HamNoSys – Representing Sign Language Data in Language Resources and Language Processing Contexts

Thomas Hanke

University of Hamburg
Institute of German Sign Language and Communication of the Deaf
Binderstraße 34, 20146 Hamburg, Germany
Thomas.Hanke@sign-lang.uni-hamburg.de

Abstract

This paper gives a short overview of the Hamburg Notation System for Sign Languages (HamNoSys) and describes its application areas in language resources for sign languages and in sign language processing.

1. Introduction

The Hamburg Notation System for Sign Languages (HamNoSys) is an alphabetic system describing signs on a mostly phonetic level. As many sign notation systems developed in the last 30 years, it has its roots in the Stokoe notation system that introduced an alphabetic system to describe the sublexical parameters location, hand configuration (in most cases, the handshape only) and movement to give a phonological description of American Sign Language signs (Stokoe, 1960).

HamNoSys (first version defined in 1984, first published version Prillwitz et al., 1987), however, was designed to be usable in a variety of contexts with the following goals in mind:

- International use: HamNoSys transcriptions should be possible for virtually all sign languages in the world, and the notation should not rely on conventions differing from country to country, such as the national fingerspelling alphabets.
- Iconicity: As the large number of possible parameter variations did not allow for a standard alphabet (e.g. Roman alphabet) familiar to the users, newly created glyphs should be designed a way that helps to memorise or even deduct the meaning of the symbols wherever possible.
- Economy: While it should be possible to transcribe any signed utterance (even sign errors) with HamNoSys, notation of the majority of signs should make use of principles such as symmetry conditions, resulting in much shorter notation for the average sign.
- Integration with standard computer tools: The notation system should be usable within computer-supported transcription as well as in standard text processing and database applications.
- Formal syntax: The notation language should have a well-defined syntax, and its semantics should generally follow the compositionality principle.
- Extensibility: As it seemed obvious that, given the state of the art in sign language research, a notation system would not be capable of addressing all aspects of sign formation description for all sign languages right from the beginning, HamNoSys should allow both for a general evolution and specialisations. New versions of the system should not render old transcriptions invalid.

More than fifteen years after the first published version, HamNoSys is now at version 4 (Schmaling/Hanke, 2001). This latest version filled some minor gaps and introduced some shortcuts, but more importantly addressed issues related to using HamNoSys in a sign language generation context. For the latter purpose, it was also complemented with a new set of systems to encode nonmanual behaviour in a detailedness not previously possible in HamNoSys.

2. Overview of the System

2.1. General Structure

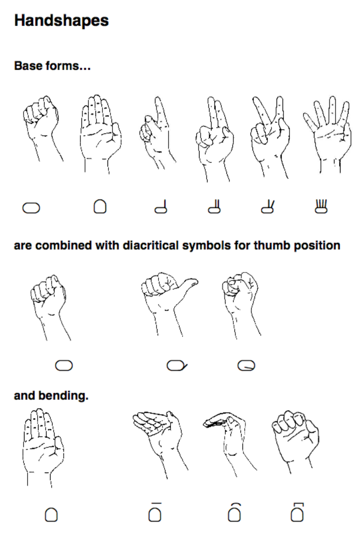
A HamNoSys notation for a single sign consists of a description of the initial posture (describing nonmanual features, handshape, hand orientation and location) plus the actions changing this posture in sequence or in parallel. For two-handed signs, the initial posture notation is preceded by a symmetry operator that defines how the description of the dominant hand copies to the non-dominant hand unless otherwise specified.

Specifications of nonmanual features and actions are optional. If the location specification is missing, a default location is assumed.

2.2. Handshapes

The description of a handshape is composed of symbols for basic forms and diacritics for thumb position and bending. In addition, deviations from this general description with respect to the fingers involved or the form of individual fingers can be specified. Where necessary, intermediate forms can be described as well.

By this combinatorial approach, the set of describable handshapes is rather large and is

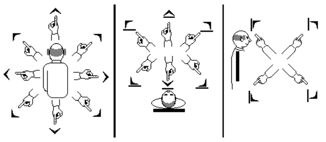


supposed to include all handshapes actually used in sign languages documented so far.

