Using Timing Information to Improve the Performance of Avatars

Thomas Hanke, Silke Matthes, Anja Regen, Jakob Storz, Satu Worseck
University of Hamburg
{thomas.hanke,silke.matthes,anja.regen,jakob.storz, satu.worseck}@sign-lang.uni-hamburg.de

Ralph Elliott, John Glauert, Richard Kennaway
University of East Anglia
{R.Elliott,J.Glauert,R.Kennaway}@uea.ac.uk

ABSTRACT
We present a small-scale study that provides detailed timing information for individual sign parameters in natural signing with a time resolution of 1/50 of a second as well as the method and tools used to collect these data. The avatar system was improved to be able to play back signing annotated in a combination of symbolic movement description and precise timing information. We report on microtesting conducted to verify the impact of these changes on subjective quality ratings of Deaf signers.

Categories and Subject Descriptors
I.2.7 [**Artificial Intelligence**]: Natural Language Processing – *language generation*; I.6.2 [**Simulation and Modeling**]: Simulation Languages – *miscellaneous*; K.4.2 [**Computers and Society**]: Social Issues – *assistive technologies for persons with disabilities*.

General Terms
Experimentation, Human Factors, Languages, Performance, Verification.

Keywords
German Sign Language, Corpus Annotation, Animation, Accessibility Technology for People who are Deaf.

1. INTRODUCTION
In recent years, much work has been done to improve the performance of avatars used to generate continuous signing from notation. However, while much effort has been spent on the manual performance of the signing avatars, especially on hand configurations, comparatively little attention has been paid to rhythm in signing. Sign language produced by an avatar driven from symbolic description of sign sequences is often reported as unnatural or boring, or difficult to segment, and our belief is that improvements on the avatar's signing rhythm would mean a significant step in making avatar movements look more natural and be easier to interpret.

SLTAT 2011, 23 October 2011, Dundee, UK.

Obviously, there are different issues involved in the dynamics of signing:

- Movement speed contours of the articulators moving in space within and in-between signs
- Timing of the different articulators involved

While the first issue is addressed by recent research using motion capture data [1, 2], e.g. suggesting that different accelerations help the observer to tell apart inter-sign transitions from intra-sign transitions, and is subject to empirical animation research [6], the second issue is well known in the literature [7, 8], but supporting data sets have not been available so far.

According to Johnson/Liddell [7], signs show a sequentially organised sublexical structure consisting of postural and transitional segments. During a transition changes may occur in several parameters, however these changes do not necessarily coincide and parameters are not all in place at exactly the same time. While the model for phonetic transcription proposed by Johnson/Liddell leaves aside the exact timing of the individual parameters, the approach does allow for detailed specification of timing information for the different parameters.
Within the Dicta-Sign project the avatars' performance is generated automatically by using SiGML, a mark-up language derived from HamNoSys notation. HamNoSys [3] provides detailed information on the hand configuration and other parameters as well as information about different kinds of movements within a sign. While the HamNoSys notation does reflect both simultaneity and sequentiality in signs, it does not specify exact timing information regarding changes in each of the individual parameters. For generating signs based on HamNoSys notation these movements are therefore processed as simultaneous changes in all parameters. The same holds for transitions between signs where the changeover from the last posture of the preceding sign to the first posture of the subsequent sign is generated automatically.

In the framework of the small-scale study presented here, we annotated natural sign language data from the currently compiled Dicta-Sign corpus. The video data was annotated combining the two models, i.e. the explicit modelling for movements provided by HamNoSys notation with features to specify timing information as described by Johnson/Liddell.
For the real time transformation of HamNoSys notation into motion data for our avatar a component of our system called Animgen [9, 10] is used. Animgen uses its knowledge of the geometry of the target avatar to calculate the position and orientation of both hands as well as the finger joint angles necessary to produce the specified hand shapes at the beginning and end of every movement segment. Ordinarily these three properties are animated synchronously, however we have now

extended the animation method to allow Animgen to animate the change in handshape or orientation to lead or lag the change in position. This allows us to modify the SiGML data according to the exact timing of the individual parameters found in our data.
Microtesting with six Deaf informants was conducted on a small data set in order to verify the impact the modifications in per-parameter timing have on the avatar performance and how much this actually improves subjective quality ratings.

