Open-ended Resources in Greek Sign Language: Development of an e-Learning Platform

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Abstract

In this paper we present the creation of dynamic linguistic resources of Greek Sign Language (GSL). The resources will feed the development of an educational multitask platform within the SYNENNOESE project for the teaching of and in GSL. The platform combines avatar and animation technologies for the production of sign sequences/streams, exploiting digital linguistic resources of both lexicon and grammar of GSL. In SYNENNOESE, the input is written Greek text, which is then transformed into GSL and appears animated on screen. A syntactic parser decodes the structural patterns of written Greek and matches them into equivalent patterns in GSL, which are then signed by a virtual human. The adopted notation system for the lexical database is HamNoSys (Hamburg Notation System). For the implementation of the digital signer tool, the signer's synthetic movement follows MPEG-4 standard and frame H-Anim with the use of VRML language.

1. Introduction

Primary target user group are the deaf pupils who need teaching tools and educational material for the GSL grammar class. Till very recently educational material was available to students with hearing impairments only in written Greek form. Formal teaching of GSL as a first language from the very early school years, and relevant development of educational content is becoming very urgent since law 2817/2000 was put into action by the Hellenic State. This law defines that «the official school language of deaf and hard hearing students is the Greek Sign Language» and that «knowledge of the Greek Sign Language is a prerequisite for the positioning of tutors and special education staff at the schools that host deaf and hard hearing students». In this context the new education programs of the Pedagogical Institute[1] (in print) require that all educational material, which will be produced from now on, must be accessible to the deaf students through the use of the Greek Sign Language.

In consultancy with the Pedagogical Institute, SYNENNOESE helps pupils acquire the proper linguistic background so that they can take full advantage of the new accessible educational material. The platform offers students the possibility of systematic and structured learning of GSL for either self-tutoring or participation to virtual classroom sessions of asynchronous teaching, and its design is compatible with the principles that generally define systems of open and distant learning. Besides teaching GSL as a first language, in its present form the platform can be used for the learning of written Greek through GSL, and it will also be open to future applications in areas of other subjects in the school curriculum.

2. Greek Sign Language – the background

Greek Sign Language (GSL) is a natural visual language used by the members of the Greek Deaf Community with several thousands of native or non-native signers. Research on the grammar of GSL per se is limited; some work has been done on individual aspects of its syntax (negation (Antzakas & Woll, 2001), morphology (Lampropoulou, 1992)), as well as on applied and educational linguistics. It is assumed that GSL as we now know it is a combination of the older type of Greek sign language dialects with French sign language influence (Lampropoulou, 1997). Comparison of core vocabulary lists exhibit many similarities with sign languages of neighboring countries, while in morphosyntax GSL shares the same cross-linguistic tendencies as many other well analysed sign languages (Bellugi & Fischer, 1972 ; Liddell, 1980).

GSL has developed in a social and linguistic context similar to most other sign languages (Kyle & Woll, 1985 ; Brennan, 1987). It is used widely in the Greek deaf community and the estimation for GSL users is about 40,600 (1986 syrvey of Gallaudet Univ.). There is also a large number of hearing non-native signers of GSL, mainly students of GSL and families of deaf people. Although the exact number of hearing students of GSL in Greece is unknown, records of the Greek Federation of the Deaf (GFD) show that, in the year 2003 about 300 people were registered for classes of GSL as a second language. The recent increase of mainstreamed deaf students in education, as well as the population of deaf students scattered in other institutions, minor town units for the deaf and private tuition may well double the total number of secondary and potential sign language users. Official settings where GSL is being used include 11 Deaf

[1] Pedagogical Institute (PI) is the official organisation that validates all educational programs of primary and secondary education in Greece.

clubs in Greek urban centers and a total of 14 Deaf primary, secondary and tertiary educational settings.

