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CREATING AN ANIMATED CHARACTER FOR A COMPUTERIZED DEAF TRANSLATION SYSTEM

Abstract

The article explores the diversity of sign languages using 3D avatars in the context of deaf translation. The research aims to develop algorithms and a 3D avatar based on the visual characteristics of sign language. Special attention is given to the formalization of algorithms and the development of code for 3D avatars, serving as visual demonstrators in sign language translation. Differences between post-Soviet languages using Russian sign language and Kazakhstan, which employs its sign language, are analyzed. The results of the research on the 3D avatar for Turkish sign language are presented, including code development and efficiency evaluation, considering the possibility of algorithm formalization. The research methodology involves analyzing and comparing Kazakh sign language with Turkish attempts or the potential adoption of the Latin script in Kazakhstan. Using a Turkish 3D demonstrator, an animated character model has been created for a computerized sign language translation system into Kazakh Sign Language. The creation of the model utilized the cross-platform graphical package Unity3D. The concluding part emphasizes the significance of such innovations in sign language and their potential application in improving communication for individuals with hearing impairments.

Keywords: computer translation, computational linguistics, 3D avatar, sign language, sign language interpreter, dactyl, visual demonstrator.

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КОМПЬЮТЕРЛІК СУДРОАУДАРМА ЖҮЙЕСІ ҮШІН АНИМАЦИЯЛЫҚ КЕЙІПКЕРДІ ҚҰРУ

Аңдатпа

Бұл мақала сурдоаударма контекстінде 3D аватарларын қолданатын ым тілдерінің әртүрлілігін зерттейді. Зерттеудің мақсаты – ым тілінің визуалды ерекшеліктеріне негізделген алгоритмдер мен 3D аватарын жасау. Алгоритмдерді ресімдеуге және сурдоаудармада көрнекі демонстранттар ретінде қызмет ететін 3D аватарларына арналған кодты әзірлеуге ерекше назар аударылады. Орыс ым тілін қолданатын посткеңестік тілдер мен өз ым тілін қолданатын Қазақстан арасындағы айырмашылықтар талданады. Мақалада түрік ым тіліне арналған 3D аватарын зерттеу нәтижелері, оның ішінде алгоритмдерді формализациялау мүмкіндігін ескере отырып, кодты әзірлеу және өнімділікті бағалау берілген. Зерттеу әдісі ретінде қазақ ым тілін түрік тілімен немесе Қазақстанда латын әліпбиін енгізу мүмкіндігімен салыстыру және талдау негізге алынды. Түрік 3D демонстраторының көмегімен қазақ ым тіліне арналған компьютерлік сурдоаударма жүйесі үшін анимациялық кейіпкердің үлгісі жасалды, модельді құру үшін Unity3D графикалық пакеті пайдаланылды. Қорытынды бөлімде ым тіліндегі осындай инновациялардың маңыздылығы және олардың есту қабілеті нашар адамдар үшін коммуникацияны жақсартудағы әлеуетті қолданбалары көрсетіледі.

Түйін сөздер: компьютерлік аударма, компьютерлік лингвистика, 3D аватар, ым тілі, сурдоаудармашы, дактил, визуалды демонстрация.

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РАЗРАБОТКА АНИМИРОВАННОГО ПЕРСОНАЖА ДЛЯ СИСТЕМЫ КОМПЬЮТЕРНОГО СУРДОПЕРЕВОДА

Аннотация

В статье исследуется разнообразие жестовых языков с использованием 3D-аватаров в контексте сурдоперевода. Целью исследования является разработка алгоритмов и 3D-аватара на основе визуальных особенностей жестового языка. Особое внимание уделяется формализации алгоритмов и разработке кода для 3D-аватаров, которые служат визуальными демонстраторами в переводе жестового языка. Проанализированы различия между постсоветскими языками, использующими русский жестовый язык, и Казахстаном, который использует свой жестовый язык. В статье представлены результаты исследования 3D-аватара для турецкого жестового языка, включая разработку кода и оценку эффективности, с учетом возможности формализации алгоритмов. Как метод исследования в основу взят анализ и сравнение казахского жестового языка с турецким, попытками или возможностью внедрения латиницы в Казахстане. С помощью турецкого 3D-демонстратора создана модель анимированного персонажа для системы компьютерного сурдоперевода под казахский жестовый язык. Для создания модели были использованы кроссплатформенный графический пакет Unity3D. Заключительная часть подчеркивает важность таких инноваций в области жестового языка и их потенциальное применение в улучшении коммуникации для лиц с нарушениями слуха.

Ключевые слова: компьютерный перевод, компьютерная лингвистика, 3D аватар, жестовый язык, сурдопереводчик, дактиль, визуальный демонстратор.

Introduction

According to WHO, more than 5% of the world's population, or 430 million people (including 34 million children), require rehabilitation to address disabling hearing loss. By 2050, this number is estimated to increase to over 700 million people, representing 10% of the global population. "Disabling" refers to hearing loss in the better ear exceeding 35 decibels (dB). Nearly 80% of individuals with disabling hearing loss reside in low- and middle-income countries. The prevalence of hearing loss rises with age, affecting over 25% of individuals over 60 years old [1].

