Analysis for Synthesis: Investigating Corpora for Supporting the Automatic Generation of Role Shift

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Abstract

In signed languages, role shift is a process that can facilitate the description of statements, actions or thoughts of someone other than the person who is signing, and sign synthesis systems must be able to automatically create animations that portray it effectively. Animation is only as good as the data used to create it, which is the motivation for using corpus analyses when developing new tools and techniques. This paper describes work-in-progress towards automatically generating role shift in discourse. This effort includes consideration of the underlying representation necessary to generate a role shift automatically and a survey of current annotation approaches to ascertain whether they supply sufficient data for the representation to generate the role shift.

Keywords: sign language synthesis, avatar technology, corpus annotation guidelines, role shift

1. Introduction

In signed languages, role shift is a process that can facilitate the description of statements, actions or thoughts of someone other than the person who is signing. It is an important structure in many signed languages, and thus sign synthesis systems must be able to portray it. Animation is only as good as the data used to create it, which is the motivation for using corpus analyses when developing new tools and techniques. This paper describes work-in-progress towards automatically generating role shift in discourse. In order to complete this effort, we need to address two questions:

- What underlying representation is necessary to generate a role shift automatically?
- Can current corpora supply sufficient data for the representation to generate the role shift?

2. Linguistic theory

Role shift has been a topic of study in signed language linguistics almost since the inception of the discipline. This section is a condensed review of the history of linguistic theory concerning role shift. For a more comprehensive treatment, see (Lillo-Martin, 2012).

Friedman (1975) observed that when reporting a dialog in American Sign Language (ASL), a signer can designate a protagonist via a third-person referent and then assume the role of that protagonist. Analyzing the phenomenon further, Liddell & Metzger (1998) noted that a role shift in ASL could convey constructed action as well as thoughts or dialog, and introduced the concept of "mental spaces" as a framework to account for constructed action.

Morgan (1999) described a framework of three spaces in British Sign Language (BSL). The first, *narrator space*, was used by signers to introduce protagonists and plot motivation. The second, *fixed referential framework*, accounted for establishing scenes involving topographic space and setting up pronominal points toward spatial loci. Once these loci have been designated, the signer can exploit them to form agreement verbs. This space interacts with the third framework, called the *shifted referential framework*, which is used to describe dialog, actions, and thoughts of the protagonists. When performing a role shift, the signer uses the shifted referential framework, but can still make use of other loci previously designated in the fixed referential framework (Figure 1). Thus the spaces interact during discourse.

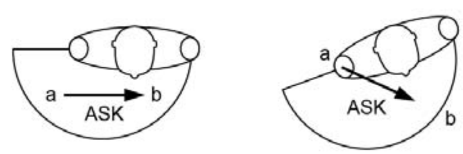

Figure 1: Fixed and Shifted Referential Frameworks.

When considering the depiction of objects and events in ASL, Dudis (2004) further explored the concept of interacting spaces. He noted that different spaces will scale (size) the depictions differently. He used an example of a motorcyclist climbing a hill. When the signer assumes the role of the motorcyclist gripping the handles, the motorcycle is life-sized. However, when the signer uses a vehicle classifier to show the steep slope of the road, the motorcycle shrinks to the size of the signer's hand. Further, only the signer's hand portrays the vehicle classifier while the rest of the signer's body is still riding the motorcycle. Thus the two spaces interact, in what he called a *blend*.

In a study of spatial coherence in German Sign Language (DGS), Perniss (2007) introduced the terms *observer perspective* and *character perspective* to describe the two spaces and to motivate the types of scaling. Observer perspective is analogous to having an imaginary camera set sufficiently far away with a field-of-view wide enough to encompass the entire space. Since the entire space is visible through the imaginary viewfinder, the depicted distances between entities are small. On the other hand, in character perspective, the signer assumes the role of a previously-designated protagonist. In this space, an imaginary camera would have the same view and perspective as the protagonist, and the distances between objects would be much closer to life-sized.

The metaphor of a camera is also useful when discussing Janzen's research (2004) on space rotation and perspective shift in ASL. He described a narrated story of a police officer and a driver. Although the two characters would have been face-to-face during the incident, the narrator did not shift to assume the roles of the driver and the officer. Janzen described this as mentally rotating “their conceptualized space so that third-person referents realign with the signer’s own stance. Body shifts toward a designated space do not occur.”(Janzen, p. 149) In other words, the narrator was performing each protagonist as seen through a camera from the addressee’s vantage point.

3. Visual indications of a role shift

Findings from linguistic theory yield a rich set of information describing the visual aspects of a role shift. They are a set of specifications, or a metric against which we can evaluate the quality of animations from signed language synthesis systems. Thus an important question to consider is, “What needs to be portrayed in an animation to convey a role shift? “

Early studies emphasize the gross motor movement of the spinal column. Friedman (1975) mentions the orientation of a signer’s body or the turning of the head to distinguish one third-person referent from another. Liddell & Metzger (1998) describes the types of constructed action that can occur within a role shift (Table 1). These give the scope of the animation required.

