GESL Vocabulary and Innovation Technologies

Tamar Makharoblidze, George Mirianashvili
Ilia State University
e-mail: tamar.makharoblidze@iliauni.edu.ge, gmirian@gmail.com

Abstract

Georgian sign language (GESL) is a language of Deaf and Hard of Hearing people (DHH) in Georgia. The current researches on GESL are connected with computational linguistics and lexicology. Our group at Ilia State University works on a sign language universal translator, which will be able to translate the texts from any sign language into spoken and vice versa. This issue is concerning the communication problems of DHH worldwide.

We elaborated the theory of neutral signs (NS). For the current moment we are building the mini corpora for GESL to test the elaborated software prototype. We collect data according to the proper methodology structuring the information, analyzing and comparing the signs from different sign languages (SL), creating the special API for integration with any other SL corpora, revealing and then testing the elaborated algorithms for the universal SL translator, developing the software and hardware design concepts for the final product.

Keywords: Georgian sign language; sign recognizing engine; sign language machinery interpreter; SL soft

1 About Georgian Sign Language (GESL)

The scientific investigations concerning the structure of the Georgian sign language (GESL) do not have a long history. Georgian sign language (GESL) is a language of Deaf and Hard of Hearing people (DHH) in Georgia. In the Soviet period the sign languages were under the influence of Russian. The reasons for this were the following circumstances: (a) In Georgia many active members of the deaf community were non-Georgian native speakers, and (b) In that period there were no books about GESL at all and the local DHH had no choice. They had to accept (only) the Russian books for their special schools. This Russian influence on GESL is easy to find in the old Georgian dactyl alphabet, which was totally based on the Russian one. The GESL vocabulary also was mainly based on the Russian sign language (SL) lexical data. On the one hand, the Deaf people could communicate via this "Soviet sign language" and they tried to keep this possibility, but on the other hand, the process of nationalization began everywhere in the post Soviet space and the sign languages are reintegrating. Although it should be mentioned that the grammar of GESL more or less follows the spoken Georgian language structure and it is free from Russian elements. Thus, the process of SL reintegration is better reflected on the lexical level of the language. Last few years the lexical and grammatical levels of the language hierarchy of GESL were investigated and a few books were published (See Makharoblidze in the list of references).

1.1 Current Researches on GESL

The current researches on GESL are connected with computational linguistics and lexicology. The small group of scientists at Ilia State University is elaborating the sign language universal translator.

The universal SL translator will be able to translate the texts from any sign language into spoken and vice versa. This engine will be first tested on GESL data. Needless to say, that the issue is the communication problem for Deaf and Hard of Hearing (DHH) people worldwide. Several million DHH worldwide can benefit from the final version /product of this project.

2 Theory of Neutral Signs

In order to overcome the main problem of Sign Language (SL) translations into spoken languages, we elaborated the theory of neutral signs (NS) – the meaningless signs between the lexical signs. NS is a sign (as a word) separator. The smooth flow of the signs made impossible for the experimental computer translating engines to recognize the dynamic signs while signing. According to our theory, NS – the meaningless units are the spaces for SL texts and SL corpora. The irrelevant short/small (one-phase or static) signs between the lexical (meaningful) signs are NS - neutral signs. There can be two ways for collecting NS data:
A. Online open sources could fill the SL universal big data from different SL and SL texts will provide a big variety of NS – later this data could be kept as NS archive;
B. We can offer the general parameters for NS. Basing on these parameters the engine can recognize NS and identify it as a space between the words/signs in the fluent text.