3. Linguistic research background in the area of sign languages

In Greece there have been some serious attempts of lexicography in the recent past (PROKLESE, a Dictionary of Computing Signs, NOEMA: a Multimedia Dictionary of GSL Basic Vocabulary and A Children's Dictionary of GSL) mainly for educational purposes (Kourbetis, 1999 ; Kourbetis & Efthimiou, 2003), but complete decoding of the language structure is not yet publicly available.

The linguistic part of the project is based on overall assumptions for the adequacy of signed languages as by Stokoe (1960, 1978), Woll & Kyle (1985), Valli & Lucas (1995), Sutton-Spence & Woll (1999), Neidle et al. (2000), Gee & Goodhart, (1985) among many. Greek sign language is analyzed to its linear and non-linear (simultaneous) components (Padden, 1989 ; Engberg – Pedersen, 1993). The linear part of the language involves any sequences of lexical and functional tokens and their syntactic relations, while non-linear structures in GSL, as in all known sign languages, are present in all levels of the grammar. Each sign in GSL is described as to its handshape, location, movement, orientation, number of hands and use of any obligatory non-manually articulated elements (referred to as nmf, i.e. mouth patterns, head and shoulder movements and other non-manual features), based on the Stokoe model (ibid).

In the project it was considered essential that the output is as close to native GSL as used in the Greek deaf community. In this respect, forms of 'signed Greek' or other manual codes for the teaching of Greek were excluded and the two languages (GSL and Greek) were treated as the first and second language respectively for the users of the platform, quite as other bilingual platforms may function outside the domain of special education.

4. The project's language resources

Implementation of both the tutoring and the summarization tools of the platform require collection of extensive electronic language resources for GSL as regards the lexicon and the structural rules of the language (Efthimiou et al., 2004). The actual data of the study are based on basic research on GSL analysis undertaken since 1999 as well as on experience gained by projects NOEMA and PROKLISI (Efthimiou & Katsoyannou, 2001 ; Efthimiou & Katsoyannou, 2002). The data consist of digitized language productions of deaf native GSL signers and of the existing databases of bilingual GSL dictionaries, triangulated with the participation of deaf GSL signers in focus group discussions. The project follows methodological principles on data collection and analysis suitable to the minority status of GSL. Wherever the status of individual GSL signs is in consideration, the Greek Federation of the Deaf is advised upon, too.

Many of the grammar rules of GSL are derived from the analysis of a digital corpus that has been created by videotaping native signers in a discussion situation or when performing a narration. This procedure is required because there exists little previous analysis of GSL as a natural language. The basic design of the system, except for the educational content this currently supports, focuses on the ability to generate sign phrases, which respect the GSL grammar rules in a degree of accuracy that allows them to be recognised by native signers as correct utterances of the language.

In this respect SYNENNOESE offers a great challenge for in-depth work on both directions, lexicography and linguistic analysis of GSL; for the first time research will go beyond a mere collection of glosses (Logiadis & Logiadis, 1985) and move further from many previous bilingual dictionaries of sign languages (Brien & Brennan, 1992)), into the domain of productive lexicon (Wilcox et al., 1994), i.e. the possibility of building new GSL glosses following known structural rules, and also challenge automatic translation in predictable environments, using an effective module/interface for the matching of structural patterns between the written input and the signed output of the platform. It is a design prerequisite that the system of GSL description should have an open design, so that it may be easily extendible allowing additions of lemmas and more complicate rules, with the long term objective to create an environment for storage and maintenance of a complete computational grammar of GSL. From a linguistic point of view the resulting database of glosses, rules and tendencies of GSL will be a significant by-product of the project, of great value to future applications.