As of the end of 2023, the Ministry of Labor and Social Protection of the Population reports that in Kazakhstan, 724,982 people are registered as disabled. The largest group of disabled individuals in Kazakhstan falls under the third disability category (individuals with hearing impairments belong to this group) [2].

Sign language, as a form of visual communication, presents unique challenges and opportunities for exploration. This study is focused on developing algorithms and 3D avatars to facilitate effective visual representation of sign language, particularly in the context of deaf interpreters. The formalization of algorithms and the development of corresponding code play a pivotal role in creating visual demonstrators for sign language translation [3,4].

The literature review emphasizes the diversity of sign languages and their peculiarities in different countries. The insufficient exploration of local sign languages, especially in post-Soviet countries, remains a pertinent issue. Turkish sign language serves as the subject of detailed study and comparison with Kazakh and other sign languages [5,6].

The aim of the research is to develop algorithms and 3D avatars for visual representation of sign language in Kazakhstan. Key objectives include the formalization of algorithms, the development of relevant software code, and the analysis of the effectiveness of the developed visual demonstrators. The study utilizes the results of the analysis of a 3D avatar for Turkish Sign Language, including code analysis and effectiveness evaluation using developed algorithms. The analysis of Turkish Sign Language reveals limitations in the vocabulary of the 3D avatar, underscoring the need for expanding the word base. Additionally, active development of a 3D avatar for Kazakh Sign Language is highlighted, incorporating new words and gestures.

Dynamic and static gestures are thoroughly discussed, emphasizing the importance of three-dimensional avatars in learning and preserving sign language. The use of algorithms for optimizing the process of translating gestures into visual demonstrations is examined [7,8].

This study underscores the importance of algorithms and code in developing 3D avatars for efficient visualization of sign language, especially in the realm of deaf interpretation. The research proposes prospective directions for advancing this field, emphasizing the role of educational tools in preserving sign language in contemporary society.

The relevance of this article is determined by several key aspects:

1. Advancement in Deaf Translation Technologies: In the context of rapid technological development, especially in the fields of artificial intelligence and visualization, the creation of 3D avatars for sign language represents an innovative and promising approach in the field of deaf translation technologies.

2. Exploration of Sign Language Diversity: The diversity of sign languages in different countries and cultures is a pressing issue, as it influences the effectiveness of communication for individuals with hearing impairments. Comparing and analyzing such languages through 3D avatars provides a unique perspective.

3. Issues in Studying Local Sign Languages: The insufficient study of local sign languages, especially in post-Soviet countries, is noted. This opens up opportunities for the research and development of new methods for studying and preserving such languages.

4. Active Technological Development in Education: 3D avatars serve as effective tools for learning sign language. By utilizing algorithms and code, the article emphasizes their role in optimizing the process of learning and preserving sign language.

5. Prospects for Integration with Public Services: The development of 3D avatars for sign language can be beneficial for integration into social services, polyclinics, and hospitals, streamlining processes for serving individuals with hearing impairments.

Thus, the article provides current research in the field of sign language, deaf translation technologies, and their potential applications in contemporary society.

Research methodology

In contemporary society, deaf individuals face various challenges in the realms of communication and education, emphasizing the need for the development and improvement of sign languages. This literature review examines current trends in the evolution of sign languages in post-Soviet countries and explores new technological solutions, such as 3D translators, in the context of enhancing learning and communication for deaf individuals.

Within the post-Soviet space, including countries like Kyrgyzstan, Uzbekistan, Tajikistan, and others, there is a significant ongoing process of learning sign languages within deaf communities. It is essential to note that each of these countries is developing its unique sign language with distinctive words and gestures. However, the question of naming these languages remains open, and research and standardization of national sign languages represent a pertinent task [9].

The Turkish Sign Language, studied since the Ottoman period, garners attention due to its extensive linguistic foundation and the utilization of 3D avatars on the Unity platform. The project incorporates interesting features, such as the ability to view signs from various perspectives, adjust playback speed, and translate entire sentences. However, as noted in the review, limitations in vocabulary and the use of a dactylic alphabet in some cases pose challenges that require further research and development [10, 11].

Kazakhstan, transitioning to the Latin alphabet, is also exploring opportunities to enrich its sign language. Optimizing text-to-sign language translators, similar to the Turkish project, facilitates an effective learning and communication process. A significant advancement in technology for the deaf community is the 3D translator, offering dynamic gestures and the ability to display entire sentences. This innovative approach provides new perspectives for education and service for the deaf in various fields, including social services and medicine.

Contemporary research in sign language development and sign language translation technologies reflects crucial steps toward ensuring equal access and communication for deaf individuals. The implementation of innovative solutions, such as 3D translators with databases of Kazakh signs and words, significantly enhances the quality of education and communication, making them more accessible and efficient for deaf communities.

Kyrgyzstan, Uzbekistan, and Tajikistan (post-Soviet countries) use Russian Sign Language. Since 2019, these countries have also intensely begun studying sign language. They have distinctive words and corresponding gestures, indicating the need for their own signs. However, the question of officially naming it the Uzbek Sign Language remains open [12].

