

Classes	1	2	5	6	10	7	8	3	4	9	13	14	15	11	12	Class precision
1	**97**	1	0	0	0	0	0	0	0	0	0	0	0	0	0	98,98%
2	3	**99**	0	0	0	0	0	0	0	0	0	0	0	0	0	97,06%
5	0	0	**98**	0	0	0	0	0	0	0	0	0	0	0	0	100,00%
6	0	0	0	**100**	0	0	0	0	0	0	0	0	0	0	0	100,00%
10	0	0	0	0	**98**	0	0	0	0	0	0	0	0	0	0	100,00%
7	0	0	1	0	0	**109**	0	0	0	0	0	0	0	0	0	99,09%
8	0	0	0	0	1	0	**102**	0	0	0	0	0	0	0	0	99,03%
3	0	0	0	0	0	0	0	**101**	0	0	0	0	0	0	0	100,00%
4	0	0	0	0	0	0	0	0	**100**	0	0	0	0	0	0	100,00%
9	0	0	0	0	0	0	0	0	0	**99**	0	0	0	0	0	100,00%
13	0	0	0	0	0	0	0	0	0	0	**100**	0	0	0	0	100,00%
14	0	0	0	0	0	1	0	0	0	0	0	**100**	0	0	0	99,01%
15	0	0	0	0	0	0	0	0	0	0	0	0	**97**	0	0	100,00%
11	0	0	0	0	0	0	0	0	0	0	0	0	0	**104**	0	100,00%
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**100**	100,00%
Class Recall	97%	99%	98,99%	100%	98,99%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	

The table 50 represents the results obtained by the application that unifies the 5dt gloves with Kinect. This results are very satisfactory but in a future work new tests will be made with more than 100 words to see if similar results are achieved. In general, the results obtained are promising. Even words very similar like “Olá” and “Adeus” have been detected correctly.

With all this results I believe that the program will be very talked in a near future.

8 Conclusion and future work

The VirtualSign bidirectional translator contributes to the accessibility of deaf people by creating an easy way of communication with non-deaf. The VirtualSign system is prepared to work with several distinct sign languages making it possible to have deaf people from different countries understanding each other.

In general the results obtained in this dissertation are very promising. The machine learning techniques used to process the inputs from Kinect and the 5dt Gloves is able to identify the signs being represented with high accuracy.

The bidirectional translator has many potential applications. It can be applied in locals with public attendance to facilitate the communication among deaf and non-deaf people. It is naturally accepted that having assistance to understand sign language in places like fire departments, police stations, restaurants, museums and airports, among many others, will be of clear added value in the promotion of equal opportunities and social inclusion of the deaf and hearing impaired.

The VirtualSign translator was tested by several users. The estimated accuracy of the conversion from gestures to text reaches values of 97%. Although these results have been obtained with a reduced sample with 15 words, these preliminary results are very promising.

With the VirtualSign Studio configurator, it is possible to say that is only a matter of time to get the 3D avatar to translate all the 10000 words of the Portuguese Sign Language. The configurator also permits the creation of gestures of other languages like Libras (Brazilian sign language) and dialects of the sign languages.

With the system that the 3D avatar has been created it was possible to use the parametrization of animations to reproduce all the text with the most precision possible and include all the dictionary of Portuguese sign language without take all the space of the disk. This system was created to work on other avatars that use the system of humanoid rig, becoming more easy to use the avatar that the user prefers most.

The implemented systems is scalable to grow and to have much more development with the creation of various application that can use the avatar as the translator component. One possibility for using the avatar is create an API to translate all the websites in sign language, this will create some possible implementations.

For future work on the translator gesture to text is create a system with the same precision and accuracy without using gloves. This system will permit to put the translator working on cell phones and with that archiving more users to our application.

Other thing that will be made in the future is create an intermediate system of semantics between the Portuguese sign language and the written Portuguese. The semantics are very important because the translation between the Portuguese languages are not direct.

Another thing to do in the future is the possibility of using the glove and the Kinect to create the gestures that the avatar will use to translate the text, with this system it was easy and will take less time to configure all the words.

The VirtualSign studio have been presented in a conference on Brazil to a public audience with 50 persons, that 50 persons 5 of them are deaf and the other 45 are specialists of sign language. With this opportunity it was easy to understand a little bit more about the difficulties that the deaf community sense in each day of they life. After the conference, the program was put on an Officine to all the persons present in the conference test the program. They liked a lot of working with the VSS and every time they ask how can they become part of the project.

To conclude this thesis I think the project have achieved the main objective, almost all the objectives have been fulfil. In all the work performed permitted me to understand more about the difficult that the deaf people have in they life.

In terms of informatics this project permitted me to understand more about sensors and how to work with classifiers, it help me to improve my knowledge about the Unity and the other applications used on this dissertation.

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10 Annexes

10.1 Annexes A – classification tests

		Marcelo	Pedro	Jorge
		Accuracy		
Marcelo	1	1	1	1
	2	1	1	1
	3	0,975	0,975	0,975
	4	1	1	1
	5	1	1	1
	6	1	1	1
	7	1	1	1
	8	1	1	1
	9	1	1	1
	10	1	0,9333	1
	11	1	0,98	1
	12	1	1	1
	13	1	1	1
		Marcelo	Pedro	Jorge
		Accuracy		
Jorge	1	1	1	1
	2	1	1	1
	3	0,975	0,975	0,975
	4	1	1	1
	5	1	1	1
	6	1	1	1
	7	1	1	1
	8	1	1	1
	9	1	1	1
	10	1	0,9666	0,9666
	11	1	1	1
	12	1	1	1
	13	1	1	1
		Marcelo	Pedro	Jorge
		Accuracy		
Pedro	1	1	1	1
	2	1	1	1
	3	1	0,975	1
	4	0,98333	0,98333	1

	5	1	0,95	1
	6	0,9666	0,933	0,9666
	7	1	1	1
	8	0,9333	0,9333	1
	9	1	0,9	1
	10	1	1	1
	11	0,98	0,96	1
	12	1	0,9666	1
	13	1	0,95	1
		Marcelo	Pedro	Jorge
		Accuracy		
Pedro_Marcelo	1	1	1	1
	2	1	1	1
	3	0,975	1	1
	4	1	1	1
	5	1	1	1
	6	1	1	1
	7	1	1	1
	8	1	1	1
	9	1	1	1
	10	1	1	1
	11	1	1	0,98
	12	1	1	1
	13	1	1	1
		Marcelo	Pedro	Jorge
		Accuracy		
Pedro_Jorge	1	1	1	1
	2	1	1	1
	3	1	0,975	1
	4	1	1	1
	5	1	1	1
	6	0,96	1	1
	7	1	0,97	1
	8	1	1	1
	9	1	1	1
	10	1	1	1
	11	1	1	1
	12	1	1	1
	13	1	1	1
		Marcelo	Pedro	Jorge
		Accuracy		
Marcelo_Jorge	1	1	1	1
	2	1	1	1

	3	0,975	0,95	1
	4	1	1	1
	5	1	1	1
	6	1	1	1
	7	1	1	1
	8	1	1	1
	9	1	1	1
	10	1	1	1
	11	1	1	1
	12	1	1	1
	13	1	1	1
		Marcelo	Pedro	Jorge
		Accuracy		
Everyone	1	1	1	1
	2	1	1	1
	3	1	0,975	0,975
	4	1	1	1
	5	1	1	1
	6	1	1	1
	7	1	1	1
	8	1	1	1
	9	0,975	1	1
	10	1	1	1
	11	1	1	1
	12	1	1	1
	13	1	1	1

10.2 Annexes B – Questionnaire

Bidirectional translator sign language

*Obrigatório

How is the text translation to gesture? *

	1	2	3	4	5	
very bad	○	○	○	○	○	very good

How is the application translation of gestures into text? *

	1	2	3	4	5	
very bad	○	○	○	○	○	very good

The application interface is intuitive? *

	1	2	3	4	5	
very bad	○	○	○	○	○	very good

The configurator is easy to use? *

	1	2	3	4	5	
very hard	○	○	○	○	○	very easy

The application helps the communication with deaf people? *

	1	2	3	4	5	
very bad	○	○	○	○	○	very good

The application helps with misspellings? *

	1	2	3	4	5	
very bad	○	○	○	○	○	very good

The application provides support when there are syntax errors in the sentence? *

	1	2	3	4	5	
very bad	○	○	○	○	○	very good

The user can easily understand the functions of the aplication? *

	1	2	3	4	5	
very bad	○	○	○	○	○	very good

Do you recommend the application to other users? *

	1	2	3	4	5	
never	○	○	○	○	○	definitely

Do you have any sugestions or recomendations?