2. BACKGROUND

In his early approach to analyse signing discourse, Jouison [8] describes signs as consisting of minimal units whose accumulation in time leads to the construction of static or dynamic images. Static images are (in the example given) built up from a "choice of the fingers" and the arms, followed by their "positioning". Dynamic images emerge where a movement is added. Jouison points out that the accumulation process follows a precise order that may not be inverted.[1]

According to Johnson/Liddell [7] signs may not only be analysed as consisting of simultaneously occurring parameters but can also be divided into sequences of segments. They argue that signs show a sequentially organised sublexical structure consisting of alternating static and transitional phases. For their analysis Johnson/Liddell distinguish three manual components – hand configuration (HC), placement (PL), and facing (FA) – as well as nonmanual components (NM). For each of these components phases of configuration change or persistence can be observed, often indicated by the clarity or fuzziness of the picture in a sign language video. Changes may occur in several parameters at a time, however these changes do not necessarily coincide and parameters are not all in place at exactly the same time. In their example of the sign CHICAGO, the initial HC remains during the whole sign (i.e. excluding inter sign transitions), whereas three occurrences of PL can be observed, the first two of them being established where a change of movement direction occurs and only lasts for one frame each. The FA of the hand remains for several frames and changes only once during the sign (described as a change of wrist position from hyperextended to flexed). The NM component specified here refers to mouth behaviour which changes twice throughout the sign.
The detailed segmentation for each of the individual components reveals the varying timing of changes happening during a sign: the components are neither established all at the same time nor do they change simultaneously. In both the signs CHICAGO and VANISH the PL is established latest. In CHICAGO all parameters are released simultaneously (if changing at all), while for VANISH (comprising a ballistic movement) the HC changes significantly later than PL and FA. *"This probably reflects the difficulty of controlling multiple movements of the body simultaneously and demonstrates that producing a sign involves a complex coordination of multiple and possibly competing articulatory complexes as they move through time and space."* [7], pp. 415-416.
With their goal of establishing a phonetic description of sign language Johnson/Liddell aim at identifying sequentially organised segments of a sign that may be described using a finite set of descriptive features. Therefore they leave aside the specific timing of the individual parameters but concentrate on two distinct types of phonetic segments: postural and trans-forming gestures. A postural gesture refers to those moments where the componential states of all the parameters are stable and momentarily aligned (which may even last for only one frame).[2] The picture of the hand is stated to be clearer than during the rest of the sign, which might be due to a slow down of the hand's movements. Any part of the sign where at least one of the parameters is changing is called a trans-forming gesture.[3]

The Hamburg Notation System for Sign Languages (HamNoSys) [3] is an alphabetic system that allows for description of signs on a very detailed, mostly phonetic level. Parameters that are specified are handshape, hand orientation, location, actions and nonmanual features. A symmetry operator may be added for symmetric two-handed signs.
For the notation of a sign an initial posture is assumed which is described by specifying the parameters handshape, hand orientation (divided into extended finger direction and palm orientation) and location. This may then be complemented by a description of simultaneously or sequentially performed actions that change this initial posture. Manual actions are in-place movements, where a change in handshape and/or orientation takes place, or path movements that result in a change of position of the hand. Path movements may be targeted (i.e. the end configuration is specified) or relative (i.e. the end location is determined by the direction and size of the movement).
While the HamNoSys notation does reflect sequentiality of configurations within a sign, it does not specify exact timing information regarding changes in each of the individual parameters. For generating signs based on HamNoSys notation these movements therefore have been processed hitherto as simultaneous changes in all parameters. The same holds for transitions between signs where the changeover from the last posture of the preceding sign to the first posture of the subsequent sign is generated automatically. With the aim of improving the avatar performance detailed timing information was collected following the Johnson/Liddell approach described above.