2.1 Parameters of Neutral Signs

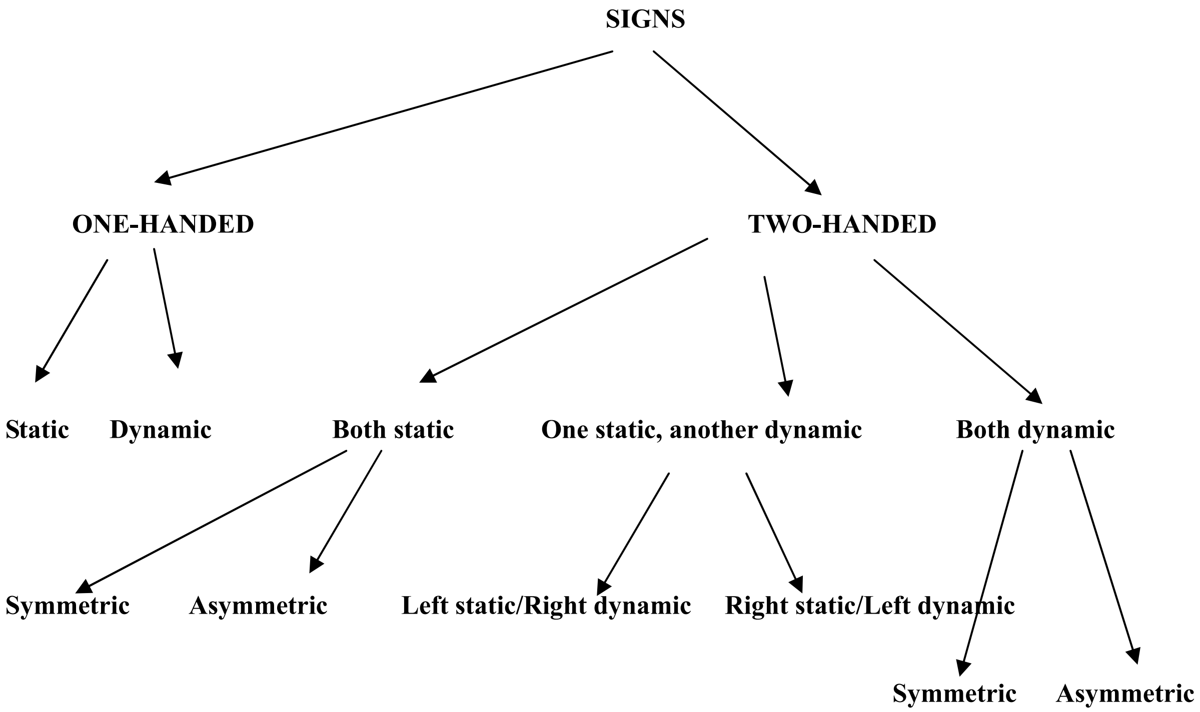
It is doubtless, that all NSs are dynamic gestures. The difficulties are connected with dynamic movement as well. These signs (NS) in all SL will have the following parameters:

- Palm orientation is down in most cases (if the previous or the next signs are not with the palms up);
- Fingers are in the so-called neutral position (slightly curved);
- Fingers in most cases move slightly or their movements could be discarded;
- The neutral signs can be recognized by:
  a. Low converging data of Leap-Motion and MYO,
  b. Kinetics /statics between the two recognized signs (units),
  c. Creating the international NS big data.

The recognition of NS can take place via synergetic approach or in terms of one syntactic unit. The theory of NS makes it possible to operate with the units as with words.

3 Classification of Signs

The signs can be static or dynamic, one- or two-handed. Two-handed signs may be symmetric or asymmetric. Besides, in two-handed signs either both hands are producing dynamic or static signs, or one hand produces a static sign while another one does a dynamic sign. Schematically it looks as follows:



For sign classification we used the combination approach:

- Dynamical gradation (with space and time parameters) - The signs are statistic or/and dynamic. Dynamic signs may have one, two or more movement(s)/phase(s);
- Composition of a sign/sign structure – the signs may have one, two, three or four (very rarely five) element(s) or the independent signs with (sometimes totally different) meanings. Signs may be as following A=a; A=a+b, A=a+b+c, etc.;
- For our description one-handed and two-handed signs can be described in the same way. But it is worth mentioning that there can be a significant difference between the sign producers and their moving/sign producing kinetics.