Turkish politicians actively use sign language interpreters in pre-election campaigns, aiming to convey their plans to all categories of citizens. This makes sense, considering that Turkey has around 90,000 deaf and 60,000 hard-of-hearing individuals.

The Ukrainian Sign Language belongs to the family of French Sign Languages. Awareness of the Ukrainian Sign Language sharply increased in 2014. In USL, like in other sign languages, dactylology serves as a form of borrowing from Ukrainian. It is used for proper names, technical terms without USL equivalents, abbreviations of longer Ukrainian words, and some colloquial Ukrainian words. Fingerpelling may also be used for emphasis instead of a synonymous sign [13].

Kazakh sign language is based on the Russian language. However, they have different gestures for different words. Since the syntax and grammar of the Kazakh verbal language differ from the Russian language, sign language also has its own peculiarities. Since 2017, the sign language in Kazakhstan has been studied from all sides, an electronic dictionary surdo.kz has been invented and is currently developing more and more. The syntax of sign language is quite different from the Russian sign language. There are certain words that are not found in Russian sign language, and due to this, new gestures appear that are used only among users of Kazakh sign language.

If we consider the similarity with the Turkic-speaking sign languages, only the Turkish sign language has its own dactylic alphabet and a research base on sign languages. Kazakh and Turkish have more similarities in verbal language than in sign language. Many words and pronunciation of letters are quite similar. But they differ in sign language, one of the reasons is that the Kazakh dactylic alphabet is based on Cyrillic, and the Turkish dactylic alphabet is based on Latin.

Fig. 1 shows that post-Soviet countries take their basis from the Russian sign language.

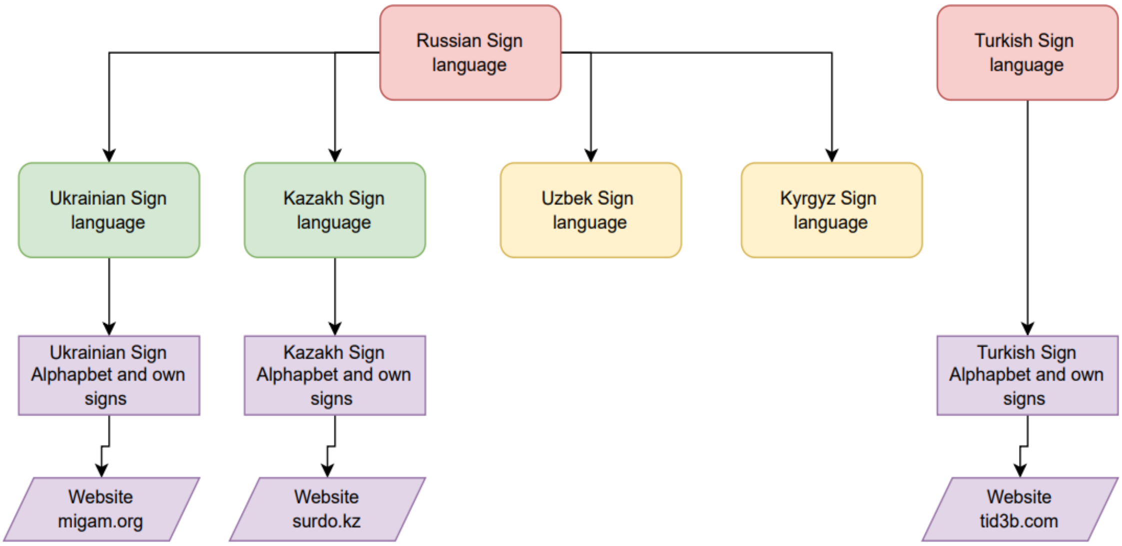

Figure 1. Comparative analysis of sign languages of some countries
Note - compiled by the author based on the source [14]

Among them, Kazakh and Ukrainian sign languages have their own alphabet, that is, converted from the Russian sign language, and already have their own unique gestures, according to certain words that are found only in their culture, traditions, etc. This means that these two countries are going further in the development of sign language and are developing on all fronts, as proof we can cite websites that are already functioning and require further development. But many other post-Soviet countries still use Russian sign language. But some sources give information that they also have changes in gestures, because new words appear, and some old gestures lose relevance and gesture users come up with new gestures. But do scientists study their sign language? Are they added to some kind of database? Are tutorials being created? Many news articles say that they do not have research as such and hearing-impaired people need specialized schools.

The research aims to develop algorithms and a 3D avatar based on the visual characteristics of sign language.

Among the Turkic languages, Turkish sign language has achieved a lot, they have their own alphabet, their own gestures, and even not one, but several sites for learning sign language, some sites make it possible to show words and sentences with the help of a virtual assistant.

Communication between the Turkic-speaking countries will reach a level with the gradual transition of Kazakhstan from Cyrillic to Latin from 2023. In 2017, the first President of Kazakhstan, Nursultan Nazarbayev, signed a decree on the transition of the Kazakh alphabet from Cyrillic to Latin. Following this, the National Alphabet Commission was established and work began on the transition to a new alphabet throughout the country. Since then, the practice of writing the names of streets, shops, pharmacies and especially state institutions in the Kazakh language in the Latin alphabet has spread widely in the country.