3. AVATAR ANIMATION

The component of our system that transforms HamNoSys notation into motion data for a specific avatar in real time is called Animgen [9, 10]. Animgen in fact reads a more detailed notation called SiGML (Signing Gesture Markup Language), which HamNoSys is first translated into. All of HamNoSys can be translated into SiGML, but SiGML can also express some more detailed aspects of movement that go beyond the capabilities of HamNoSys.
Animgen uses its knowledge of the geometry of the target avatar to calculate the position and orientation of both hands, and the finger joint angles necessary to produce the specified hand shapes, at the beginning and end of every movement segment. The movement is then animated by interpolating hand position, shape, and orientation between the beginning and end. Ordinarily these three properties are animated synchronously, i.e. when, say, 30% of the change in position of the hands has happened, so has 30% of the changes in both orientation and shape. The mapping of proportion of elapsed time to proportion of hand movement,

[1] "(...) to invert in time the choice of the fingers and orientation would result in making the first one a 'modification' of the form already oriented, therefore a movement (...)" [8], p. 341.

[2] While differences in timing can be observed e.g. for ballistic

[2] While differences in timing can be observed e.g. for ballistic and antagonistic movements these do not seem to be contrastive and are therefore not specified in the model [7].

[3] In a further step postural segments are divided into postures (P) and detentions (D) and trans-forming segments in trans-forms (T) and shifts (S), depending on their duration [7].

which we call the "manner", can be varied to produce natural accelerations, and to distinguish intentional from non-intentional movement segments. The rest of the arm and shoulder is positioned by inverse kinematics.

We have extended the animation method to allow Animgen to animate the change in orientation or shape to lead or lag the change in position by specifying a "lead" parameter for both properties. It uses this as a parameter to a warping function which maps the proportion of positional movement achieved to the proportion of orientation or shape change. For example, if 30% of the positional movement has happened, and the handshape is required to change in advance of hand position, then 80% of the shape change may have happened by that point. At the extremes, the "shape lead" parameter can be adjusted to produce the shape change instantly at the beginning of the movement, or delayed until the final instant, or provide any smoothly advanced or retarded trajectory in between, and similarly for the "orientation lead" parameter. The warping function that we currently implement is illustrated in the figure below (see Figure 1). p is the proportion of positional movement and f the proportion of shape or orientation change. f is calculated from p by the formula $f = p(1+k)/(1-k(1-2p))$, where k is the lead/lag parameter, varying from -1 (maximal lag) to $+1$ (maximal lead). This formula was chosen as an initial guess for subsequent experimental testing. p itself is a function of time designed to give realistic accelerations and decelerations, of the form p = manner(t,m), where t is the proportion of elapsed time (thus varying from 0 to 1) and p the resulting proportion of positional movement. m is a parameter to select any of the different manners of movement available in HamNoSys: normal, tense, etc.

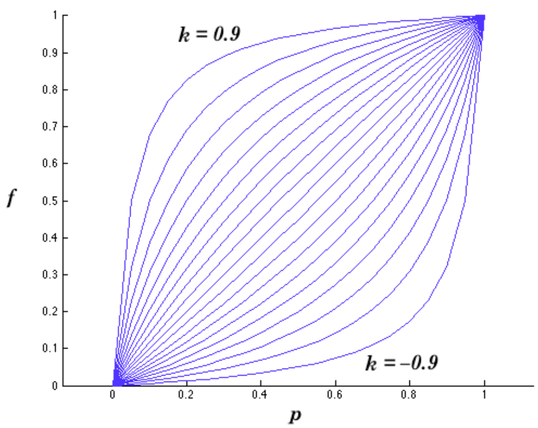

Figure 1. Currently implemented warping function.

This method takes p to be in a sense the primary aspect of movement, as it is not modified by lead or lag, with shape and orientation timing being defined relative to p. An alternative, which may be tested in future experiments, would be to apply a warping function such as the above to the time, and then to apply the manner function. This would allow all three aspects of hand movement – position, shape, and orientation – to have independently specified leads or lags relative to the time interval over which the complete movement is to occur. Other warping functions may be tried, such as the simple linear compression shown in the next figure (see Figure 2).

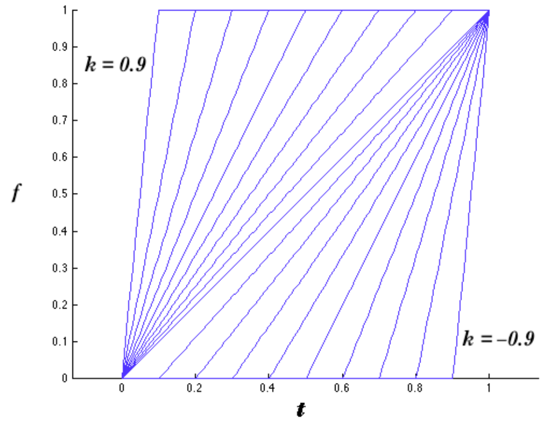

Figure 2. Alternative warping function: Simple linear compression.