4 Method Used

We use the average correlation comparison – Pearson's Correlation method.

$$r = \frac{\sum d_x d_y - \frac{(\sum d_x)\times(\sum d_y)}{N}}{\sqrt{\sum d_x^2 - \frac{(\sum d_x)^2}{N}} \times \sqrt{\sum d_y^2 - \frac{(\sum d_y)^2}{N}}}$$

where,

d_x = Deviation of X series from assumed mean

d_y = Deviation of Y series from assumed mean

$\sum d_x d_y$ = Sum of multiples of d_x and d_y

$\sum d_x^2$ = Sum of squares of d_x

$\sum d_y^2$ = Sum of squares of d_y

$\sum d_x$ = Sum of deviations of X series

$\sum d_y$ = Sum of deviations of Y series

N = Total numbers of observations

5 New Approach

The innovative solution is to build the corpora in 3D instead of 2D video filming with several cameras. Filmed signs also can be attached to the material in order to have a visual format. The corpora will be performed in 3D with Leap-Motion data. There are a number of very expensive devices to get hands movements data. Leap-Motion is cheap and easy to use with great development API and community support. We had also tested Microsoft's Kinect, although we found out that Leap-Motion was more suitable for our needs. For the final version of the core software there will be prepared a combination of the parameters for Leap-Motion and Myo able to convert any exact data coordinates into relative abstractly usable data. The so-called «bridge» will be written, in order to transmit the data from our soft to Avatar and/or text-to-speech engines. The existing solutions really do not work – still DHH have the communication problems worldwide. Our innovative (fast and cheap) corpora building program /concepts will be easy to adopt for any SL and the final product can solve the existing communication problem.

5.1 Final Product Expectation

Currently, we are in the process of building the mini corpora for GESL to test the elaborated software prototype. We should collect data according to the proper methodology structuring the information, analyzing and comparing the signs from different SL, creating the special API for integration to any other SL corpora and revealing and then testing the elaborated algorithms for the universal SL translator, developing the software and hardware design concepts for the final product. The final product will be Universal SL translator and the engine can work with any kind of SL data - including body language (as paralinguistic elements for pragmatic and/or neurocognitive linguistics). The software can be free via Google (http://www.gnu.org/licenses/licenses.en.html) and it will be possible to insert it in the different devices (mobiles, laptops, tablets, etc.) /or we can elaborate a new type of free access device for DHH - as they really do not need the sound-telephones.

5.2 Engine Elaboration Process

We set our targets to create whole system step by step:

1. Develop simple application which can create and detect custom SLK (Sign Language Kinetics);
2. Leap-Motion has prebuilt set of hand gestures already:

- Circle Gesture - A circular movement by a finger,
- Swipe Gesture - A straight line movement by the hand with fingers extended,
- Screen Tap Gesture - A forward tapping movement by a finger,
- Key Tap Gesture - A downward tapping movement by a finger,

3. Create application to detect sequence of the custom gestures;
4. Create a-la Linguistic Corpora, collect SLK data;
5. Create analyzer/translator which finds appropriate sign/gesture in the Corpora and gives its textual equivalent, or sends data to the special collector to keep unresolved SLK.

The very first step was complicated, because SL Kinetic (SLK) is slightly different and more complex then already known the so-called usual gestures. We came to the solution to describe and divide SLK (level) like as following:

1. Static (easy), it is a gesture when hands and fingers merely move;

2. Dynamic (medium), it is a gesture when hands move, but on a strictly defined trajectory, this trajectory is a constant;
3. Complex Dynamic (hard), it is gesture when hands or fingers repeat some movements and the number of repetitions may vary;
4. Compound (hard), this kind of gestures can contain several (already known) Static gestures and also repeated movements.

Leap-Motion gives JSON structured data with these main parameters (each of them hold full sets of data with x, y, z, coordinates, rotation angles, etc)
1. Frame, contains a set of hand and point able tracking data;
2. Hand, contains tracking data for the detected hand;
3. Point able, contains tracking data for the detected finger or tool;
4. Gesture, represents a recognized gesture (already defined and known by Leap-Motion).