Protagonist actions	What they indicate
Articulation of words or signs or emblems	What the protagonist says or thinks
Direction of head and eye gaze	Direction protagonist is looking
Facial expressions of affect, effort, etc.	How the protagonist feels
Gestures of hands and arms	Gestures produced by the protagonist

Table 1: Types of constructed action.

The phenomenon has been studied in many sign languages. In 2000, Cuxac presented several classes of “personal transfer” in French Sign Language (LSF) similar to role shifts in ASL (Meurant, 2004). When investigating role shift forms to convey non-direct speech in the Sign Language of Southern Belgium (LSFB) Meurant (2004) found that eye gaze is the main mechanism, rather than body leans or tilts for reference. Quer (2005) analyzed role shift in Catalan Sign Language (LSC) and made cross linguistic comparisons with studies of ASL, Italian Sign Language (LIS) and Danish Sign Language (DTS) data. The following are a list of nonmanual markings that may indicate a role shift:

- a slight body shift towards the locus of the previously-designated protagonist;
- a change in eye gaze contact from the actual to the purported addressee of the reported dialog;
- a change in head orientation;
- facial expression (linguistic and affective) associated with the protagonist.

Although this list enumerates a diverse set of nonmanual markings, Herrmann & Steinbach (2012) have found that only the change in eye gaze is obligatory for marking a role shift in DGS, and body shifts and changes in head orientation are optional.

4. Corpus studies involving role shift

The introduction of multimedia annotation tools such as iLex (Hanke, 2002) and ELAN (Crasborn & Sloetjes, 2008) and the establishment of transcription systems such as HamNoSys (Hanke, 2004) and annotation guidelines, including the ECHO conventions (Nonhebel, Crasborn, & van der Kooij, 2004) and the Auslan corpus guidelines (Johnston, 2009) have facilitated a blossoming of signed language corpus research, including investigations involving role shift. Both sets of annotation guidelines specify a role (or role/constructed action) tier. Annotations in the tier indicate start and end times of a role shift in addition to the character being assumed by the signer. Using Johnston’s annotation guidelines, de Beuzeville (2008) investigated verb modification and recorded the frequency of co-occurrence of constructed action (role shift) with modified and unmodified signs.

Other researchers created customized tiers for their study of role shift but were mindful of the challenges of using consistent annotations. In their study of iconic representations (depictions), Dudis et al. (2008) developed a flowchart to guide annotation. In ELAN, they used two tiers, one to annotate instances of character perspective and another to annotate instances of event depictions in observer perspective.

Several recent studies of role shift have carefully analyzed eye gaze. While building a corpus for a cross-linguistic project investigating the signed languages of Germany, Ireland, and the Netherlands, Herrmann (2008) discovered that previously established annotation guidelines for eye gaze did not provide sufficient precision for her investigation. One of her goals was to use an annotation protocol that was as precise and as detailed as possible without ascribing to any particular theory. She proposed an approach which would accurately and continuously annotate eye gaze and blinks. This new approach opens the possibility for studying blink and gaze contribution to role shift.

The question of using theory-neutral annotations, as contrasted with those that are theory-dependent, is an ongoing issue that affects studies of role shift. The method that Zwitserlood, Özyürek & Perniss (2008) used was to separate the coding into two sets of tiers. The analytic tiers contain theory dependent interpretations. The descriptive tiers are annotated in terms of phonetic / phonological forms only and are theory neutral. An analytic tier contains referent annotations. These are connected to annotations on descriptive tiers by virtue of their co-occurrence.

In a study of BSL, Cormier & Smith (2011) defined a set of eight tiers to study constructed action. Six of these are dedicated to forms (articulators) used to support role shift / constructed action and include tiers for eye gaze, head, face, torso, dominant arm/hand and nondominant arm/hand. The remaining two tiers specify the primary role and secondary role. For the primary role (Role1), the narrator is the default; otherwise the tier indicates the protagonist whose role the signer assumes. The second role (Role2) could be the narrator if Role1 is designating a protagonist. In this way, they can accommodate the blended spaces such as the motorcyclist story described by Dudis (2004).

For eye gaze, Herrmann and Cormier & Smith use a coding system that is similar to the ECHO guidelines (Nonhebel, Crasborn, & van der Kooij, 2004), which is reproduced in Figure 2.

r-90	to the right, close to 90 degrees of MSP
r	to the right, close to 45 degrees of MSP
l-90	to the left, close to 90 degrees of MSP
l	to the left, close to 45 degrees of MSP
lh	to the left hand (for RH tier)
rh	to the right hand (for LH tier)
u	upward, higher than lexical default height
d	downward, lower than lexical default height
a	ahead, more to the front than lexical default
s	towards the signer, close to the signer
p	toward a person present

Figure 2: Coding for eye gaze, ECHO guidelines

There are four options for a lateral gaze that are not directed at the hands, two to the right and two to the left of the midsagittal plane (MSP). In contrast, as seen in Figure 3, Zwitserlood (2008) uses a streamlined scheme involving a single deviation on either side of the MSP.