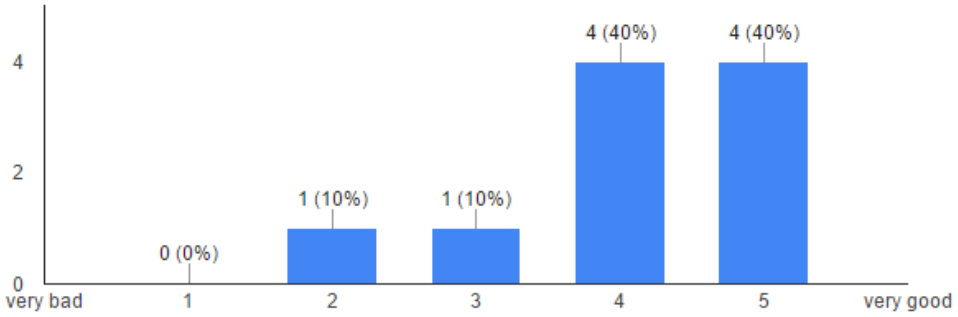
A sua resposta

SUBMETER

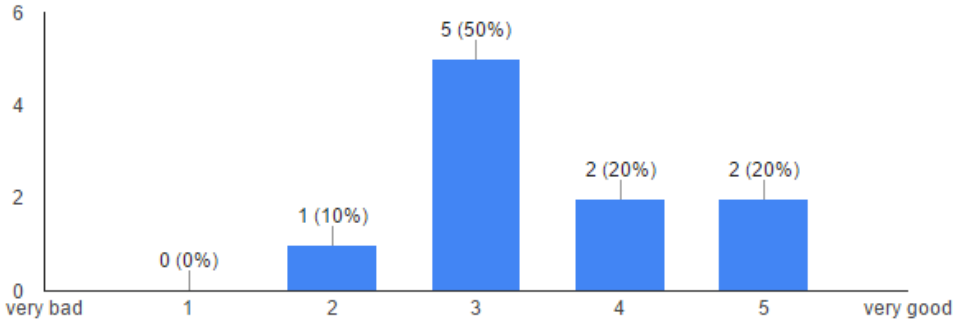
Nunca envie palavras-passe através dos Formulários do Google.

10.3 Annexes C – responses

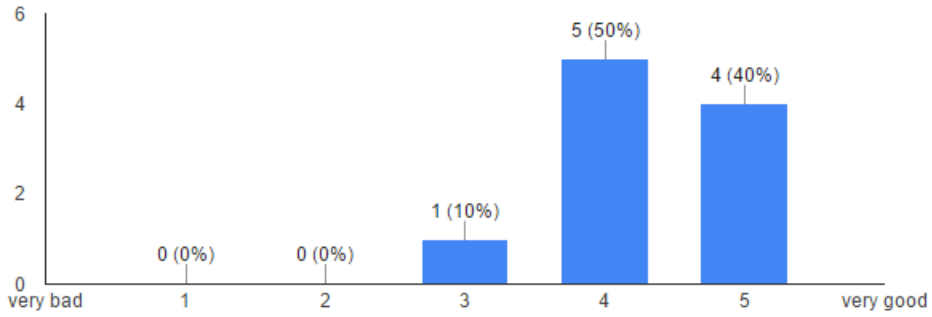
How is the text translation to gesture? (10 respostas)



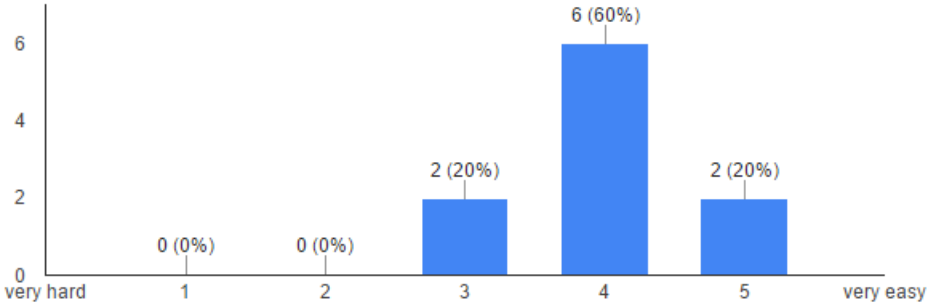
How is the application translation of gestures into text? (10 respostas)



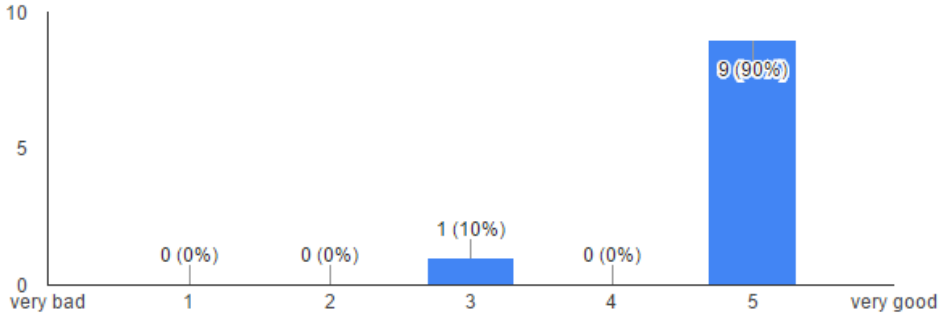
The application interface is intuitive? (10 respostas)



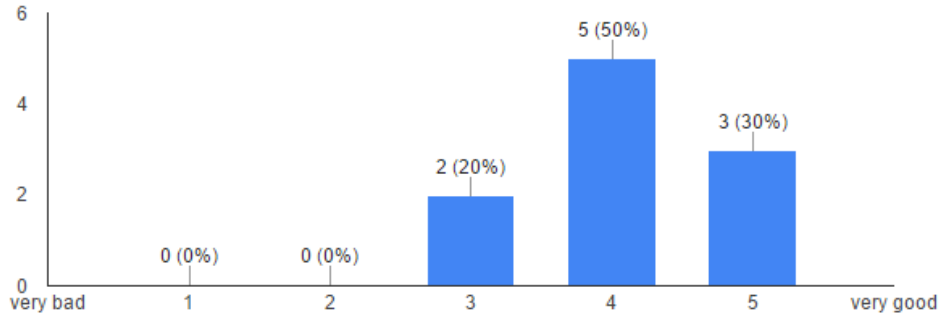
The configurator is easy to use? (10 respostas)



The application helps the communication with deaf people? (10 respostas)