The manner function generates realistic accelerations and decelerations by means of a semi-abstract model of the task of reaching to a target, with parameters that determine how fast the movement starts, how suddenly it stops, and how uniform the accelerations are throughout. HamNoSys allows several manners to be notated: normal, tense, or a sudden stop. Each of these is defined by Animgen as a set of parameters to the general model, to generate for each one a suitable mapping of times from 0 to 1 to movement fractions from 0 to 1. It also defines the duration of each manner of movement as some proportion of the time for a normal movement. In addition, Animgen defines several manners that are implied by context: "lax" non-intentional movement for most inter-sign transitions, collision of a hand with the body at the end of a movement, and a few others.

The lax manner is designed to lack the visual appearance of "intentionality" possessed by the movements that constitute a sign. Inter-sign transitions (ISTs) are animated with lax manner, except in the case where the HamNoSys notation of the following sign specifies just a single posture with no explicit movement (e.g. the BSL sign ME). In this case Animgen generates the IST as a normal, i.e. intentional movement. Within a sign, all movements are animated as intentional, with the exception of the return strokes of most repeated movements, which are animated as lax. An example is the BSL sign NOW, which performs two intentional downwards movements of the hands with a lax return between.

The duration and manner of the component movements of a sign can be explicitly notated in SiGML, allowing Animgen's default rules for timing and manner to be overridden.

4. ANNOTATION AND MICROTESTING

4.1 Corpus Data

In the framework of the Dicta-Sign project a multilingual sign language corpus is being compiled. For the data collection Deaf informants were filmed in pairs interacting with each other. Elicitation materials were designed to stimulate language production in our target domain ('travel in Europe'), aiming at as high a level of naturalness possible with semi-spontaneous utterances under lab conditions [11]. The studio setup included seven cameras (five HD cameras plus two stereo cameras), allowing us to record both informants from frontal and side view as well as from birds-eye perspective [4]. The multiple camera perspectives, meant to help transcribers to interpret the signing, turned out to be an extremely useful if not essential requirement for a detailed annotation as described here.

The annotation of the Dicta-Sign corpus is done using iLex, an annotation environment that provides video layouts for multi-camera recordings as used within the project [5]. In the annotation process of our corpus the signing stream is segmented into individual signs, lemmatised and annotated for mouth patterns. Lemmatisation (type-token matching) results in gloss labels as well as HamNoSys descriptions of the inflected types.

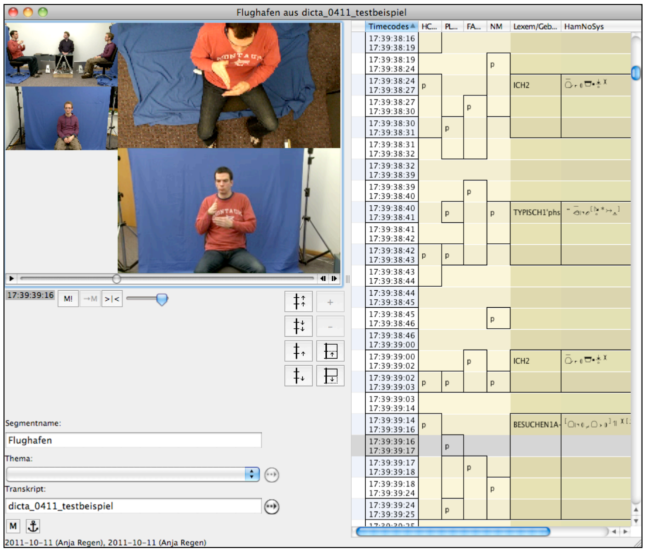

Figure 3. Annotation in iLex of HC, PL, FA, NM, glosses, and HamNoSys.