For future development, we choose JavaScript which can easily translate our code to any platform, use it on client-side or server-side environment. First and simple translator followed these steps:

- Record using JavaScript SLK in some array (this means to keep JSON data somewhere).
- Compare newly obtained JSON with the earlier (the existing) one.

It is clear that any SLK cannot be repeated with exact accuracy of moving hands, arms, fingers positions. Comparing any two SLK means to find approximation, relativity of the two data. Our first attempt was to solve this problem by comparing data on every Leap-Motion so called Frame (this data can vary from 25 up 120 frames per second). The method of comparison was simple: average values of tracking data were compared with one another and the changes were revealed.
/pseudocode/
avarage=(maxValueofGivenTrackData-minValueofGivenTrackData)/2

5.3 Static Sign Recognition

The above described method was good when dealing with Static gestures. It works with validation about 90%. The next step was to use the same method on dynamic SLK. It did work, but with much less validation. In this case (with dynamic signs) we needed to compare not only position values, but also detect arms, hands, fingers movement speed and velocity. For better operations we began to build GESL mini corpora basing on the Georgian Sign Language Dictionary by Professor Tamar Makharoblidze. The dictionary data was translated to the database. The web-based SLK recorder was created to save each word/SLK (in real SLK's raw JSON data). The four native speakers participated in this process. Collecting data from the several persons made possible to have more accurate data analysis and to learn average speakers' characteristics.

5.4 SLK and NS in Process

Meanwhile we started to translate sentences with several words. As expected, the most problematic task turned out to be finding the so-called separators between words in sentences. As explained above, we used NS as separators. The reason for such a methodical choice was the fact that NS characteristics are similar to SLK, only without lexical meaning. The experiments revealed that NS has slower movement than usual SLK.

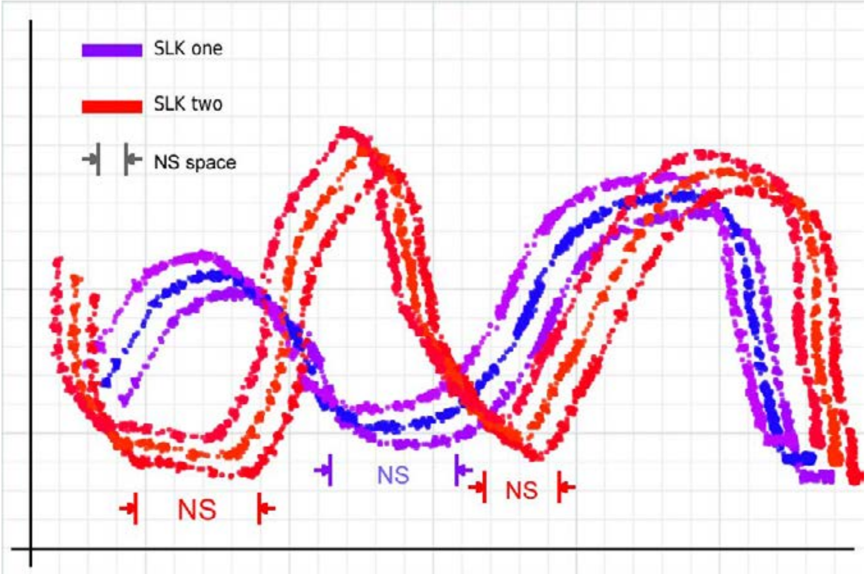


Figure 1: Conditional graphics of two SLK with NS.

In spite the fact that the main features for the NS were identified, in real life, in the process of signing it is very difficult to identify these NS and to understand the sentences correctly. We decided to divide a sentence into chunks with size that equals already recorded SLK unit maximum size (including T parameter - timing) in the GESL (incomplete) Corpora.

```
/pseudo code/
chunk=sentenceData/maxLength(slgData)
for each chunk in sentenceData
      comparison=compare(chunk to  slgData in Corpora)
            if (comparison<70%)  then
             noDataFound=TRUE
            go to next chunk
            else
            noDataFound=FALSE
            show sentence
if noDataFound then
decrease chunk size
use recursively
```

This method was successful for some cases, but others revealed the necessity of too many iterations in order to compare data to the all existing signs/words in GESL Corpora, especially when dividing them into smaller chunks and recursively trying to find related values. The next task is to reduce the data iterations and increase the guess probability.