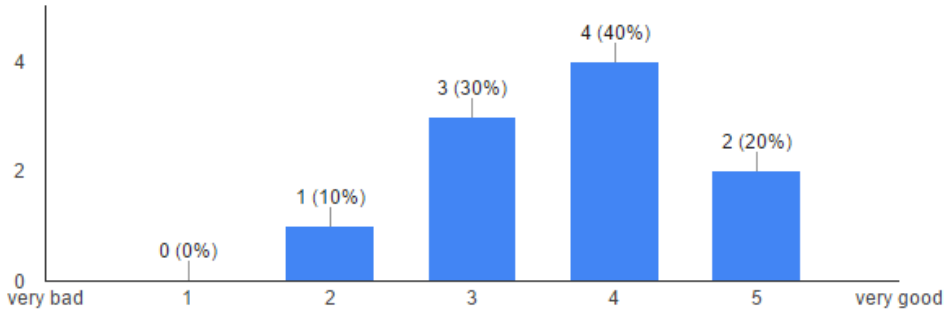


The application helps with misspellings? (10 respostas)

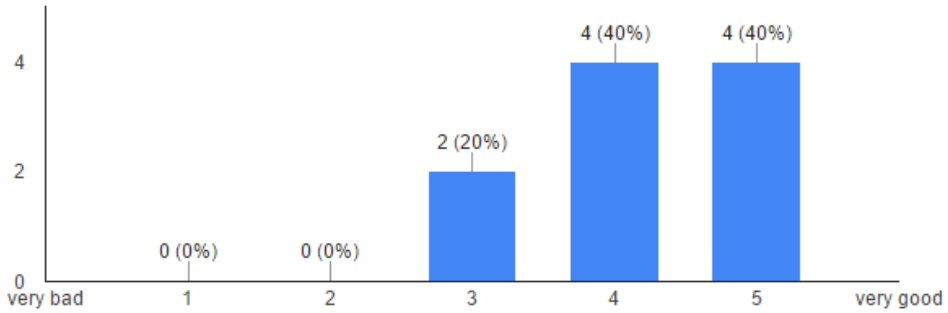


The application provides support when there are syntax errors in the sentence?

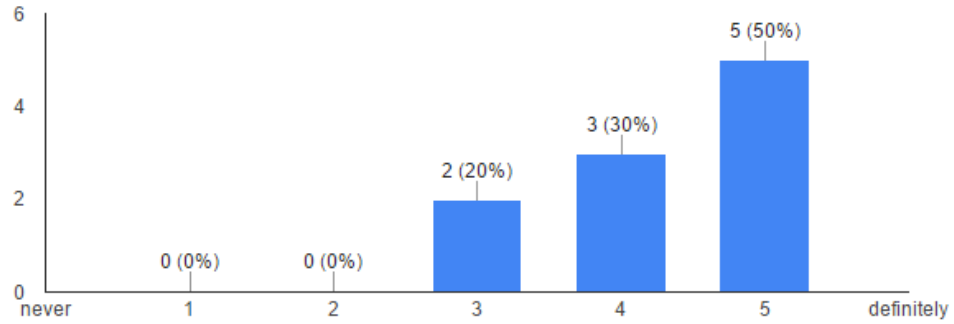
(10 respostas)



The user can easily understand the functions of the aplication? (10 respostas)



Do you recommend the application to other users? (10 respostas)



Do you have any sugestions or recomendations? (2 respostas)

There should be an option to change the avatar

i think it was very funny to have a possability to use the configurator with the glove to create the gestures