4.1 Grammar content definition

In the early implementation phase, the subsystem for the teaching of GSL grammar covers a restricted vocabulary and a core grammar capable of analysing a restricted number of main GSL grammatical phenomena, which might be argued that belong to signing universals:

The objective of the 18-month project is to transcribe the digitized avi files with GSL individual signs and store them in a retrievable database. This requires the analysis of the GSL signs into their phonological parts and their semantics. It was agreed that only monomorphemic signs that use only one handshape are analyzed in this early stage, so that feedback from the technical team will determine further steps (Johnston & Schembri, 1999). Non-manual grammatical features (Boyes Braem & Sutton-Spence, 2001) and polymorphemic signs are acknowledged but not included in this stage. In the second stage longer sequential structures of signs will be considered (e.g. compound word-signs) and once individual signs are transcribed and stored in a database, additional tiers such as non-manual features can be added without technical difficulties.

At the stage of grammatical analysis international findings on sign language grammars, as well as the views of our deaf native user consultants are taken into account in order to verify findings. It is admitted that there is even more work to be done on the pragmatics of GSL and its relation with real-world situations (e.g. for the use of indexes or classifiers), and these are noted as future aims of the platform.

An interesting parameter of a virtual signer is the ability to sign letters of the written alphabet (fingerspelling). This technique is useful in cases of proper nouns, acronyms, terminology or general terms for which no specific sign exists. Fingerspelling is used extensively in some other sign languages such as ASL or BSL (Sutton-Spence 1994), while our evidence in GSL suggests that it is only

used occasionally, rarely incorporating fingerspelled loans into the core of the language. From a technical point of view, however, generally it is quite simple for an avatar to fingerspell as fingerspelling includes no syntax, movement in signing space or non-manual grammatical elements. Many previous attempts of sign animation would go up to the level of fingerspelling or signing only sequential structures of a representation of the written or spoken language. Since then technology has developed and so has linguistic description of sign language structures.On the other hand few deaf people in Greece use fingerspelling or a code such as 'Signed Exact Greek' extensively. For these reasons the present project aims to represent a form of GSL as close to natural fluent signing as possible, and only uses fingerspelling occasionally, for example in language games, where teaching of written Greek is the focus.

4.2 Notation and glossing

In order to decide on the notation to be followed for sign recording in the lexical resources DB, the existing international systems of sign language recording were evaluated in respect to effectiveness as to determination of the intermediate language of the system (see also Pizzuto & Pietrandrea (2000), for a more theoretical discussion). The latter consists an important part of the whole engine as it serves for the communication between the linguistic subsystem that determines the meaningful movements in the context of GSL and the technological subsystem that performs these movements with a synthetic 3D model signer.

Tools for transcription and notation of GSL include HamNoSys, a pictographic notation system developed by the University of Hamburg for the description of the phonology of signs (Prillwitz et al., 1989). HML files in HamNoSys will form the corpus of GSL lemmas while for the representation of sequential structures (i.e. in the phrase level) ELAN language annotator developed by the Max-Planck Institute of Psycholinguistics in Nijmegen, the Netherlands, will be used. We considered these two systems as most suitable to the text-to-sign animation according to reviews of recent relevant projects. The classic Stokoe model is used for the morpho-phonological description, with one additional tier with written Greek words of harsh semantic equivalents of utterances. It is an aim of the project to add more tiers as the project continues, such as those mentioned above on the use of non-manual features and on pragmatics, using the esxisting symbols in HamNoSys and ELAN. Signwriting was another transcribing tool under consideration, but was not chosen, given the expected compatibility of HamNoSys within the Elan tiers in the near future.

5. Tutoring system description - corpus of educational material

The user interface under development is based on technologies (experience gained in previous SPERO and Faethon projects) which enable tracing the personal characteristics of specific users, on the basis of combination of personal data and his/her responses, previously acquired knowledge and user classification, so that the teaching process may be best customised. The test bed learning procedure concerns teaching of GSL grammar to early primary school pupils, whereas the platform also incorporates a subsystem that allows approach by the deaf learner to material available only in written Greek form by means of a signed summary. The learning process in practice will involve an initiator of the session, the student-s in groups or alone and a teacher-facilitator of the process, physically present with the students. The process can take place in real-time or can be relayed. There is provision of a whiteboard, icon banks and chat board visible in the screen along with the virtual signer for common use in the classroom. The participants will also be able to see each other in real time through a web camera, in order to verify results of GSL learning.