4.2 Segmentation of individual parameters

In order to inform the avatar animation about detailed timing of the individual parameters as wished for in this study, a small data set was further analysed following the Johnson/Liddell approach described above. Video data with a rate of 50 frames per second was analysed from two different signers of DGS (German Sign Language), segmented for each of the individual parameters. The data available so far are of a length of 01:45min in total (fully annotated for HC, PL and FA of the dominant hand, a subset additionally for the non-dominant hand and for mouth patterns), resulting in a total number of 1125 tags[4].

Segmenting a parameter frame by frame for static and transitional phases turned out to be an extremely time consuming and difficult task. The suggestion given by Johnson/Liddell to distinguish clear pictures of the hand from fuzzy ones was mostly not applicable for our data as it depends heavily on the cameras used (esp. frame rate and exposure time). For PL we found changes in movement direction to be the most reliable marker for its segmentation, which partly resulted in PL postural tags of only one frame length. Having used videos with a frame rate of 50fps (i.e. larger than the 30fps available for the Johnson/Liddell data), we had expected to be able to recognise distinct static phases for PLs. However, the more frames there are, the more details are visible. This holds especially for signs that – on a first glance – inherit a comparably long PL (e.g. INDEX pointing at something). Looking at these occurrences frame by frame on a high frame rate basis reveals the almost nonstop minor movements happening "naturally". It becomes evident that a certain threshold would be needed to filter out these movements, which is, however, hardly possible for human annotators to apply consistently by looking at a video frame by frame. This hold especially if annotation is conducted by more than one person. Another aspect is the importance of using pictures from different camera perspectives, as for many signs significant path movements are happening that can not be recognised on a front view camera. For HC phases of no change are mostly longer and therefore easier to determine. However, a lot of minor changes were again only detected through the different camera perspectives, and similar difficulties arise regarding the precision of segmentation (this holds for all parameters). Regarding FA only those phases were tagged where both the HamNoSys orientation components 'extended finger direction' and 'palm orientation' were static, which again made these tags often short in duration.

Analysing the data, it was found that static configurations of the different parameters hardly coincide, which confirms the findings by Johnson/Liddell. However, the results are very diverse regarding the relation between the individual parameters and with the small amount of data annotated so far no generalisation is possible on the duration and whether certain parameters are established/ released before or after others. A fixed order in the accumulation of components – as suggested by Jouison – can therefore not be supported by our data so far. With the technical possibilities given (i.e. comparatively high frame rate and different camera perspectives) the tagging of static phases is often short and in some cases results in no temporal overlap of the parameters. In these cases a structure of postures and detentions in Johnson/Liddell's sense can not be stated without applying thresholding.

4.3 Microtesting

The data annotation as described above provides detailed timing information and demonstrates that the behaviour of the individual parameters is by no means simultaneous. By modifying the avatar animation accordingly, the aim of the microtesting was to verify if a difference can be noticed and how much this actually improves subjective recognisability.

For the microtesting we extracted a coherent sequence of signs from our data consisting of 17 signs of one signer. In a first step HamNoSys notation of the annotated data was translated into SiGML which was then modified manually for precise timing information. Focussing on the beginning of each sign, the inter-sign transitions (ISTs) were modified according to our data in that lead or lag parameters were added to both HC and FA. However, not all findings from our data annotation could be implemented. Being based on HamNoSys notation Animgen relies on a start and end posture of a sign, i.e. while transitions may now be modified, all parameters have to be in sync at certain times. This is congruent with the Johnson/Liddell model but not always with our findings. As a result of that, if HC or FA are established after PL in our data this can not be animated by using a lag parameter. A modification is only possible in such a way that their transition is realised relatively later to that of the PL but leading to a full establishment of all parameters at a certain point of time. Another issue is the timing of the nondominant hand, which is momentarily only possible in relation to postures of the dominant hand (i.e. again the parameters can not be modelled to occur later than the posture of the dominant hand).

4 As the different phases are alternating, only static phases were tagged as such.

Different versions of avatar animation were used for the microtesting:

- Direct translation of the HamNoSys notation without any modification (i.e. steady changes of all parameters)
- Modification of the SiGML notation to match timing information from our data as closely as possible
- Modification of the SiGML notation with exaggerated lead or lag parameters

In a first step, the whole sign sequence was shown to the informants, both in unmodified and "naturally" modified version. The informants were asked for feedback regarding differences between the versions as well as clarification needs regarding the signing presented. In a second step three individual parts of the sequence were shown, consisting of three to five signs. For each part again the two versions were presented and feedback was asked for. If no differences could be noticed, the third version was shown as well.