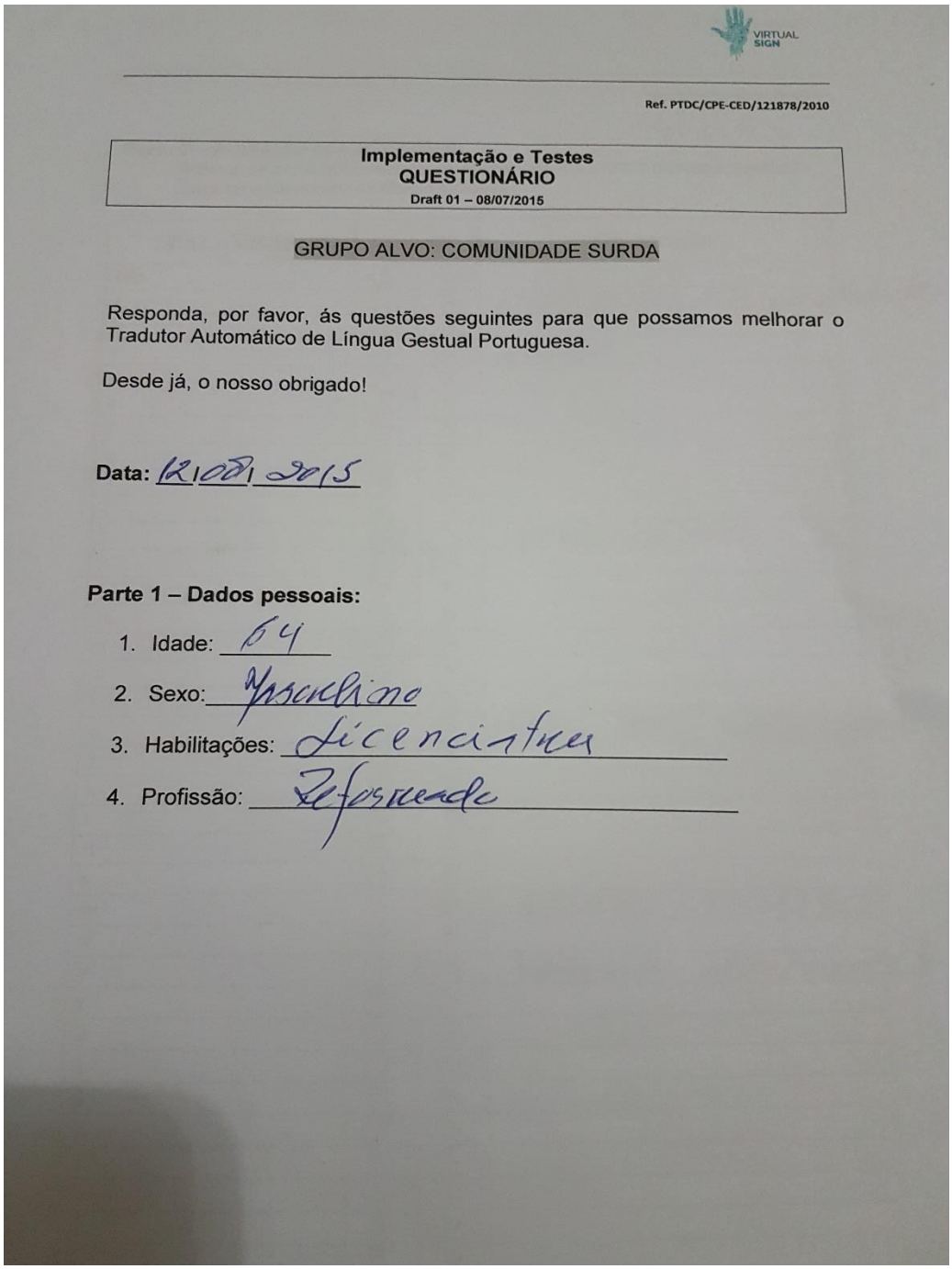
10.4 Annexes D – QEF

		Wfk - Fullfilment (%)		
Requirement	Metric Evaluation	0	50	100
FF01 - Avatar reproduction of LPG translation	the avatar reproduces Portuguese sign language	No	-	Yes
FF02 - Avatar have facial expressions	the avatar when translates make facial expressions	No	-	Yes
FF03 - The application can connect with kinect	the application can connect with the module gesture to text	No	-	Yes
FF04 - the application can translate gestures to text	the application can make recogniton of gestures and translate them into text	No	-	Yes
FF05 - The application have a posible to add new words	the application has the option to use the configurator to create gesture	No	-	Yes
FF06 - Avatar translates the incoming mensages of kinect	the avatar translates effectively incoming messages through the kinect	No	-	Yes
FF07 - The application highlights misspellings	it is possible to tell the difference in the text when there are errors in the sentence	No	-	Yes
FF08 - The application help in the syntax of the sentences	the application provides support when there are syntax errors in the sentence	no	sometimes	yes
FF09 - The application helps the semantics of phrases	the application provides support when there are semantics errors in the sentence	no	sometimes	yes
FUI01 - The application interface is intuitive	The user can easily control the application	0-1 positive questionnaires	2-3 positive questionnaires	4-6 positive questionnaires
FUI02 - the application menu shows all possibilities	The user can easily understand the functions of the aplication	0-1 positive questionnaires	2-3 positive questionnaires	4-6 positive questionnaires
FUI03 - In the translator text to gesture is shown all the words	in the text to gesture app it is possible to find all the words	No	Partial	Yes
FUI04 - In the translator gesture to text is shown the skelleton	in the kinect app it is possible to find the skelleton	No	Partial	Yes
FUI05 - In kinect menu all the translated words are shown in the text box	In the kinect function all the words performed by the avatar appear in the textbox	No	-	Yes
FUI06 - In kinect menu the person performing the gestures is visible	in the kinect function the person is visible and well placed	No	partial	Yes
FUI05 - In translator menu it is possible to change the avatar	the translator menu it is possible to change the avatar	No	-	Yes
FUI06 - In translator menu the avatar is visible	in the translator function the avatar is visible and well placed	No	partial	Yes
FCQ01 - All product information is well organized	the information about the aplication is weel organized and produced	No	-	Yes
FCQ02 - The texts are well written and all the setences make perfect sense (annexed standards)	all the texts that appear in the aplication are correct written and makes sense	No	-	Yes
FCQ03 - All the messages are easy to understand and human personified	the aplication messages are understandable	No	-	Yes
FCQ04 - All the contents are related to the product	all the contents are related to the product objective	No	-	Yes

		Wfk - Fullfilment (%)		
Requirement	Metric Evaluation	0	50	100
AV01 - Different operative systems compatibility	The application works correctly with different operative systems	Lower or equal than 1	Between 2 and 3	4 or more
AV02 - Different mobile compatibility	The application works correctly with different mobiles operative system	Lower or equal than 1	Equal to 2	3 or more
AM01 - Adding possibility of new features	Applications have the possibility to add new features (for example: the language)	No	-	Yes

	Wfk - Fullfilment (%)		
Metric Evaluation	0	50	100
ES01 - Product has a good structure and allows users to access contents in an intuitive way to the main functions	No	-	Yes
ES02 - Application user interface is quick and fast responsive	More than 5 seconds	Lower than 5 seconds and higher than 2 seconds	Lower than 2 seconds
EC01 - Continuous operation	No	-	Yes
EC02 - Outputs according to user inputs	No	-	Yes
EI01 - Contents related with product	0	Lower than 3 more than 1	more than 3

10.5 Annexes E – questionnaires



VIRTUAL SIGN

Ref. PTDC/CPE-CED/121878/2010

Implementação e Testes
QUESTIONÁRIO
Draft 01 – 08/07/2015

GRUPO ALVO: COMUNIDADE SURDA

Responda, por favor, ás questões seguintes para que possamos melhorar o Tradutor Automático de Língua Gestual Portuguesa.

Desde já, o nosso obrigado!

Data: 12/08/2015

Parte 1 – Dados pessoais:

1. Idade: 64
2. Sexo: Masculino
3. Habilitações: Licenciatura
4. Profissão: Reformado

Parte 2 – Avaliação das animações:

Indique se consegue entender as animações (do avatar) correspondentes a cada uma das palavras abaixo indicadas.

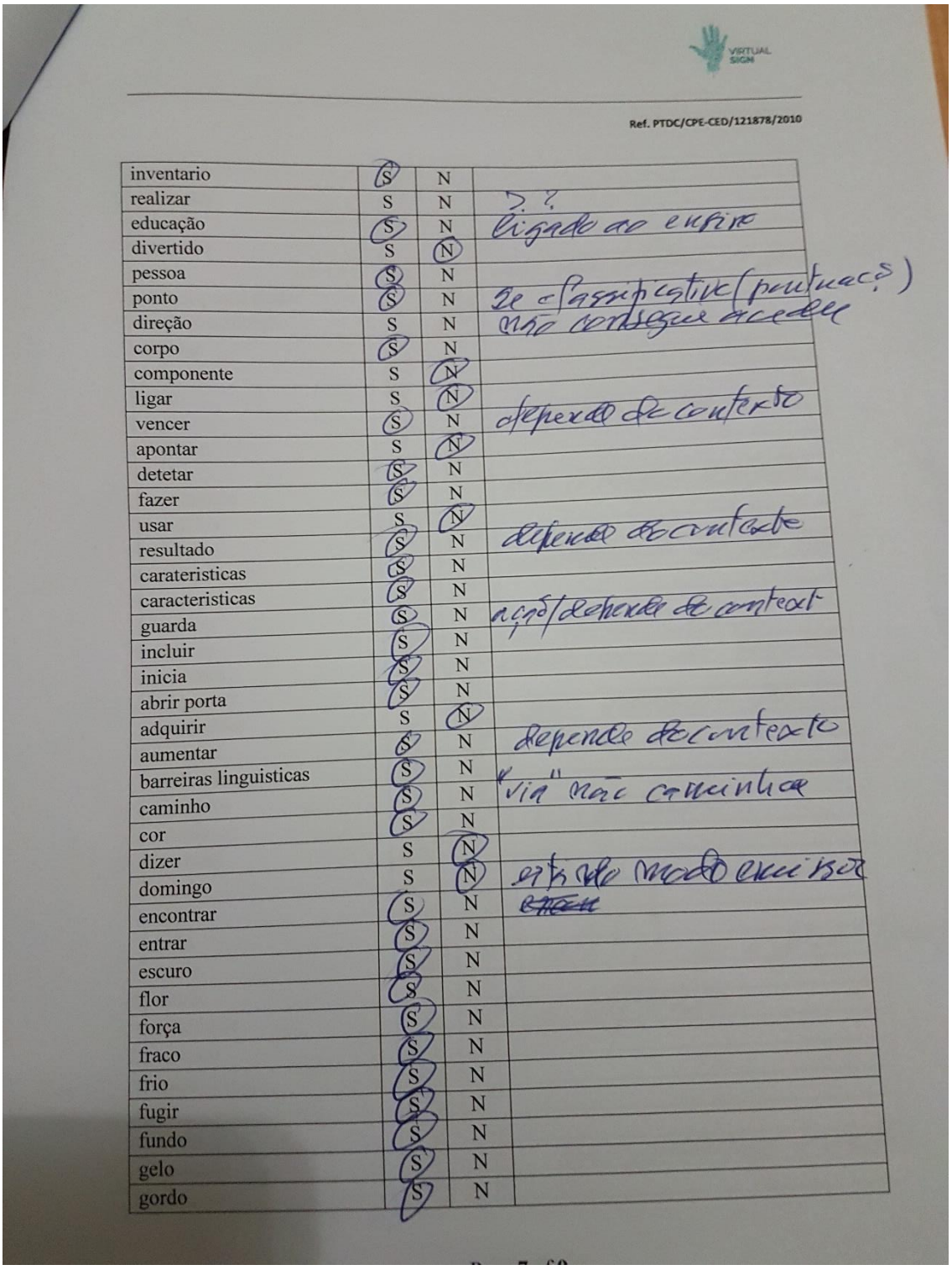
PALAVRAS	Entendi		Observações
Ola	S	N	
a	S	N	atenção postura lado mindinho/faz
b	S	N	
c	S	N	errado
d	S	N	
e	S	N	
f	S	N	
g	S	N	
h	S	N	
i	S	N	
j	S	N	pouco claro
k	S	N	
l	S	N	
m	S	N	
n	S	N	
o	S	N	
p	S	N	
q	S	N	falta mov. descendente
r	S	N	
s	S	N	
t	S	N	
u	S	N	
v	S	N	
w	S	N	recetor / emissor
x	S	N	
y	S	N	falta mov. descendente
z	S	N	
0	S	N	
1	S	N	
2	S	N	
3	S	N	
4	S	N	
5	S	N	
6	S	N	
7	S	N	