Soon Kazakhstan will switch to the Latin alphabet, with a high probability we can say that some changes will be required in the Kazakh sign language. If the main alphabet of Kazakhstan changes to the Latin alphabet completely, it will be relevant to change the alphabet of the sign language. At the same time, the Turkic sign language can be taken as a basis. One of the reasons is the similarity of many letters [14].

The new Kazakh alphabet corresponds to the international phonetic alphabet (it has 107 letters and 52 diacritics) and the UNICODE system. The Kazakh Latin alphabet borrowed all this. The new alphabet is developed according to the same principles as the Turkish, Azerbaijani and Gagauz Latin alphabet. This means that deeper integration between the Turkic peoples is possible. The new version of the Latin alphabet is similar to the unified Turkic alphabet, adopted back in 1991. In addition, there are several letters that are identical in the Kazakh and Turkish alphabets, such as Y, Ө, but not found in the Russian alphabet (Fig. 2) [15].

Figure 2. Turkish, Russian, Kazakh sign alphabet [16]

It should be noted that there are a lot of words in the Kazakh language that are similar in sound to the Turkish language. Both languages belong to the Turkic language group, so the grammatical and lexical construction of sentences is also similar.

Character Design Method. Specialized programs such as MakeHuman and Blender were employed for creating the animated character. The steps involved defining physical characteristics, appearance, and adjusting the character's movements.

Animation Method. Unity3D and other software tools were utilized for character animation. The process included adding a skeleton, configuring movements, and creating animation libraries.

Character Modeling. Parameters in MakeHuman were set for creating the basic model, and Blender was employed for detailed adjustments to appearance, clothing, and textures.

Sign Database. The process of querying a database to find corresponding signs was described. It detailed how the system was trained and how it associated words with signs [17].

These methods and materials not only provide insight into the technical aspects of creating an animated character but also offer readers a foundation for replication and further research in this field.

Results of the study

A prototype is being made to create an automated translator from the text of the Kazakh language into sign language. In the development of such an application, several words in the Kazakh language have been collected. At a certain stage of this study, it was found that sign language does not use prefixes, suffixes and prepositions.

Starting the creation of an avatar involves designing a human model first. MakeHuman, a free interactive open-source modeling tool for creating custom 3D characters, was utilized for this purpose. Additionally, the 3D graphics program Blender was employed. Photoshop was used for configuring clothing textures. Animation setup and the creation of "clips" were done in the Unity3D graphics engine. When creating the human model, we begin by specifying gender characteristics for our future avatar in the MakeHuman program, including gender, age, muscle structure, weight, height, proportions, and even racial identity. The MakeHuman avatar model is then exported in .obj format. Working in Blender, we import the avatar model created in MakeHuman, stored in a .obj file. Working with the polygon mesh model, we define the contours of the avatar's clothing, grouping polygons for each type of clothing. Clothing can be textured on both a 2D plane and the 3D model itself. The 2D model can be saved as an image and further textured in Photoshop. In Blender, by adding a skeleton to the avatar model, we can more precisely position joints on the arms and fingers, crucial for gesture displays. Before exporting the avatar model from Blender to Unity3D, it is necessary to set the appropriate scale. In Unity3D, all textures related to our avatar model are imported – clothing, shoes, hair, eyebrows, and eyes. The functionality of the Unity3D package satisfies all requirements for working with the avatar: it allows the creation of clip libraries and the customization of animations based on gesture notation components, utilizing the gesture notation dictionary we created for the Sign Language Notation System (SLNS) [17, 18].

The figure 3 shows an example of how you can use synonyms and translate words into the infinitive. For example, words such as КӨМЕКТЕСЕ - КӨМЕК - КӨМЕКТІ = Word_Komek, is the process of grouping single-root words that help formalize the Kazakh text language.

During the syntactic and semantic analysis of a sentence (text), many phrases and phrases are revealed, of course, all these compounds have a semantic meaning. And in this regard, it is necessary to optimize a lot of phrases (F). As well as all semantic relationships between the meanings of words in the text can be reduced to a minimum number of semantic relationships (Formula 1).