We asked six Deaf informants to watch the avatar signing and to report on differences between the avatar versions, on their impressions of what has been changed and which impact it has on the naturalness of the avatar. The informants were seated in front of two monitors where the different avatar animations were displayed in alternating order. In all cases the informants did not know which version was shown first and on which screen.

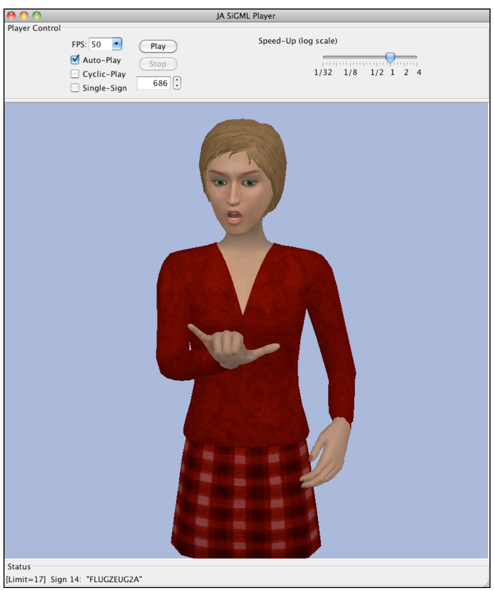

Figure 4. Avatar signing AIRPORT

In most cases content clarifications were needed at the beginning, because some signs were not intelligible to the informants by watching them once or even twice.[5] In general, differences that were seen quite often between the modified and unmodified versions included prosodic aspects and speed. However, in some cases informants' statements were contradictory or no differences could be detected at all (i.e. neither for the "naturally" modified version nor the exaggerated one).

For the long segment shown first nearly all informants judged the modified version positively. It was said to be more fluent (4 informants) and faster (3). The signing rhythm seemed less monotonous (2). Two informants stated a better comprehension of the modified version. Only one informant rated the unmodified version as the more fluent and smoother one.[6]

While for the long segment all informants stated that they recognised differences, for the short segments there were occasions when no differences were noticed. In general, similar aspects were mentioned for the short segments (fluency, smoothness, speed, …), however the answers regarding which version was the "better one" were much more diverse. Very often, the avatar appearing on the same screen was judged similar to the previous one, even though the versions alternated. Additionally, the informants were more often distracted by concentrating on the mouth patterns or sign forms that they thought to be incorrect.

5. CONCLUSION

The work presented here is work in progress, aiming at improving the performance of automatically animated avatars by applying exact timing information. As supporting data sets have not been available, we started by annotating a small set of our corpus, combining HamNoSys notation with the approach developed by Johnson/Liddell. It became obvious that per-parameter segmentation for natural sign language data is a complicated and time consuming task. As described, the definition of static versus transitional segments used by Johnson/Liddell becomes difficult as soon as different technology comes into play. While using video data from different camera perspectives with a resolution of 1/50 of a second allows for a more accurate segmentation it also reveals new challenges: changes can often be recognised for each frame which makes it difficult to define a static segment. We therefore defined the moment were a change of movement direction occurs as a "static" segment. Furthermore, the short segments do not necessarily show an overlap in time (i.e. postures in Johnson/Liddell's sense). It becomes apparent that a certain threshold for minimal motions would need to be applied, however reliability becomes an issue for human annotators.

In the framework of this small-scale study only a very small data set could be fully annotated and findings can not be generalised. A bigger data set is therefore desirable, including more signers and possibly different sign languages.

New features were applied to Animgen in order to modify the avatar animation according to our data using lead and lag parameters. While a modification for HC and FA is possible with the current version, a lead or lag of PL can not be animated yet. Further improvements are planned for to allow more timing details to be implemented.

We conducted microtesting to verify the impact modifications of timing according to our data have on the avatar performance. The feedback we got from our Deaf participants suggests a positive influence of the modified timing for the longer sequence of signs. The diverse answers regarding the short sign sequences (esp. the fact that similar answers were given for presentations on the same screen) however reveal that there is no clear perception of what the differences might be. Again more data are needed to generalise the findings and improve the test material.