8	S	N	
9	S	N	
zero	S	N	
um	S	N	
dois	S	N	
tres	S	N	circunflexo acento
quatro	S	N	
cinco	S	N	
seis	S	N	
sete	S	N	
oito	S	N	
nove	S	N	
tudo	S	N	
nao acredito	S	N	
Não acredito	S	N	
jogar	S	N	
engenheiro	S	N	
dormir	S	N	
dar apoio	S	N	
comprido	S	N	
comer	S	N	
claro	S	N	
ciume	S	N	
casa	S	N	
calor	S	N	
bonito	S	N	
bom dia	S	N	
bem	S	N	
beber	S	N	
bebe	S	N	?
bébe	S	N	
azul	S	N	
amor	S	N	
amarelo	S	N	
amanha	S	N	?
amanhã	S	N	
agua	S	N	?
água	S	N	
acordar	S	N	
gosto de conhecer pessoas novas	S	N	

olá	S	N	
tecnologias	S	N	
com	S	N	
novas	S	N	
fica	S	N	
mais	S	N	
simples	S	N	
aprender	S	N	
lingua	S	N	
gestual	S	N	
portugal	S	N	
implementação	S	N	
sistema	S	N	
tradução	S	N	
portuguesa	S	N	falta feminino
ensino	S	N	
aprendizagem	S	N	
linguagem	S	N	
ludica	S	N	
momentos	S	N	?
lazer	S	N	
serie	S	N	
trabalho	S	N	
orador	S	N	
atender	S	N	? depende situação
parametros	S	N	?
definem	S	N	
manual	S	N	
Não	S	N	
configuração	S	N	
mãos	S	N	
orientação	S	N	
local	S	N	
articulação	S	N	
movimento	S	N	
corporal	S	N	
expressão	S	N	
facial	S	N	??
constituido	S	N	não consegui ouvir
módulos	S	N	

interligados	S	N	
tradutor	S	N	
gestos	S	N	?
texto	S	N	
jogo	S	N	
didático	S	N	
fornecer	S	N	
informação	S	N	
dividir	S	N	
conquistar	S	N	
inicio	S	N	
definido	S	N	?
adoção	S	N	
dominante	S	N	
término	S	N	
marcado	S	N	
retorno	S	N	
posição	S	N	
neutra	S	N	
mudança	S	N	
abecedário	S	N	
fornecem	S	N	
permitindo	S	N	
estimar	S	N	
fornece	S	N	
comparação	S	N	
séries	S	N	
pontos	S	N	se classificativo
efetuada	S	N	
aplicando	S	N	
algoritmo	S	N	
sequencias	S	N	
sequencia	S	N	
resultante	S	N	
constituir	S	N	
palavra	S	N	
usando	S	N	
classificamos	S	N	
análise	S	N	
aspetos	S	N	

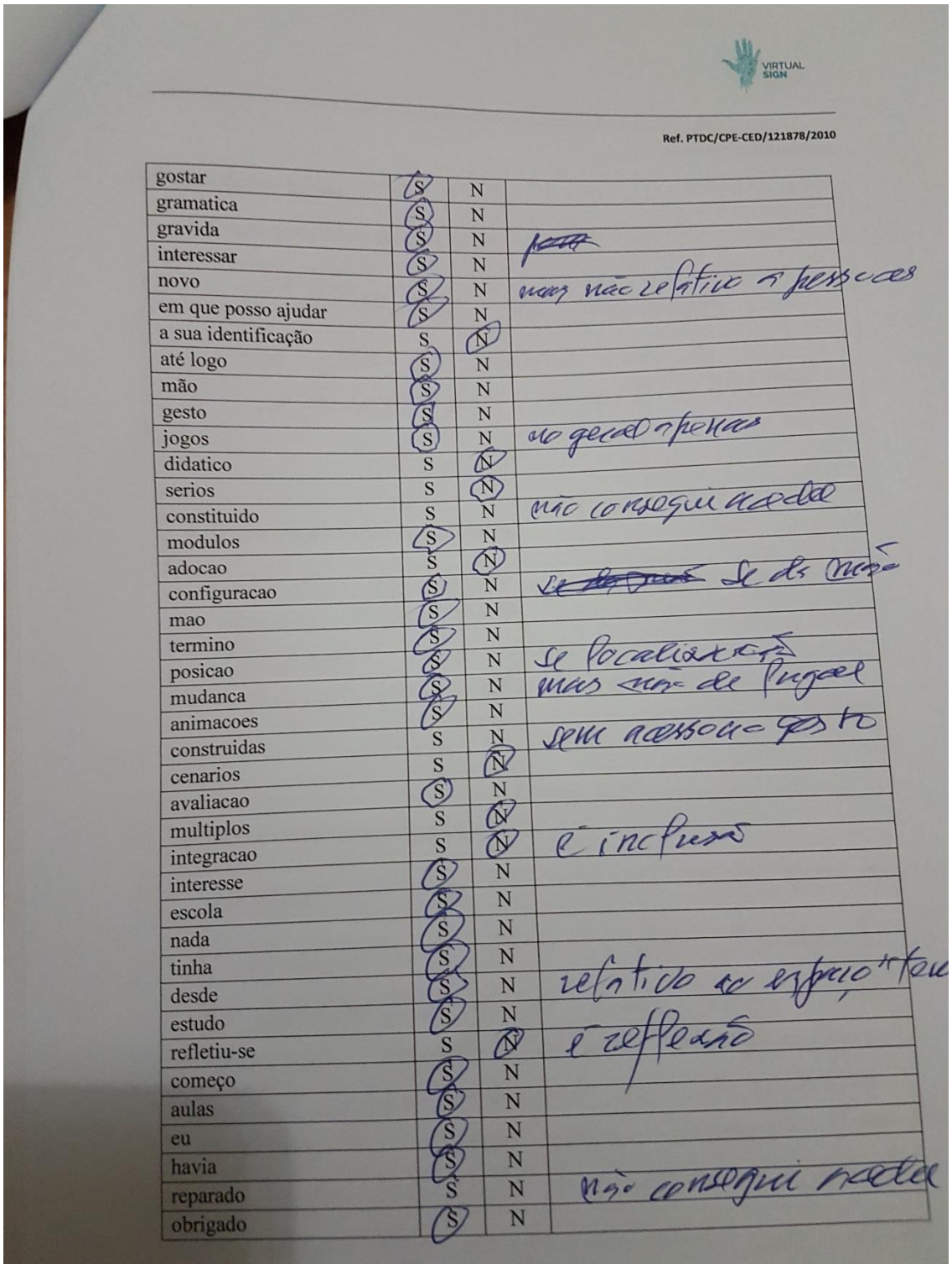
dados	S	N	
recolhidos	S	N	
classificador	S	N	
animações	S	N	
construídas	S	N	
podem	S	N	
utilizadas	S	N	
outros	S	N	
efetua	S	N	
correção	S	N	depende contexto
integração	S	N	isto é incluir
comunicação	S	N	
distância	S	N	
palavras	S	N	
cenários	S	N	
avaliação	S	N	
conhecimentos	S	N	
múltiplos	S	N	
interação	S	N	
cenário	S	N	
alfabeto	S	N	
interativos	S	N	
navegação	S	N	
livre	S	N	
jogador	S	N	
escolhe	S	N	
ordem	S	N	
eventos	S	N	
futurístico	S	N	
frases	S	N	
específicas	S	N	
ativam	S	N	
didatica	S	N	
bomdia	S	N	
mapas	S	N	~~porque dos mapas~~
larga	S	N	
dimensão	S	N	
ambiente	S	N	
interativo	S	N	
jogabilidade	S	N	