Dynamic handshapes as defined for German Sign Language by Prillwitz et al. (2002) are not considered primitives in HamNoSys. Instead, the initial handshape of an opening or closing dynamic pair appears within the posture, whereas the second one appears as the target of a handshape change action. For wiggling etc., one representative handshape is described in the posture, the wiggling itself, however, is described as an action.

2.3. Hand Orientation

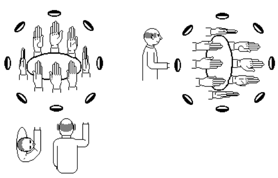
HamNoSys describes the orientation of the hand by combining two components: extended finger direction (i.e. for index hands the index direction) specifying two degrees of freedom, and palm orientation determining the third degree. By providing symbols for both components in a distance of 45°, a sufficiently fine-grained determination of the 3D-orientation of the hand becomes possible.



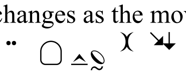
The three perspectives used for the extended finger direction (signer's view, birds' view, and view from the right) are reflected in the glyphs by no reference line, a horizontal reference line, or a vertical reference line representing the signer's body. (The same model is used for movements.)

Redundant symbols, such as ⊩, are not used. Insofar, there is a priority ordering between the three views determining which view to be used for each symbol.

For the third degree of freedom, only eight symbols are needed. The meaning of a symbol is defined relative to the extended finger direction (⏶⬭ palm down, ˄⬭ palm away from the body etc.).



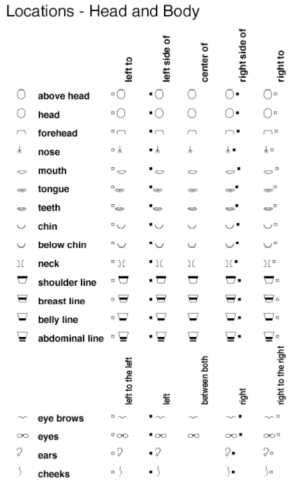
By adding a subscript, hand orientation can be made relative to the movement, e.g. the palm orientation changes as the movement direction changes:



HOUSE

2.4. Location

As with hand orientation, location specifications are split into two components: The first determines the location within the frontal plane (x and y coordinates, whereas the second determines the z coordinate. If the second part is missing, a "natural" distance of the hand from the body is assumed. If both parts are missing, the hand is assumed to be located in "neutral signing space", i.e. with "natural" distance in front of the upper torso.

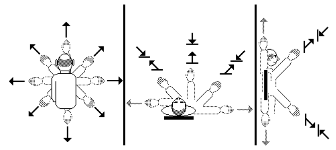


For two-handed signs, the location may also describe the relation of the two hands to each other ("hand constellation") as describing the positions of the two hands with respect two body parts might not be precise enough.

2.5. Actions

Actions are combinations of path movements (i.e. movements changing the position of the hand) and in-place movements of the hands as well as nonmanual movements. The combinations can be performed either sequentially or cotemporally.

In HamNoSys, path movement buildings blocks are straight lines, curved and zigzag lines, circles and similar forms. Here again, a quantization with 45° is applied.



Path movements can be specified either as targeted movements (target specified as location) or relative movements (target determined by the direction and the size of the movement).

In-place movements are changes in handshape or hand orientation as well as wiggling, twisting etc.

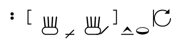
For all movement components, diacritic symbols to specify size can be added. Furthermore, for each movement a mode (such as slow or sudden stop) can be specified.

Repetitions of actions can be specified either by exact numbers as multiple repetition. In each case, a repetition can be continuous or recurrent.

The mere concatenation of actions means their performance in sequence, whereas actions in square brackets are done in parallel. E.g. a circle movement in square brackets with a straight movement results in a spiral movement. For two-handed actions, it is possible to specify different actions for each hand to be performed simultaneously.