Specifications for the formation of GSL resources of the application are crucially based on exhaustive research in the official, recently reformed, guidelines for the teaching of Greek language and of GSL in primary schools for the deaf (Kourbetis & Efthimiou, 2003). The educational content of the platform follows the same guidelines as the hearing children's curriculum, so that the same grammatical and semantic units can be taught in the two languages, GSL and spoken / written Greek. Concepts such as subject-object relations, types of verbs, discourse functions of the language form the units of the curriculum in SYNENNOESE so that the same principles are taught under the same umbrella, but without projecting onto GSL a mirror image of the Greek grammar. For the selection and arrangement of the educational material the project is in close cooperation with the Pedagogical Institute in Athens, which is the main official agency in charge of the development of educational material.

According to EU principles for accessibility to information in special education (see also WP COM (2000) 284 final), all Greek schools have been provided with suitable equipment for unrestricted Internet access, so the deliverables of the project can be readily applicable to real life school routine. Unfortunately, though, there have been no official educational resources for primary education of the deaf in the area of languages, until the time of writing of the current work. SYNENNOESE is the first applicable project for open and distance learning for the deaf, either individually or in group sessions. After month 12 of the beginning of the project there will be a trial period in sample student and tutor groups with the aid of the Pedagogical Institute for feedback and corrections.

6. Technical considerations

The implementation team has reviewed currently available avatar and animation technologies for the representation of sign language in order to adopt one of the most prominent technological solutions. The movements of a synthetic 3D signing model have to be recorded in a higher and friendly level of description, before they are transformed in parameters of body movement (Body Animation Parameters –BAPs) according to the MPEG-4 model. In the area of text-to-sign animation there have been some similar projects (VISICAST, Thetos, SignSynth and eSIGN among them) that SYNENNOESE uses as background.

Technologies considered for the viewing and interaction of 3D models wereVRML (Virtual Reality Modeling Language), X3D (eXtensible 3D) and H-ANIM. VRML (Virtual Reality Modelling Language) is a high level formal language with the ability to describe 3D interactive

objects and worlds. It is a hierarchical scene description language that defines the geometry and behaviour of a 3D scene or "world" and the way in which this is navigated by the user. VRML is the only standardised (ISO/IEC 14772) 3D format suitable for Web delivery.
X3D is the next-generation open standard for 3D on the web. It is an extensible standard that can easily be supported by content creation tools, proprietary browsers, and other 3D applications, both for importing and exporting. It replaces VRML, but also provides compatibility with existing VRML content and browsers.
H-ANIM is a set of specifications for description of human animation, based on body segments and connections. According to the H-ANIM standard, the human body consists of a number of segments (such as the forearm, hand and foot), which are connected to each other by joints (such as the elbow, wrist and ankle). H-ANIM can be used to describe the gestures. Motion tracking and haptic devices (such as CyberGrasp or Acceleration Sensing Glove with a virtual keyboard) were initially considered but it was agreed that, if quality of the results of the first transcribed signs with application of HamNoSys notation commands is acceptable, motion capture sequences will not need to be applied. In either case, both are much more flexible solutions than using 'frozen' mpeg or avi video files. Avatars are much more accessible to flexible information exchange and take advantage of the dynamic nature of phonological and syntactic rules.

7. Adopted 3D technologies

For the content designer to interact with an avatar, a scripting language is required. In our implementation, we chose the STEP language (Scripting Technology for Embodied Persona) (Huang, Eliens & Visser (2002)). as the intermediate level between the end user and the virtual actor. A major advantage of languages such as STEP is that one can separate the description of the individual gestures and signs from the definition of the geometry and hierarchy of the avatar; as a result, one may alter the definition of any action, without the need to re-model the virtual actor. The avatars that are utilized here, are compliant with the H-ANIM standard, so one can use any of the readily available or model a new one.