---

[5] While certain animation deficits may play a role, the informants also claimed a few signs were „wrong". However, the animation was purely informed by our data and reflects the informant's signing performance.

[6] It has to be noted, however, that a certain influence of the order of presentation on the informants' judgment can not be excluded for certain.

6. ACKNOWLEDGMENTS

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 231135.

7. REFERENCES

[1] Duarte, Kyle / Gibet, Sylvie (2010): Heterogeneous Data Sources for Signed Language Analysis and Synthesis: The SignCom Project. In: *Proceedings of the Seventh conference on International Language Resources and Evaluation (LREC'10)*. Paris: ELRA, pp. 461-468.

[2] Duarte, Kyle / Gibet, Sylvie (2010). Reading between the signs: How are transitions built in signed languages? In: *Proceedings of the 10th International Conference on Theoretical Issues in Sign Language Research*, West Lafayette, Indiana USA, 2010.

[3] Hanke, Thomas (2004). HamNoSys – Representing Sign Language Data in Language Resources and Language Processing Contexts. In: *Streiter, Oliver / Vettori, Chiara (eds). LREC 2004, Workshop proceedings : Representation and processing of sign languages*. Paris : ELRA, 2004, pp. 1-6.

[4] Hanke, Thomas / König, Lutz / Wagner, Sven / Matthes, Silke (2010). DGS Corpus & Dicta-Sign: The Hamburg Studio Setup. In: Dreuw, Philippe et al. (eds.): LREC 2010. 7th International Conference on Language Resources and Evaluation. Workshop Proceedings. W13. 4th Workshop on Representation and Processing of Sign Languages: Corpora and Sign Language Technologies. May 22/23 2010. Valetta – Malta. Paris : ELRA, 2010, pp. 106-109.

[5] Hanke, Thomas / Storz, Jakob / Wagner, Sven (2010). iLex: Handling Multi-Camera Recordings. In: Dreuw, Philippe et al. (eds.): LREC 2010. 7th International Conference on Language Resources and Evaluation. Workshop Proceedings. W13. 4th Workshop on Representation and Processing of Sign Languages: Corpora and Sign Language Technologies. May 22/23 2010. Valetta – Malta. Paris : ELRA, 2010, pp. 110-111.

[6] Huenerfauth, Matt (2009). A Linguistically Motivated Model for Speed and Pausing in Animations of American Sign Language. *ACM Transactions on Accessible Computing*, 2(2), Article 9.

[7] Johnson, Robert E. / Liddell, Scott K. (2011). A Segmental Framework for Representing Signs Phonetically. *Sign Language Studies* 11(3), pp.408-463.

[8] Jouison, Paul (1990). Analysis and linear transcription of sign language discourse. In: Prillwitz, Siegmund / Vollhaber, Tomas (eds.) Current trends in European sign language research. Proceedings of the 3rd European Congress on Sign Language Research. Hamburg: Signum-Verlag, pp. 337-353.

[9] Kennaway, Richard (2001). Synthetic Animation of Deaf Signing Gestures. In: *Proceedings of International Gesture Workshop*, London, U.K., 2001, pp. 146-157.

[10] Kennaway, Richard (2003). Experience with and Requirements for a Gesture Description Language for Synthetic Animation. In: *Proceedings of International Gesture Workshop*, Genova, Italy, 2003, pp. 300-311.

[11] Matthes, Silke / Hanke, Thomas / Storz, Jakob / Efthimiou, Eleni / Dimou, Nassia / Karioris, Panagiotis / Braffort, Annelies / Choisier, Annick / Pelhate, Julia, Safar, Eva (2010). Elicitation Tasks and Materials designed for Dicta-Sign's Multi-lingual Corpus. In: *Dreuw, Philippe et al. (eds.): LREC 2010. 7th International Conference on Language Resources and Evaluation. Workshop Proceedings. W13. 4th Workshop on Representation and Processing of Sign Languages: Corpora and Sign Language Technologies*. May 22/23 2010. Valetta – Malta. Paris : ELRA, 2010, pp. 158-163.