5.5 Translation Process

The visual representation of the SL translation process:

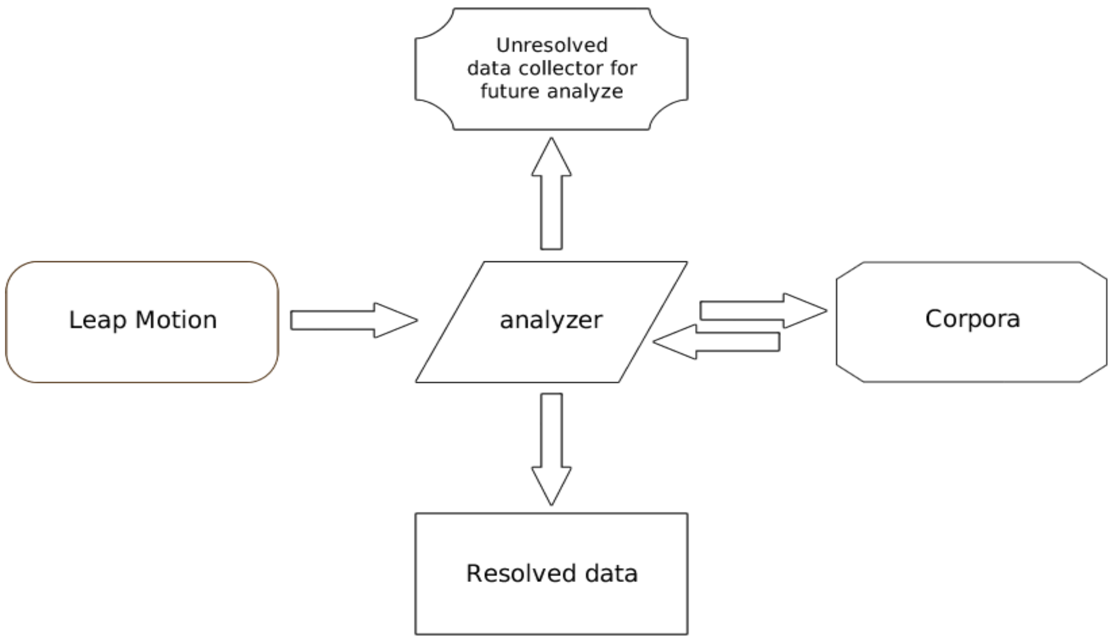


Figure 2: SL translation process.

In the corpora the documented materials will have all required parameters described above: contributors, sources, place/location, time, duration, formatting info and linguistic software descriptions through the tags. The GESL documented material and the final product will be GESL online archive / library and also some kind of easily accessible learning tools. In these terms the project is innovative and important with regard to both its content and its methods. Actually here we can display the general methods, which are: fieldwork with GESL sources / GESL native-speakers and the descriptive linguistic method, also computer programming, elaborating the software with a new type of engine.

5.6 Data Description

The database structure will be set up for future documenting GESL. In fact it will be the mini electronic linguistic corpora, where each linguistic element will be described. At the same time a Desktop Application will be created. The working format is PHP / MySQL. For data description we will use the following:

- Leap-Motion – Format JSON for describing the movement, positions, time intervals;
- Video - visualize, Full HD mp4 format;
- Text;
- Myo information about pauses - NS;
- Linguistic descriptions with the so-called tag-specific manner.