$$F = f_i \cap f_j$$

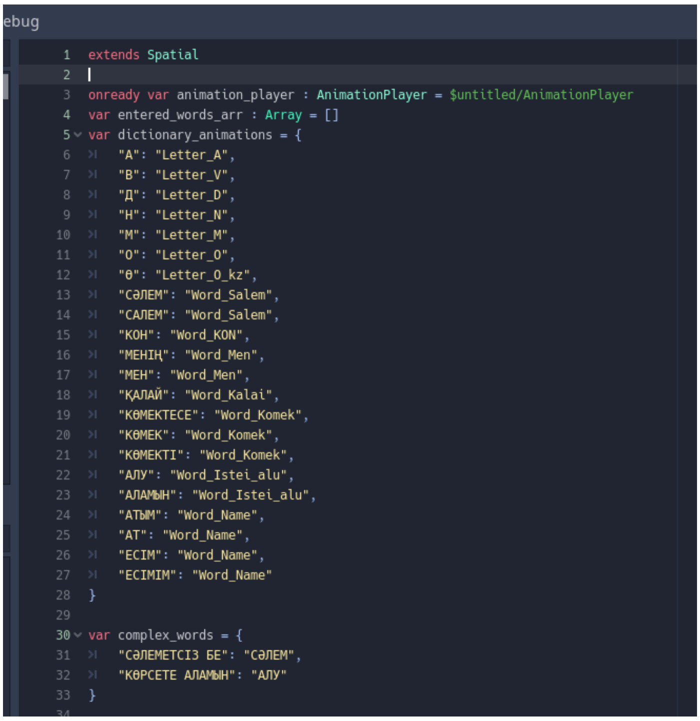

Figure 3. The process of grouping single-root words
Note - compiled by the author based on the source [19]

For visualization, it is necessary to conduct a semantic analysis and create semantic relationships, which will translate the text into a metalanguage for further processing:

«Сәлеметсіз бе! Қалай көмектесе аламын? Менің атым Дана» (Hello! How can I help? My name is Dana)

«Сәлем. Қалай Көмек Алу. Мен Есім Д-А-Н-А» (Hello. How can help? My name D-A-N- A)

$$F_1 := \{A_{sem}(inj)\}$$

$$F_2 := \left\{\begin{matrix} \{A_{sem}(ch.pr), A_{sem}(obj)\} \\ \{A_{sem}(obj), A_{sem}(act)\} \\ \{A_{sem}(ch.pr), A_{sem}(act)\} \end{matrix}\right\} \quad (1)$$

$$F_3 := \left\{\begin{matrix} \{A_{sem}(sub), A_{sem}(obj)\} \\ \{A_{sem}(sub), A_{sem}(special\ word)\} \\ \{A_{sem}(obj), A_{sem}(special\ word)\} \end{matrix}\right\} \quad (2)$$

$$F := \{F_1, F_2, F_3\}$$

Based on the study of text translation into computer language and linking it with sign language, the following basic structures have been developed that show the construction of semantic rules at the level of a simple sentence. In these formulas (1, 2) the main groups of semantic attributes were investigated and proposed: action ($A_{sem}(act)$), subject ($A_{sem}(sub)$), object ($A_{sem}(obj)$) and the characterizing parameters ($A_{sem}(ch.pr)$) [19].

To define common nouns, we have added a set of *special words*, which is a set of letters:

$$A_{sem}(special\ word) = \{letter_1, letter_2, \dots, letter_i\}$$

After formalizing the text and translating it into machine language, it will be possible to implement the algorithm and compile the code, as a result of which we will get a 3D avatar.

In Figure 4, the stages of machine translation from text to sign language are illustrated.

The first stage involves inputting the text, followed by creating an array for all words. Subsequently, the words are categorized into actions and objects. Since sign languages have their unique grammatical systems, distinct from spoken languages, the words are grouped accordingly. For instance, American Sign Language (ASL) follows the Subject-Verb-Object (SVO) word order, while British Sign Language (BSL) uses the Subject-Object-Verb (SOV) word order. The Kazakh Sign Language must adhere to the Subject-Verb-Object (SVO) word order. In the second stage, there is a connection to the database, involving a query for specific words and corresponding signs. The database seeks simpler versions of complex words and phrases if an exact match is not found. Afterward, the words are replaced with signs for animation, and the signs are then outputted [19].