2.6. Two-handed Signs

The notation of a two-handed sign begins with a symmetry marker. This symbol determines how to copy the specification for the dominant hand to the non-dominant hand. Exceptions can always be specified by separately describing configurations or actions for each hand. Example:



(German Sign Language NINETEEN): Both hands have the same hand orientation and the same movement, but they differ in their handshapes.

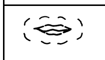
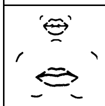
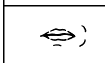
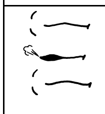
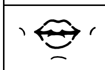
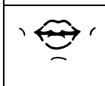
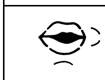
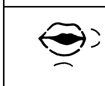
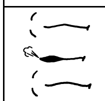
2.7. Nonmanual Components

As most notation systems, HamNoSys focuses on the description of the manual activities within a sign. The descriptive power of the existing system with respect to nonmanuals is rather limited: For each action, HamNoSys allows to specify an articulator to replace the hand. The actions available are those introduced for the hands. This allows appropriate descriptions for shoulder shrugging, head movements etc. but not necessarily facial expressions or mouth movements.

Originally, it was planned to add a facial circle to be complemented with diacritics for eyes, eyebrows, nose, cheeks, and mouth. At that time, however, practical limitations did not allow for the sheer number of diacritical symbols to be put into one font. Later suggestions added movement primitives to HamNoSys that targeted towards facial movements.

For the time being, we use a rather unsophisticated coding scheme to specify a number of nonmanual tiers in a multi-tier transcription scheme with the HamNoSys manual tier being the master tier. Synchronization is generally done on a sign level only.

Coding schemes are defined for eye gaze, facial expression (eye brows, eye lids, nose), mouth gestures and mouth pictures. The separation from the manual parts allows codes to be defined for states as well as for movements, i.e. sequences of states (e.g. TB tightly shut eyelids vs. BB eye blink). For mouth gestures, the coding scheme simply enumerates all gestures identified so far, e.g.:

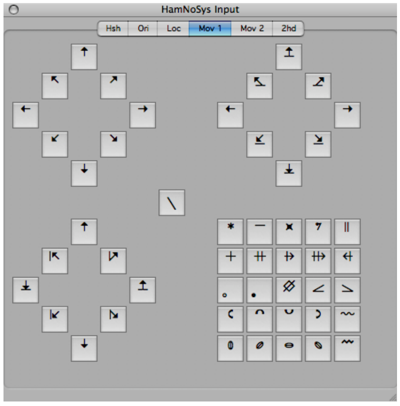
	C01	cheeks puffed	(static)
	C02	cheeks and upper and lower lip areas puffed	(static)
	C03	cheeks puffed gradually	(dynamic)
	C04(C)	one cheek puffed	(static)
	C05(C)	one cheek puffed; blow out air briefly at corner of one‘s mouth	(dynamic)
	C06(C)	one cheek puffed; blow out air briefly at corner of one’s mouth when touching cheek with index finger	(dynamic)
	C07	cheeks sucked in, without sucking in air	(static)
	C08	cheeks sucked in, sucking in air through slightly open lips	(dynamic)
	C09(C)	tongue pushed into cheek (visible from outside)	(static)
	C10(C)	tongue pushed into cheek several times (visible from outside)	(dynamic)
	C11(C)	one cheek puffed; blow out air briefly at corner of one‘s mouth several times	(dynamic)
	C12	lips closed, tongue pushed behind bottom lip/chin (visible from outside)	(static)

A complete documentation of these nonmanual coding schemes can be found in Hanke et al. (2001).

2.8. Implementation

The HamNoSys symbols are available as a Unicode font, with the characters mapped into the Private Use area of Unicode.

For MacOS X, a keyboard layout has been defined that can be automatically activated once text in the HamNoSys font is selected. This keyboard graphically arranges the characters on the keyboard, e.g. the arrows in circles with 45° sectors. This makes learning keyboard input rather easy for those using HamNoSys every day. For people who use the system less frequently, even this keyboard is too much to memorise. Here we offer (for both MacOS and Win) a small input utility that allows the user to construct the HamNoSys string by clicking on the appropriate symbols on (user-configurable) palettes:



A syntax-oriented editor was available for HamNoSys 2 (Schulmeister, 1990), but has not been updated since then. Within the ViSiCAST project (cf. Schulmeister, 2001), SiGML, an XML equivalent to HamNoSys, has been defined (Elliott et al., 2000).