Technological process: The core software will be prepared, the program specifically for Leap-Motion will be scripted and it can convert any exact data coordinates into relative, and it will not be dependent on the private «standard» person, but it will be abstractly usable data (so that any person can be used to fill the corpora). At the same times, the so-called «bridge» will be written, in order to transmit the data form Leap-Motion to the so-called Avatar engines. From the outset, there will be compatibility. The reference system will be scripted to assist the corpora personnel in documenting the phrases, words or idioms. The software interface will be prepared.

5.7 Expected Engine User-System

The corpora information will be put in the form of a website, which will have the function of administrating. The authorized personnel in accordance with the authority granted by the administrator of the site, can add the information, change or delete the items, can add the tags. Any user will be able to see the text, video, audio and may use the following options:

A. Sorting in alphabetical order;
B. Sorting / separation: words, phrases, alphabet, idioms;
C. Divisions / Sort by tag-specific items according to the linguistic information;
D. Sorting video-types by duration;
E. Sorting / separation: the signs by hand positions and configuration;
F. Sorting / separation: by static and dynamic signs.

The last steps: Creation of special API for easy integration into other international corpora;
Testing of the elaborated mini-corpora in real time and inputting the information; starting filling the mini-corpora, structuring the information; Launching the website, disclosure of the elaborated material; Perform a real environment testing; Turning on the mobile analogue (the site will be optimized for mobile devices as well) and API application programming interface.

6 New Challenges

Meanwhile we are working on the alternative approach via artificial intelligence, or in other words, via artificial neural networks (ANN) – neuro-nets. ANN is a system of interconnected "neurons" which can exchange the information between one other. ANN models usually are simple mathematical models defining a function $f : X \rightarrow Y$ or a distribution over X or both X and Y, but sometimes models are also intimately associated with a particular learning algorithm or learning rule. In our case, we have to lay down the sign learning rules. We need to build a system where a sign will be a separate unit and machine-learning process will be the base component for sign recognition as usually signs are not absolutely same each time. The core soft will be something like handwriting recognition system.
After creating the so-called raw (primary) data and creating GESL mini-corpora - as it was described above, the next step in this direction will be the interpretation of the existing data and finding the methodology for functioning of the network. We would probably try to use a few versions in this case:

- Graphically using data and making the histograms;
- Projecting the data information and determine the matrix approach;

- Identifying the direct approach and comparing data.

Our method will take into consideration a single sign object as an abstract data, which may have some additional descriptive information, but during the machine learning it has no description of any parameters (graphical, audio or any other type) - although it is possible. In the row of signs during the signing the so-called “clustering” could be used, with the corrections implying the general characteristics for the signs in the corpora. The advantage of using this methodology is that it does not decode the signs to find the connections between them, or to find the similarities. The disadvantage is that it is very difficult to build the network with preferred form and with demanded finite data.

6.1 The Importance of the Product

With our product, local DHH (and not only) will be able to have better communication and it will provide the successful integration into the civil society improving the level of social, cultural and economic life for GESL native speaker DHH.

7 References

Aarons, Debra, Bahan Benjamin, Kegl Judy & Niedle Carol. 1991. Clausal Structure and a tier for grammatical marking in American Sign Language. *Nordic Journal of Linguistics*. 15. 103-142.

Bahan, Benjamin. 1996. *Non-manual realization of agreement in American Sign Language*. PHD dissertation. Boston University.

Baker-Shenk, Charlotte & Cokely, Dennis. 1991. *American Sign Language. A Teacher's Resource Text of Grammar and Culture.* Clerc Books. Gallaudet University Press. Washington D.C.

Brentari, Diane. 2010. *Sign Languages*. Cambridge University Press, Cambridge.

Emmorey, Karen & Reilly, Judy. 1995. *Language, Gesture, and Space.* Ed. Lawrence Erlbaum Associates: Hillsdale, NJ.

Fischer Susan and Gough Bonnie. 1978. Verbs in American Sign Language. *Sign Language Studies.* 7(18) 17-48.

Janis, Wynne. 1995. A Crosslinguistic Perspective on ASL Verb Agreement. In the book edited by Emmorey, K. & Reilly, J. *Language, Gesture, and Space.* Lawrence Erlbaum Associates. Hillsdale, New Jersy, Hove, UK 195-224.