VIRTUAL SIGN

Ref. PTDC/CPE-CED/121878/2010

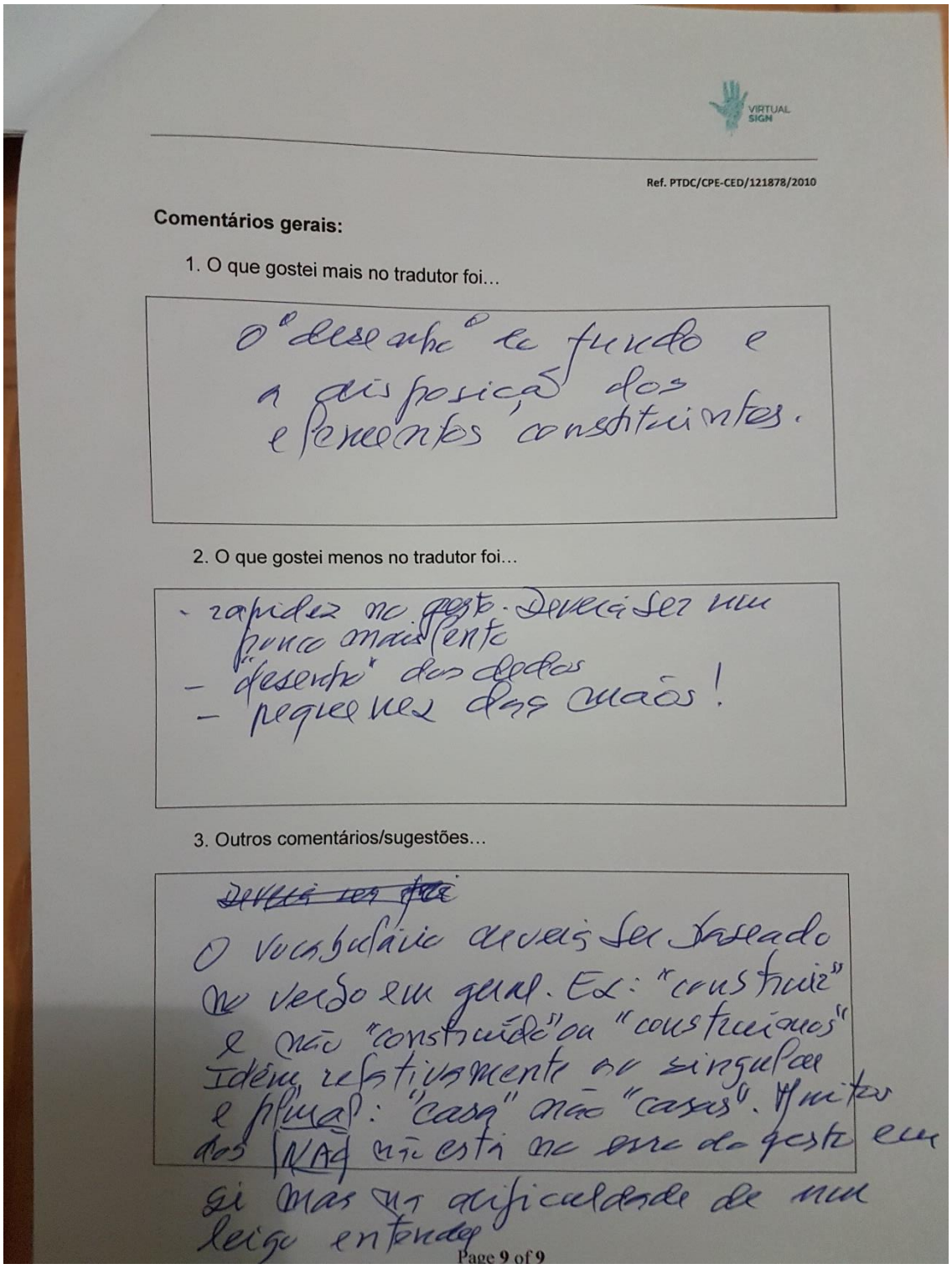
inventario	S	N	
realizar	S	N	? ?
educação	S	N	ligado ao exprimir
divertido	S	N	
pessoa	S	N	
ponto	S	N	se classificativo (pontuação) não consegue aceder
direção	S	N	
corpo	S	N	
componente	S	N	
ligar	S	N	
vencer	S	N	depende de contexto
apontar	S	N	
detetar	S	N	
fazer	S	N	
usar	S	N	
resultado	S	N	depende do contexto
carateristicas	S	N	
caracteristicas	S	N	
guarda	S	N	ação/depende de contexto
incluir	S	N	
inicia	S	N	
abrir porta	S	N	
adquirir	S	N	
aumentar	S	N	depende do contexto
barreiras linguisticas	S	N	"via" não comunicação
caminho	S	N	
cor	S	N	
dizer	S	N	
domingo	S	N	está de modo excisor
encontrar	S	N	
entrar	S	N	
escuro	S	N	
flor	S	N	
força	S	N	
fraco	S	N	
frio	S	N	
fugir	S	N	
fundo	S	N	
gelo	S	N	
gordo	S	N	



VIRTUAL SIGN

Ref. PTDC/CPE-CED/121878/2010

gostar	S	N	
gramatica	S	N	
gravida	S	N	
interessar	S	N	
novo	S	N	mas não relativo a pessoas
em que posso ajudar	S	N	
a sua identificação	S	N	
até logo	S	N	
mão	S	N	
gesto	S	N	
jogos	S	N	no geral a pessoas
didatico	S	N	
serios	S	N	
constituido	S	N	não consegui acabar
modulos	S	N	
adocao	S	N	
configuracao	S	N	se das mãos
mao	S	N	
termino	S	N	
posicao	S	N	se localizar
mudanca	S	N	mas sim de lugar
animacoes	S	N	
construidas	S	N	sem acesso a gesto
cenarios	S	N	
avaliacao	S	N	
multiplos	S	N	
integracao	S	N	é incluso
interesse	S	N	
escola	S	N	
nada	S	N	
tinha	S	N	
desde	S	N	relativo ao espaço + tempo
estudo	S	N	
refletiu-se	S	N	é reflexão
começo	S	N	
aulas	S	N	
eu	S	N	
havia	S	N	
reparado	S	N	não consegui acabar
obrigado	S	N	



VIRTUAL SIGN

Ref. PTDC/CPE-CED/121878/2010

Comentários gerais:

1. O que gostei mais no tradutor foi…

O "desenho" de fundo e a disposição dos elementos constituintes.

2. O que gostei menos no tradutor foi…

- rapidez no gesto. Deveria ser um pouco mais lento
- "desenho" dos dedos
- regularidade das mãos!