3. Dictionaries

In many sign language dictionaries, you find notation as a description how to perform an entry. Depending on the media used, the notation is part of a multitude of form descriptions, e.g. video, photos or drawings with or without arrows, performance instructions in written language, etc. Today’s sign language dictionaries mostly present only the citation form of the sign, some possibly add unstructured information like “directional verb” to indicate the kind and richness of morphological derivation that can be applied to the sign.

Notation is also used to provide some means of access to the dictionary contents from the sign language side: For search access, you normally find partial matching strategies. In the case of HamNoSys with its relatively high degree of detailedness, we add fuzzy search mechanisms to allow for variation. For browsing access (and this includes of course printed dictionaries), the lexemes (or an index thereof) are ordered according to only some parameters expressed in the notation. For HamNoSys, it is obvious why the order on HamNoSys strings induced by some order of the HamNoSys alphabet is not really useful: With about 200 symbols, no user will be able to memorise this ordering, and, for a given sign, you often find several equivalent HamNoSys notations, and HamNoSys still lacks a reduction method to identify one of these as the canonical notation. (For an example, cf. Konrad et al., 2003.)

4. Transcription of Signed Corpora

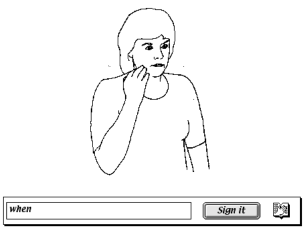
Notation is used to transcribe linguistic data (by viewing video) to provide an efficient form description and to make it accessible to analysis. In the first years, notation was that part of the transcription that came closest to raw data. But even after the integration of digital video, notation did not become superfluous as it makes data searchable for phonetic aspects (cf. Hanke/Prillwitz, 1995 and Hanke, 2001).

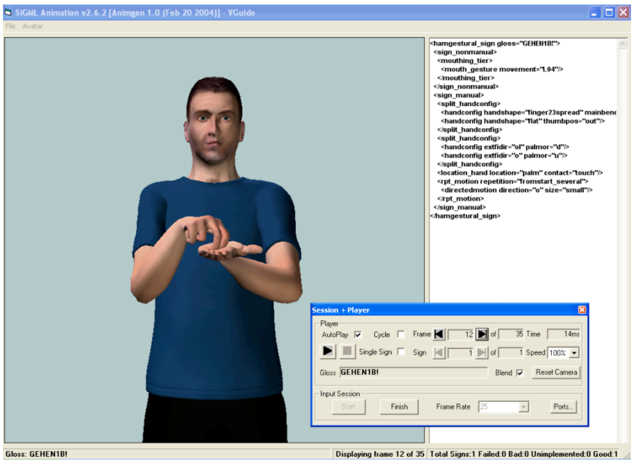
In most cases, the notation was used to describe the observed event at a certain level of detailedness. No attempt was made to relate the observed token to its type. One exception is the work by Johnston (1991), who, after giving the citation form of the type, describes how the token deviates from the type. In the context he introduced this notational convention, he considered those derivations only that are morphologically relevant, but it is easy to see how this could be extended.

ilex, our recent approach to corpus transcription (Hanke, 2002a), ties a lexicon into the transcription system and requires the user to relate each token to a type, a function considered absolutely necessary to ensure data consistency in larger corpora transcriptions that usually are team efforts and therefore cannot rely on the transcriber's intimate knowledge of the data already processed. What may be substituted in spoken language corpora by automatically searching the transcription data cannot be avoided for sign language corpora as long as HamNoSys or other notation systems do not establish a working orthography.