Kendon, Adam. 1994. *"Human Gestures"* In: K.R. Gibson and T. Ingold (ed.) *Tools, Language and Cognition in Human Evolution*. Cambridge: Cambridge University Press. pp. 43-63.

Lavie, A., Waibel, A., Levin, L., Finke, M., Gates, D., Gavalda, M., Zeppenfeld, T., & Zhan, P. (1997). JANUS III: Speech-To-Speech Translation In Multiple Languages. IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP-97), Munich, Germany, 1, 99–102.

Liddell, Scott. 2003. *Grammar Gesture and Meaning in American Sign Language*. Cambridge: Cambridge University Press.

Lillo-Martin, Diane. Two kinds of null arguments in American Sign Language. Natural Language*and* Linguistic Theory 4. 1986. 415-44.

Makharoblidze, T. (2012) *Georgian Sign Language*. Ministry of Education and Science of Georgia. USAID, Save the Children International. Tbilisi (in Georgian).

Makharoblidze, T. (2012) *Georgian Sign Language*. Training Manual. Level 3, Trainer's Guide.

Ministry of Education and Science of Georgia. USAID, Save the Children International. Tbilisi (in Georgian).

Makharoblidze, T. (2012) *Georgian Sign Language*. Training Manual. Level 3, Training Participants Notebook. Ministry of Education and Science of Georgia. USAID, Save the Children International. Tbilisi (in Georgian).

Makharoblidze, T. (2015) *Georgian Sign Language Dictionary*. Ilia State University, Shota Rustaveli National Science Foundation. Tbilisi. ISBN 978-9941-16-225-5 1368 p. (in Georgian).

Makharoblidze, T. (2015) *Georgian Sign Language Election Dictionary*. Ilia State University, the US Embassy. Tbilisi. ISBN 978-9941-18-224-2; 291 p. (in Georgian).

Makharoblidze, T., Batatunashvili, A. (2014) *Children's Dictionary of Georgian Sign Language*. Union of the Deaf of Georgia, Bank of Georgia. Tbilisi. Online version (in Georgian). www.geodeaf.ge http://www.gnu.org/licenses/licenses.en.html

Meier Richard. P. 1990. Person diexis in American Sign Language. In S. Fischer & P. Siple (eds.), *Theoretical Issues in Sign Language Research.* Vol. 1. Linguistics University of Chicago Press. Chicago, IL. 175-190.

Nuance Communications, Inc. (2012). Dragon Speech Recognition Software. Retrieved from http://www.nuance.com/dragon/index.htm

Padden, Carol. 1983. *Interaction of morphology and syntax in American Sign Language*. PHD dissertation. University of California, San Diego.

Pamela Perniss, Steinbach, Mark & Pfau Ronald. 2007. Grammaticalization of auxiliaries in sign languages. In: Pamela Perniss, Ronald Pfau & Markus Steinbach (eds.), *Visible variation: Comparative studies on sign language structure*. Berlin: Mouton de Gruyter, 303-339.

Perniss, Pamela. 2007. *Space and Iconicity in German Sign Language (DGS).* PHD dissertation. MPI Series in Psycholinguistics 45, Radboud University Nijmegen.

Pfau, Ronald, Steinbach, Markus & Woll, Bencie (eds.) 2012. *Sign language. An international handbook* (*HSK - Handbooks of linguistics and communication science*). Berlin: Mouton de Gruyter.

Sandler, Wendy & Lillo-Martin, Diane. 2006. *Sign language and linguistic universals*. Cambridge: Cambridge University Press.

Sapountzaki, Galini. Agreement Auxiliaries In: R. Pfau et al. (eds.), Sign Language. An international Handbook. 2012. 204-227.

Thompson Robin, Emmorey Karen & Kluender Robert. 2006. The relationship between eye gaze and verb agreement in American Sign Language: An eye tracking study. *Natural language and Linguistic theory.* 24. 571-604.