3. Outros comentários/sugestões…

~~Deveria ser feito~~

O vocabulário deveria ser baseado no verbo em geral. Ex: "constrói" e não "construído" ou "construíamos" Idem relativamente ao singular e plural: "casa" não "casas". Muitos dos [illegible] não está no ritmo do gesto em si mas na dificuldade de uma leiga entender

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10.6 Annexes F – Dissemination

Ano	Publicação	Url
05/2013	Paula Escudeiro et al. Virtual Sign Translator", Proceedings of the International Conference on Computer, Networks and Communication Engineering (ICCNCE 2013), Beijing, China	http://www.atlantis-press.com/publications/aisr/iccnce-13/
08/2013	Paula Escudeiro et al. "Automatic Sign Language Translator Model", Proceedings of the 2013: Annual International Conference on Advances Technology in Telecommunication, Broadcasting, and Satellite (TelSaTech), Jakarta (Indonesia)	http://telsatech.org/?page_id=90 http://www.aspbs.com/science.htm#202
03/2014	Nuno Escudeiro et al. "Aplicação de um Tradutor Virtual de Língua Gestual a Jogos Sérios", IV Jornadas de Informática da Universidade Aberta, Porto, Portugal	http://repositorioaberto.uab.pt/handle/10400.2/3206
04/2014	Paula Escudeiro et al. "Virtual Sign Supporting Inclusive Learning and Equity", Computers and Technology in Modern Education, 5th International Conference on Education and Educational Technologies (EET '14), Kuala Lumpur, Malaysia'	http://www.wseas.us/e-library/conferences/2014/Malaysia/EET/EET-02.pdf http://www.wseas.us/e-library/conferences/2014/Malaysia/EET/EET-00.pdf
04/2014	Paula Escudeiro et al. "VirtualSign Game - Learning Sign Language", 5th International Conference on Education and Educational Technologies (EET '14), Kuala Lumpur, Malaysia'	http://www.wseas.us/e-library/conferences/2014/Malaysia/EET/EET-04.pdf http://www.wseas.us/e-library/conferences/2014/Malaysia/EET/EET-00.pdf
04/2014	Paula Escudeiro et al. "Serious Game for Sign Language", International conference on Intelligent Systems, Data Mining and Information Technology (ICIDIT '2014), Bangkok, Thailand	http://iieng.org/siteadmin/upload/1400E0414080.pdf http://www.iieng.org/proceedingspdf.php?id=17

07/2014	"ISEP cria ferramenta para traduzir língua gestual em aulas", Article published in the Viva! with the purpose of disclose the VirtualSign project.	http://www.viva-porto.pt/Em-Destaque/isep-cria-ferramenta-para-traduzir-lingua-gestual-em-aulas.html
07/2014	"Criada ferramenta para traduzir língua gestual em aulas", Article published in the TVI 24 Online with the purpose of disclose the VirtualSign project.	http://www.tvi24.iol.pt/503/tecnologia/lingua-gestual-tradutor-investigadores-porto-ferramenta-tvi24/1565585-4069.html
07/2014	"Investigadores do Porto criam ferramenta para traduzir língua gestual em aulas - SAPO Saúde", Article published in the Sapo Online with the purpose of disclose the VirtualSign project.	http://saude.sapo.pt/noticias/saude-em-familia/investigadores-do-porto-criam-ferramenta-para-traduzir-lingua-gestual-em-aulas.html
07/2014	"Investigadores do Porto criam ferramenta para traduzir língua gestual em aulas", Article published in the RCM Pharma with the purpose of disclose the VirtualSign project.	http://www.rcmpharma.com/actualidade/id/23-07-14/investigadores-do-porto-criam-ferramenta-para-traduzir-lingua-gestual-em-aul
07/2014	"Investigadores do Porto criam ferramenta para traduzir língua gestual em aulas", Article published in the Rádio Nova Online with the purpose of disclose the VirtualSign project.	http://www.radionova.fm/noticias/ler/19291
07/2014	"Investigadores do Porto criam ferramenta para traduzir língua gestual em aulas", Article published in the Público Online with the purpose of disclose the VirtualSign project.	http://www.publico.pt/sociedade/noticia/investigadores-do-porto-criam-ferramenta-para-traduzir-lingua-gestual-em-aulas-1663921
07/2014	"Tradução bilateral de língua gestual", Article published in the Primeiro de Janeiro Online with the purpose of disclose the VirtualSign project.	http://www.oprimeirodejaneiro.pt/opj/diarias.asp?idioma=item_lingua1&cfg=0&item=14803
07/2014	"Investigadores do ISEP criam ferramenta para traduzir língua gestual em aulas", Article published in the Porto24 Online with the purpose of disclose the VirtualSign project.	http://www.porto24.pt/inteligencia/investigadores-do-isep-criam-ferramenta-para-traduzir-lingua-gestual-em-aulas/
07/2014	"Investigadores do Porto criam ferramenta para traduzir língua	http://portocanal.sapo.pt/noticia/32732/

	gestual em aulas", Article published in the Porto Canal Online with the purpose of disclose the VirtualSign project.	
07/2014	"Investigadores do Porto criam ferramenta para traduzir língua gestual em aulas", Article published in the Pontos de Vista Online with the purpose of disclose the VirtualSign project.	http://www.pontosdevista.com.pt/index.php?option=com_content&view=article&id=12126:investigadores-do-porto-criam-ferramenta-para-traduzir-lingua-gestual-em-aulas&catid=37:ciencias&Itemid=91
07/2014	"Investigadores do Porto criam ferramenta para traduzir língua gestual em aulas", Article published in the Médico Jornal Online with the purpose of disclose the VirtualSign project.	http://www.jornalmedico.pt/?p=9284
07/2014	"Investigadores do Porto criam ferramenta para traduzir língua gestual em aulas", Article published in the Diário Digital Online with the purpose of disclose the VirtualSign project.	http://diariodigital.sapo.pt/news.asp?id_news=720105
07/2014	"Portugal cria tecnologia que traduz língua gestual", Article published in the Boas Notícias Online with the purpose of disclose the VirtualSign project.	http://boasnoticias.pt/noticias_Portugal-cria-tecnologia-que-traduz-l%C3%ADngua-gestual_20383.html?page=0
07/2014	"Investigadores do Porto criam ferramenta para traduzir língua gestual em aulas", Article published in the Amarense Online with the purpose of disclose the VirtualSign project.	http://www.oamarense.com/noticia.php?id=4455
07/2014	"Virtual Sign permite tradução bilateral da língua gestual", Article published in the Jornal de Notícias with the purpose of disclose the VirtualSign project.	http://www.pt.cision.com/cp2013/ClippingDetails.aspx?id=03264c91-ec1e-417a-b7f0-05a40437dd43&analises=1
07/2014	"Porto cria tradutor de língua gestual", Article published in the Diário de Notícias with the purpose of disclose the VirtualSign project.	http://www.pt.cision.com/cp2013/ClippingDetails.aspx?id=57900a53-c8e3-4875-bd48-ee498d7dd815&analises=1
07/2014	"Assim comunicamos melhor.", Article published in the Blog Atenta Inquietude with the purpose of disclose the VirtualSign project.	http://atentainquietude.blogspot.pt/2014/07/assim-comunicamos-melhor-e-bom.html