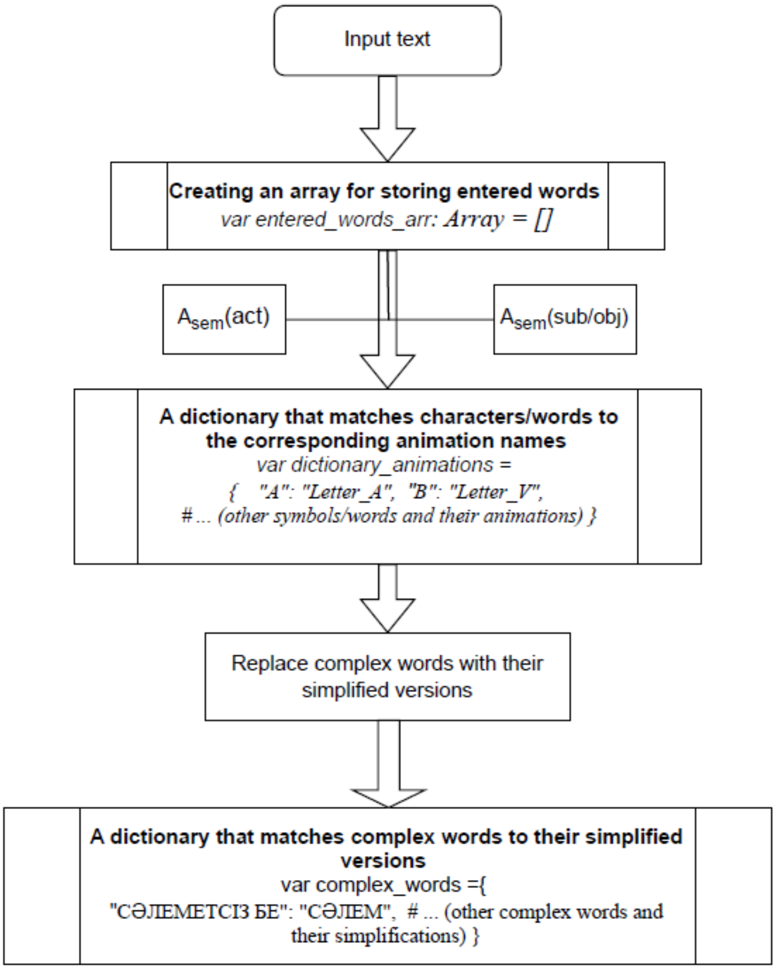

Figure 4. The machine translation algorithm
Note - compiled by the author based on the source [19]

Turkish sign language has a 3D avatar that translates words and text into gestures. This program is made on Unity and is easy to use. Unity is used in most cases to create video games, respectively, such an avatar that is created through Unity has a good visual. This avatar has several functions: you can view the indication of gestures from different angles, change the speed of gestures, translate both, words and sentences. However, during testing, it turned out that there are not so many words in the database and the avatar uses the dactylology of the alphabet when translating some words. Fig. 5 illustrates gestures that are not in the database. Accordingly, when indicating these gestures, the dactyl alphabet is used. Also, the type of letters begins with uppercase or lowercase plays a very important role. When they wrote the word "Benım" (mine) with a capital letter, the avatar began to show using dactyl, this led to the idea that the avatar does not understand words that have additional endings or suffixes, that is, translates only the root of the word. But when writing the same word with lowercase letters, the gesture of the word "benim" (mine) showed. As a conclusion, we come back to the fact that the vocabulary of this avatar is not so great. According to the information that is shown on the site, we can say that the project was created recently and now new words are still being researched and added to the database [20].

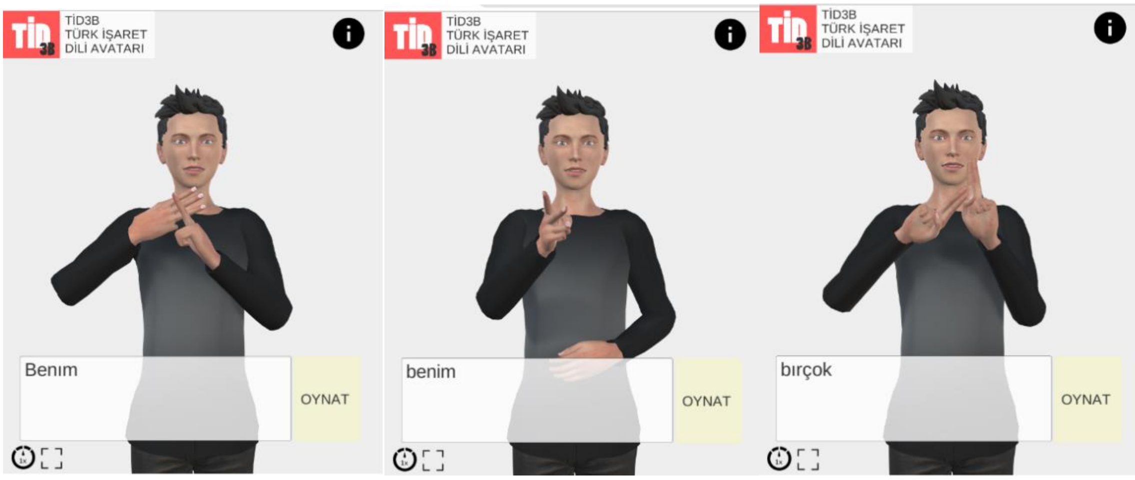

Figure 5. Using the dactyl alphabet (comparing lowercase and uppercase letters) [20]

When integrated into social services (PSC, polyclinics and hospitals), this avatar will benefit and help in optimizing the process. When combining gesture recognition with such an avatar, you will get a full-fledged robot that will serve people with hearing loss. Accordingly, the virtual assistant fully shows its importance and relevance.

After analyzing and fully studying the 3D translator from the text of the Turkish language to the Turkish sign language, we made our avatar with a database of Kazakh words for translation into the Kazakh sign language.

```
# Link to the code AnimationPlayer
onready var animation_player : AnimationPlayer = $untitled/AnimationPlayer
# An array for storing the entered words
var entered_words_arr : Array = []
  # A dictionary that matches characters/
words to the corresponding animation names                                  (3)
var dictionary_animations = {
  "A": "Letter_A",
  "B": "Letter_V",
  # ... (other symbols/words and their animations)
}
# A dictionary that matches complex words to their simplified versions
var complex_words = {
  "СӘЛЕМЕТСІЗ БЕ": "СӘЛЕМ",
  # ... (other complex words and their simplifications)
}
```