5. Generation

One of the first projects HamNoSys was used in is H.AN.D.S. (Hamburg Animated Dictionary of Signs, cf. Prillwitz/Schulmeister, 1987) which represented dictionary entries by the notation and a two-dimensional animation automatically created from the notation. Due to the immense number of high-precision drawings needed for that purpose, only a subset of HamNoSys could be correctly animated at the end of the project. The upcoming digital video technology then pushed animation to the background as far as sign language dictionaries were concerned. However, in the context of spoken-to-sign language translation systems, animation promises far better results than digital video: While Krapez/Solina (1999) describe a method to improve sign-to-sign video blending, they also outline the limitations. Animation technology can not only model transitional movements between signs, but, based on a suitable language model, provide uncountable morphological variations of sign lexicon entries as needed for locatable signs, directional verbs etc. Kennaway (2002, 2004) describes the ViSiCAST animation component based on SiGML:





The language model used in ViSiCAST is an HPSG feature structure. Depending on the morphological richness of a lexical entry, the structure may be fully instantiated with HamNoSys values, or might contain more complex structures only finally reducible into HamNoSys values. For a locatable sign like HOUSE in German Sign Language, this roughly looks as follows:

Handedness	
Handshape	
Orientation	
Handconstellation	
Location	1
Movement	

Using HamNoSys symbols as HPSG feature values is quite convenient as the user can immediately grasp the meaning of the values, and the approach has been successfully applied to a range of sign language specific phenomena such as classifier and number incorporation, directional verb signs and locatable signs. Problems remain where the independence of sign parameters is an over-simplification. This is easily illustrated with the example MOVE–classifier:car–source:right-side-in-front-of-the-signer–goal:left-side-in-front-of-the-signer. Once the feature structure for double-track vehicles

Handedness	
Handshape	
Orientation	
Handconstellation	

is unified with the lexical entry for MOVE and everything from source and goal except the height in signing space, the result is equivalent to the following lambda expression:

$\lambda \aleph .$ ▢ ‹⊖ $\aleph^{\leftarrow}$

With heights above chest level, this results in highly unnatural signing: Instead of

one would sign

Apparently the assumption that a classifier feature structure should specify whole handshapes and hand orientations is too restrictive. Instead, one might want to specify a part of the hand and this part's orientation. While it is always possible to translate the fully instantiated structures into standard HamNoSys to feed into the animation component, this would distribute the need for anatomical knowledge over two system components: The language model and the animation component, a highly undesirable situation. Instead, it might be a better idea to allow parts of handshapes and orientations thereof instead of complete handshapes with hand orientation in HamNoSys itself. A suggestion in this direction also discussing other classes of examples has been made by Hanke (2002b).

6. Applications beyond Sign Language

While Miller (2001) reports that HamNoSys and the family of derivatives of the Stokoe notation are the most widely used systems in research, it seems that even more people use HamNoSys outside sign language research, namely in gesture research.

In the Berlin Dictionary of Everyday Gestures (Posner et al., in prep.), HamNoSys is used in toto to describe the form of the gestures in addition to photos and verbal descriptions.

A number of gesture description schemes inherit structure and/or feature values from HamNoSys, such as MURML (Kopp et al., 2004), FORM (Martell, 2002) and CoGesT (Gut et al., 2003). KINOTE (Hofmann/Hommel, 1997) was described by the authors as a kinematic transcription of a subset of HamNoSys. Some of these representation languages are also the target for gesture recognition, be they based on data gloves or video, so that HamNoSys is indirectly also used in recognition contexts for gesture.

7. Outlook

New application areas will always pose new requirements on a system such as HamNoSys. So we currently see no end in the development of the system.

Obviously, one application area for HamNoSys is still missing: Sign language recognition. Only a few sign language recognition systems work on a sublexical level (e.g. Vogler/Metaxas, 2004), and all recognition systems today work with rather small sign inventories. In the future, language models in connection with lexicons might help recognition systems to cover larger subsets of a sign language, and it would be interesting to see how HamNoSys fits into such a system.

For transcription schemes of signed texts as well as lexicon building, data on intra- and inter-transcriber reliability could contribute to another aspect to the question how useful a phonetic transcription of signs is.

The use of HamNoSys in a number of gesture description systems might turn out to be a useful key to link sign language resources and processing models with the larger field of multimodality.

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