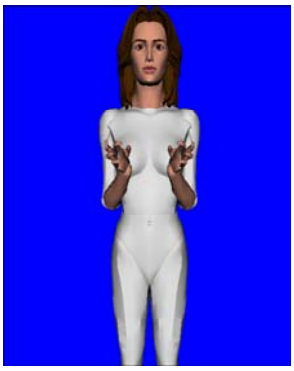

Figure 1: The virtual signer signing "radio" in GSL

An integrated system based on STEP is usually deployed in a usual HTML page, in order to maximize interoperability and be accessible to as many users as possible. This page includes an embedded VRML object, which represents the avatar and includes references to the STEP engine and the related JavaScript interface. From this setup, one may choose to create one's own script, for sign representation, and execute them independently, or embed them as JavaScript code, for maximized extensibility. The common VRML viewing plug-ins offer the possibility to select the required viewpoint at run-time, so it is possible for the user to experience the signing from any desired point of view (Kennaway, 2001 ; Kennaway, 2003 ; Huang, Eliens, & Visser, 2002). As an example, a frame of the signing sequence for "radio" is presented in figure 1.
In SYNENNOESE, a syntactic parser decodes the structural patterns of written Greek and matches them into the equivalents in GSL (Boutsis et al., 2000), and these resulting patterns are signed by a virtual human (avatar).
Using the technologies above, an internet platform will make access easy and fast, while the use of animated models instead of video files saves valuable storage space and bandwidth. Other advantages are the possibility of preview of predefined movements of the humanoid and the possibility of adding new movements and handshapes onto the system at any moment (script authoring). The advantages of an H-ANIM model (used version is v. 1.1) are its compatibility with VRML 97, flexibility on all segments and a more straightforward use.
The chart below (Figure 2) shows how the system functions and how data is transferred between machine and users. The testbed includes a page with and embedded VRML97 object, a JavaScript form for communication with the user and a Java Applet for communication with the back-end system. As can be seen in the chart, the system does not involve recognition of speech or signs. Machine translation mechanisms are at the background while at the present the output is a medium for human to non-human communication, rather than a machine for automatic translation.

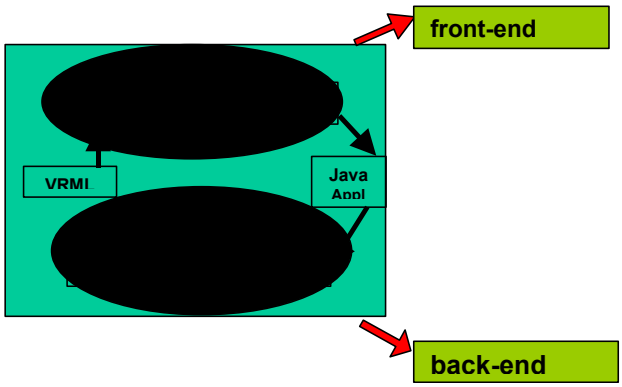

Figure 2. Data flow chart

8. Implications and extensibility of the educational platform

- As an educational tool above all, SYNENNOESE offers a user-friendly environment for young deaf pupils aged 6 to 9 so they can have visual translation of words and phrases. The signed feedback acts as a motivating tool for spelling Greek words and structuring sentences correctly, as well for evaluating one's performance. For deaf young

students as a group with special needs, the platforms draws some of the accessibility barriers, and the possibility of home use even makes it accessible to family, thus encouraging communication in GSL, but also access to the majority (Greek) language.