During initialization, the animation mixing time is adjusted to control the smoothness of transitions between different animations. This is important for creating visually appealing animations.

```
# The initialization function is called when the script is ready
func _ready():
# Iterate over pairs of animations and set the blending time if it is equal to 0
```

$$for\ name1\ in\ animation\_player.get\_animation\_list():$$
$$for\ name2\ in\ animation\_player.get\_animation\_list(): \quad (4)$$
$$\#\ Check\ if\ the\ mixing\ time\ between\ the\ two\ animations\ is\ equal\ 0$$
$$if(animation\_player.get\_blend\_time(name1, name2)\ ==\ 0):$$
$$\#\ Setting\ the\ mixing\ time\ to\ 0.25\ seconds\ (or\ another\ desired\ value)$$
$$animation\_player.set\_blend\_time(name1, name2, 0.25)$$
$$return$$

Discussion

A gesture in sign languages is an analogue of a word in sound languages, although this analogy is rather conditional. However, in most cases, the gesture as a whole satisfies the signs of the word: wholeness, reproducibility, correlation with a certain concept, separability in speech.

The functions of articulators in sign languages are hands, face, head and body. Depending on the articulators used by the speaker, there are three main types of gestures: manual, non-manual and combined. Manual gestures are performed by hands (for example, HOUSE, LIVE, CAT), this is the most frequent type of gestures in all known sign languages. Non-manual gestures are movements of the body, head and facial muscles. Combined gestures are a combination of manual and non-manual components in a gesture (for example, FEAR) .

Manual gestures, depending on whether both hands or only one hand are involved in their execution, can be one-handed (for example, a PERSON, TO DIE) or two-handed (READ, VILLAGE).

Like words in sound languages, gestures consist of units of an unfamiliar level. The functional analogues of phonemes in sound languages in sign languages are the realizations of gesture parameters.

Most gestures are dynamic and involve movements of the fingers, hands, or the entire hand. Less static gestures - motionless, for the understanding of which there is no need for movement. For a complete understanding and study of gestures, it is necessary to shoot a video to show it from different angles. In addition, some gestures may be similar, the difference can only be identified with the dynamics of the hands and fingers. Note that, as a rule, they remember and understand much more gestures than they can correctly depict. The number of gestures used in everyday conversation, in lectures or in technical translations, of course, is different. In a conversation on an everyday topic, one can limit oneself to knowledge of 150-200 gestures, while educated deaf people own 2000-3000 gestures. In addition, with the help of sign language, in most cases it is impossible to convey names and surnames, foreign, technical or medical terms, names of streets and cities. Therefore, along with gestural speech and in addition to it, the deaf widely use the dactyl (finger) alphabet. And to shoot all this on video, and even more so to take it from different angles, is now already inefficient and takes up a lot of memory. The 3D avatar solves these problems. Having written, in the word box we can see the gesture from different sides in order to remember the position of the hands and fingers. Such a project will be very convenient for learning the Kazakh sign language [20].

Fig. 6 shows the gestures “Сәлеметсіз бе! Қалай көмектесе аламын? (Hello! How can I help?)” and “Менің атым Дана (My name is Dana)”. All of these gestures are dynamic. In addition, such a virtual translator can show whole sentences both by dactyl and by words. In the example “Менің атым Дана (My name is Dana)”, the words “менің (my)” and “атым (name)” are shown with gestures, and the name “Dana” is shown with a dactyl.

The formulas and algorithms presented and discussed in Section 4. Materials and Methods play a pivotal role in the development of a three-dimensional avatar capable of automated translation from Kazakh text to sign language.

Figure 6. 3D translator from text to Kazakh sign language
Note - compiled by the author based on the source [20]

Conclusion

The broad significance of this study is that a 3D avatar that will translate from Kazakh text into Kazakh sign language will be very effective. All comparative analyses given in the article show that such 3D online translators are already used in different countries and are becoming more relevant. When comparing different sign languages, namely Post-Soviet ones such as Tajik, Uzbek, Kyrgyz and Ukrainian, many countries have come to the conclusion that they still use Russian and have not yet sufficiently explored their sign language. In a number of comparisons with the Turkish sign language, similar points were revealed in the verbal language and with the further addition of these novelties, if the alphabet of the verbal language of Kazakhstan changes to the Latin alphabet. In addition, during the study of the Turkish sign language, we found a lot of useful information, which we can update and implement the acquired knowledge into our project as soon as possible. The creation of a 3D model that translates from text into Kazakh sign language is already in the process. After introducing sufficient numbers of words and gestures into the database, we can publish them on the website for testing and use. At this stage, the avatar can show dynamic and static gestures, letters and words that are used in everyday life are embedded. With the help of such avatars, gestures can be viewed from different angles for full understanding and study. Such models can be very useful in places of social service.

References

[1] Deafness and hearing loss (2024), URL: https://www.who.int/ru/news-room/fact-sheets/detail/deafness-and-hearing-loss

[2] Danielle Bragg, Oscar Koller, Mary Bellard, Larwan Berke, Patrick Boudreault, Annelies Braffort, Naomi Caselli, Matt Huenerfauth, Hernisa Kacorri, Tessa Verhoef, Christian Vogler, Meredith Ringel Morris, "Sign Language Recognition, Generation, and Translation", The 21st International ACM SIGACCESS Conference on Computers and Accessibility, pp.16, 2019. doi: 10.1145/3308561.3353774.