07/2014	"ISEP cria tradutor de língua gestual em aulas", Article published in the Metro Portugal with the purpose of disclose the VirtualSign project.	http://www.pt.cision.com/cp2013/ClippingDetails.aspx?id=f9fd53d7-dff2-4e64-9de6-546fb8cc2d34&analises=1
07/2014	"Tradução nas salas de aula", Article published in the Destak with the purpose of disclose the VirtualSign project.	http://www.pt.cision.com/cp2013/ClippingDetails.aspx?id=4cc225be-32af-447f-80be-821455983134&analises=1
07/2014	"Projeto do Porto traduz linguagem gestual para texto", Interview granted to the newspaper Diário de Noticias with the purpose of disclose the VirtualSign project.	http://193.136.60.223/virtualsign/docs/Newspaper_dn_27-07-2014.pdf
07/2014	"Projeto que pretende revolucionar a comunicação com os surdos", Interview granted to the radio Antena 1 with the purpose of disclose the VirtualSign project.	http://www.pt.cision.com/cp2013/ClippingDetails.aspx?id=3ae05d69-a140-46c9-a8f8-bea9b1137c27&userId=18440d84-ada1-4565-97ee-ad56316c8df0
08/2014	“ISEP criou uma ferramenta para apoiar a comunicação com os deficientes auditivos”. Article published in the Noenigma with the purpose of disclose the VirtualSign project.	http://www.noenigma.com/2014/08/isep-criou-uma-ferramenta-para-apoiar.html
08/2014	"Tradutor para surdos traduz palavras e textos para língua gestual", Interview granted to the public TV channel RTP (Portuguese Radio and Television) with the purpose of disclose the VirtualSign project.	http://www.rtp.pt/noticias/index.php?article=759240&tm=8&layout=122&visual=61
09/2014	Paula Escudeiro et al. "Serious Game on Sign Language", XV International Conference on Human Computer Interaction, INTERACCION 2014	http://delivery.acm.org/10.1145/2670000/2662350/a97_Escudeiro.pdf?ip=193.136.60.71&id=2662350&acc=ACTIVE%20SERVICE&key=2E5699D25B4FE09E%2E6A9D8E1D9CC021F6%2E4D4702B0C3E38B35%2E4D4702B0C3E38B35&CFID=695688266&CFTOKEN=19082378&__acm__=1437661601_8376ebc44f3c47a48731d5dfd4cde6f3 http://interaccion2014.ull.es/images/Program.pdf
11/2014	"VIRTUALSIGN - O tradutor de língua gestual", Article of disclosure of the project, integrated in the number 19 of	http://193.136.60.223/virtualsign/docs/ISEP.BI.pdf

	ISEP.BI (Newsletter of the Institute of Engineering of Porto)	
11/2014	Marcelo Norberto et al. "VirtualSign Translator in Serious Games", Third International Conference on Virtual and Networked Organizations Emergent Technologies and Tools, Póvoa de Varzim, Portugal	http://2100projects.org/conferences/vinorg14/Documents/Programme_BS14_ViNOrg14.pdf http://2100projects.org/conferences/vinorg14/proceedings.htm
12/2014	Paula Escudeiro et al. "Educational Contents for the Hearing Impaired Community: Using Games to Promote Equity and Inclusion", 16th International Conference on Information Integration and Web-based Applications & Services (iiWAS2014), Hanoi, Vietnam.	http://dl.acm.org/citation.cfm?id=2684200&picked=prox
12/2014	Paula Escudeiro et al. "Educational Contents for the Hearing Impaired Community: Using Games to Promote Equity and Inclusion", 16th International Conference on Information Integration and Web-based Applications & Services (iiWAS2014), Hanoi, Vietnam.	http://repositorioaberto.uab.pt/bitstream/10400.2/3653/1/Preprint_TALE2014.pdf http://www.tale-conference.org/tale2014/proceedings.php
02/2015	José Bidarra et al. "Tradutor para surdos traduz palavras e textos para língua gestual", Interview granted to the public TV channel RTP2 (Portuguese Radio and Television) with the purpose of disclose the VirtualSign project.	http://www.rtp.pt/play/p676/universidade-aberta
02/2015	Paula Escudeiro et al. "Award cerimony for the Inclusion and Digital Literacy prize", Demonstration of VIRTUALSIGN project to the ceremony participants.	http://www.ticsociedade.pt/premiovencedores
03/2015	"Tradutor para surdos traduz palavras e textos para língua gestual", Interview granted to the public TV channel SIC	http://www.pt.cision.com/cp2013/ClippingDetails.aspx?id=f702d4fa-fefb-42fd-8057-0f948985cc72&userId=18440d84-ada1-4565-97ee-ad56316c8df0

	(Sociedade independente de comunicação) with the purpose of disclose the VirtualSign project.	
03/2015	"Tradutor para surdos traduz palavras e textos para língua gestual", Interview granted to the public TV channel SIC Noticias (Sociedade independente de comunicação) with the purpose of disclose the VirtualSign project.	http://sicnoticias.sapo.pt/pais/2015-03-14-Ferramenta-criada-no-Porto-ganhou-premio-com-tradutor-de-lingia-gestual
03/2015	"Tradutor para surdos traduz palavras e textos para língua gestual", Presentation of the text module in CAMUL masters degree class.	
03/2015	"ISEP cria ferramenta para traduzir língua gestual em aulas", Article published in the Diário dos Açores with the purpose of disclose the VirtualSign project.	http://www.pt.cision.com/cp2013/ClippingDetails.aspx?id=29bb1706-cdc9-449b-afd4-bdcbc8f0b2c6&analises=1
03/2015	José Bidarra et al. " A Kinect Game in the VirtualSign Project: Training and Learning with Gestures", 7th International Conference on Digital Arts Creating Digital e-Motions. Óbidos, Portugal.	http://www.researchgate.net/publication/273773186_A_Kinect_Game_in_the_VirtualSign_Project_Training_and_Learning_with_Gestures https://dl.dropboxusercontent.com/u/4360015/Proceedings_ARTECH2015.pdf
04/2015	Paula Escudeiro et al. "VirtualSign",Presentation of the VirtualSign project in the Acesso.02 Educação e Inclusão conference.	https://www.ipp.pt/personnel/News.aspx?id=7772&back=%2Fpersonnel%2FNews_Tag.aspx%3Ftag%3Dacesso.02
05/2015	Marcelo Norberto et al. "Real Time Bidirectional Translator of Portuguese Sign Language", 11th International Conference on Web Information Systems and Technologies.	http://www.webist.org/Program/2015/WEBIST_paperList.htm
05/2015	Paula Escudeiro et al. "VirtualSign", Presentation of the project VirtualSign in the Convenção Multidisciplinar de Educação	http://www.cme-gondomar.pt/detalhenoticias.php?nID=2#.Va0CI_lVhBc
06/2015	Marcelo Norberto and Jorge Lopes et al. "VirtualSign", Presentation of the project	

	VirtualSign to a group of teachers from Kazakhstan	
06/2015	Marcelo Norberto and Jorge Lopes et al. "VirtualSign", Demonstration of the project VirtualSign in 3ª Jornadas da Engenharia do ISEP	http://jornadasinternacionais.aeisep.pt/#section-tecno
06/2015	Marcelo Norberto et al. "Virtual Sign – A Real Time Bidirectional Translator of Portuguese Sign Language", The 6th International Conference on Software Development and Technologies for Enhancing Accessibility and Fighting Info-exclusion	http://www.dsai.ws/2015/?page_id=381#st22 http://www.journals.elsevier.com/procedia-computer-science/
06/2015	Marcelo Norberto and Jorge Lopes et al. "VirtualSign", Presentation of the project VirtualSign to another group of teachers from Kazakhstan	
07/2015	José Bidarra et al. "VirtualSign Translator", 7th International Conference on Education and New Learning Technologies, Barcelona, Spain	https://repositorioaberto.uab.pt/bitstream/10400.2/2893/1/Virtual%20Sign%20Translator.pdf http://library.iated.org/publications/EDULEARN15
	CAAI ????	
07/2015	ICMET ????	http://www.icmet.ac.cn/2015%20Bali%20conference%20program.pdf ?
09/2015	Paula Escudeiro et al. "VirtualSign in Serious Games", 5th EAI International Conference on Serious Games, Interaction and Simulation, SGAMES 2015	http://sgamesconf.org/2015/show/home