- New written texts can be launched, so SYNENNOESE may receive unlimited educational content besides primary school grammar units. On the other hand, unlimited school units, such as the increasing special units with individual deaf students in rural areas and islands can link with one another via SYNENNOESE.
- Text-to-sign translation can be extended and applied to different environments such as Greek language teaching to deaf students of higher grades, GSL teaching for hearing students, Greek for specific purposes such as to adult literacy classes for the Deaf etc.
- More domains of GSL grammar can be described and decoded, making the output closer to natural signed utterances as our analysis proceeds. This is a challenge not only for theoretical research, but also for computer science and applied linguistic research.
- Furthermore, a database with the bulk of GSL utterances, described as to their features from the phonological up to the pragmatic level will be the major outcome of the whole project. In this way the representation of GSL structures can be matched to equivalents ones of written Greek, and it will be a challenge to be able to compare directly the grammars of the two languages. In much the same way structures of GSL will easily be compared with counterparts from ASL or BSL for research across signed languages.
- From a socio-economic point of view, creating this platform will greatly contribute towards the inclusion of deaf people in Greek society in an environment of equal opportunities.

9. Problems and limitations

The main limitations of the study are described below. These are divided into linguistic, educational and technical ones. Most of the limitations are typical to sign animation projects, and they were expected before the beginning of the project.

From a linguistic and educational point of view, the major issues that need to be addressed are the following:

- In some areas of the language there are no standardized signs, so there may be some theoretical objections as to the use of particular entries. However, a platform such as the one described allows for multiple translations and does not have any limitations as to the size of files, which was the case, for example in previous GSL dictionaries in DVD form with avi video entries. Moreover, the platform will be open to updates through the script authoring process.
- A second problem is the choice of entries to be included in each stage of the platform development depending on the complexity of their phonological characteristics. As mentioned already in the section above on grammar content definition, monomorphemic entries were agreed to be included in the first stage. In the next stages there will be gradual provision for polymorphemic signs, compound signs, functional morphemes, syntactic use of non-manual elements, sequential and lastly simultaneous constructions of separate lexical signs, each stage to correspond with the level of linguistic research in GSL.
- The data available in GSL, when compared with data from Greek, for example, are dauntingly scarce. Error correction mechanisms were sought after in order to assure reliability of results. Such back-up mechanisms are the use of approved dictionaries, the consultancy of Pedagogical Institute and the feedback from the Deaf Community, along with the continuing data from GSL linguistic research.
- Lastly, all schools in Greece have recently become accessible to the Internet, Deaf settings included. In practice however, there are many more accessibility barriers for a considerable number of deaf students who have additional special needs. Relevant provisions have been made according to general accessibility principles for these students (as to text size, keyboard settings etc) but the pilot application of the platform in December 2004 after 12 months of the beginning of the project will certainly indicate more points for development.

Technical problems include:

- A solution for smooth transition between signs and fusion between handshapes so that neighboring signs in a sentence appear as naturally articulated as possible.
- Automated commands for grammatical use of eye gaze, particularly when eye gaze has to follow the track of hand movements. Similar problems are anticipated on mouth movements on prosodic features of sign phonology. Mouthing the visible part of spoken Greek words will not be an issue for the project yet, but this, too is anticipated as a problem to deal with in the future, as all of the above non manually signed features are considered as internalized parts of GSL grammar.
- It would be ideal to have a readily available system for retrieving and automatically extend phonological rules via HamNoSys notation. To the best of our knowledge such provisions are being made and the problem will meet a solution soon.
- The ultimate challenge, as in all similar projects, remains the automatic translation of the language. It is still too difficult to produce acceptable sentences in the automatic translation of any language at the moment, even more so a minor, less researched language with no written tradition such as GSL. Realistically the teams involved in the SYNENNOESE project can expect as an optimum result the successful use of automatic translation mechanisms in GSL only in

a restricted, sub-language oriented environment with predetermined semantic and syntactic characteristics.

10. Conclusion

Given that the platform under discussion consists an original research object, successful completion of its development will open the way to a complete support system for the education of the Deaf Community members in Greece.

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