[3] Cohen-Koka, S., Nir, B., Meir, I. "Variation of sign parameters in narrative and expository discourse," in Sign Language and Linguistics (Online), no. 26(2), pp. 218–257, 2023, doi.org/10.1075/sll.22001.coh.

[4] Amangeldy, N., Milosz, M., Kudubayeva, S., Kalakova, G., Zhetkenbay, L., "A Real-Time Dynamic Gesture Variability Recognition Method Based on Convolutional Neural Networks," in Applied Sciences (Switzerland), no. 13(19), 2023, doi.org/10.3390/app131910799.

[5] Ramadani, R.A., Putra, I.K.G.D., Sudarma, M., Giriantari, I.A.D. "A new technology on translating

Indonesian spoken language into Indonesian sign language system," International Journal of Electrical and Computer Engineering, no. 11(4), pp. 3338–3346, 2021, doi: 10.11591/ijece.v11i4.pp3338-3346

[6] Grif, M.G., Korolkova, O.O., "Development of a Training Bilingual Dictionary for Persons with Hearing Disabilities," in Journal of Siberian Federal University - Humanities and Social Sciences, no. 15(11), pp. 1723-1731, 2022, doi: 10.17516/1997-1370-0947.

[7] Y. S. Manueva, M. G. Griff, "Development of an algorithm for semantic analysis of speech (text) for translation into Russian sign language," in Scientific Bulletin of NSTU Conf., vol. 62, no. 1, pp. 106-119, 2016, doi: 10.17212/1814-1196-2016-1-106-119.

[8] D. Yusupov, Uzbek sign language (USL): to be, or not to be? (2022), URL: https://dilmurad.me/uzbek-sign-language-usl-to-be-or-not-to-be/

[9] Zwitserlood, I., Perniss, P., & Özyürek, A. (2017). Expression of multiple entities in Turkish Sign Language (TİD). In E. Arık (Ed.), Current directions in Turkish Sign Language research (pp. 273-302). Newcastle upon Tyne, UK: Cambridge Scholars Publishing.

[10] O. Lozynska, M. Davydov. Information technology for Ukrainian Sign Language translation based on ontologies. Econtechmod. An international quarterly journal. 2015, Vol. 04, No. 2, pp. 13–18

[11] M. Kussainova, U. Amuyeva, The transition of Kazakhstan to the Latin alphabet will bring together the Turkic-speaking countries (2021). URL: https://www.aa.com.tr/ru/

[12] V.A. Ivanchenko, Lexico-semantic group of existential gestures in Russian sign language. (2018): 68-70. https://elar.urfu.ru/bitstream/10995/25293/1/avfn_2013_15.pdf

[13] O.Lozynska, M. Davydov, V. Pasichnyk, N. Veretennikova (2019) " Rule-based Machine Translation into Ukrainian Sign Language Using Concept Dictionary". 12th International Scientific and Technical Conference on Computer Sciences and Information Technologies (CSIT). 2017, pp. 218–239. doi: 10.1109/STC-CSIT.2017.8098734

[14] Saibekova N.U., Aytaş G., The similarities of graphemes in kazakh and turkish languages. The messenger. Philology series. No1 (173), (2019): 79-82. https://philart.kaznu.kz/index.php/1-FIL/article/view/2617/2493

[15] Zametki ob NLP. http://habrahabr.ru/post/79830/ (obrashchenie 20.08.2013)

[16] Arkushin, Rotem Shalev, Amit Moryossef, and Ohad Fried. 2023. "Ham2Pose: Animating Sign Language Notation into Pose Sequences," 21046–56.

[17] H. Karal, A. Mevhibe Cosar, E.Bahcekapili, L. Silbir, S. Fis Erumit, A. Yildiz, M. Atasoy, 3D Virtual Turkish Sign Language Translator (2019). URL: https://tid3b.com/?en

[18] Mihir Deshpande, Vedant Gokhale, Adwait Gharpure, Aayush Gore, Harsh Yadav, Pankaj Kunekar, Aparna Mete Sawant, "Sign Language Detection using LSTM Deep Learning Model and Media Pipe Holistic Approach", 2023 International Conference on Artificial Intelligence and Smart Communication (AISC), pp.1072-1075, 2023.

[19] Rakhimova, D., Abilay, S., Kuralay, A. "The Task of Generating Text Based on a Semantic Approach for a Low-Resource Kazakh Language," in Communications in Computer and Information Science, pp. 585-595, 2023, doi.org/10.1007/978-3-031-42430-4_48

[20] Şılbır, L., Coşar, A.M., Kartal, Y., Atasoy, M., Özçamkan-Ayaz, G. "Graphic symbol based interactive animation development process for deaf or hard of hearing students" in International Electronic Journal of Elementary Education, 2020, no 12(4), pp. 371-382.