These annotations for eye gaze are a good starting point for creating a computer system capable of automatically generating animations depicting role shift. The next section presents previous discussions of role shift in computer animation systems.

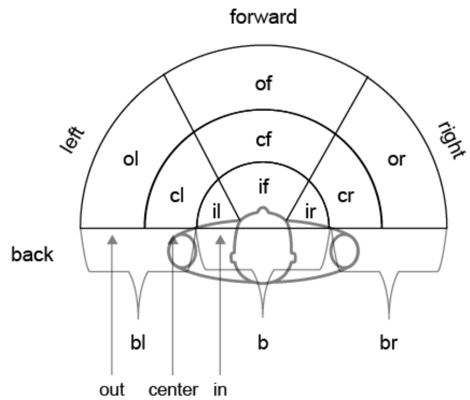

Figure 3: A 3D location grid, used facilitate specification of eye gaze direction. Zwitserlood (2008)

5. Previous efforts in synthesizing role shifts

Several research groups have included the portrayal of role shift in their animation systems. At LIMSI, Braffort and Dalle (2008) created a representation that closely reflects current linguistic theory. From an animation perspective, role shift is related to fixing referent loci and proforms. For these entities, they can accommodate characteristics such as location in signing space, orientation, shape and size, and other, syntactical (functional), semantic or cognitive features. They observe that loci for referents are always placed relative to the signer. Therefore they adopted a system of coordinates centered on the avatar and anchored on the avatar's pelvis, in order to deal with role shifts that require pelvis rotation.

In a study on improving spatial reference, Huenerfauth (2009) created “16 paragraph-length” animations that included, among other constructs, role shift. However, there was no mention of internal representation or implementation details.

The SignCom project (Duarte & Gibet, 2010a, Duarte & Gibet, 2010b) allows for the annotation of synchronized video and motion capture (mocap) data to facilitate both synthesis and analysis of LSF. For synthesis, sign data can be retrieved from different mocapped recordings and linked together via transitions created by an animation engine. The engine is capable of creating a transition that includes a role shift. This maintains discourse accuracy and comprehension.

6. Synthesizing Role Shift

From a synthesis perspective there are several problems to be solved. Our system relies on procedurally generated keys to create the basic movements of a role shift, which layer on top of signs animated as sets of sparse key-frame data. The procedures seamlessly transform the signs created in the fixed referential framework to the shifted referential framework of a constructed dialog or action.

Application of this shift is not limited to key frame data created by an animator since it layers over any previously existing avatar motion. It could also be applied to avatars that rely on motion capture data for their base animation. All that is needed is a separate set of controls for the spine, neck and eyes that allow a procedure to add the rotations of these joints onto the existing animation. As long as the motions in the sign are not extreme, adding in the small amount of rotation in the spine necessary to shift the coordinate frame will not generally cause the spine, shoulders or arms to rotate beyond their natural motion limits.

In addition to this basic transformation rooted at the spine, the system must consider eye gaze. Per Lillo-Martin (2012), transfer of eye gaze begins a role shift, and as has been noted, role shift can be indicated entirely by eye gaze, even without the torso twist that usually accompanies it. This shift in eye gaze will depend both on the referents that have been placed previously in the fixed referential framework and on the orientation of the body in the shifted referential framework.

To create a role shift with an avatar, a synthesis system must be capable of representing frameworks of reference. As a first step towards this, we will consider the frameworks from Morgan (1999) with the goal of incorporating the interaction with co-occurring representational frameworks in the future. We will focus this discussion on the mathematical modeling and the implementation required to portray the nonmanual markings comprising the first three items of Quer's (2005) inventory, including body, gaze and head orientation.

7. Spinal column and eye gaze in role shift

The first aspect that must be modeled is the transition into the shifted referential framework for a constructed dialog. To do this, the system will need to know the protagonists and addressees in the constructed dialog and where those speakers are placed in the fixed referential framework.

For indexing and verb conjugation, our system uses a collection of four key referential points spaced radially around the avatar in the fixed referential framework (Toro, 2004). These participants are placed at angles of approximately 15º and 30º on the strong side of the avatar and 30º and 45º on the weak side, relative to the midsagittal plane. The extra angular shift on the weak side is necessary because of the twist in the torso that naturally occurs when reaching across the body to point towards these loci.

Thus, for the avatar to assume the role, the protagonist will either need to:

- Be explicitly indexed in space in the discourse, in which case the system will have positions for each protagonist predefined in the fixed referential framework as one of the loci in Figure 4.
- Be inferred by the system according to the speaking order in the constructed dialog. The system will then choose contrastive positions for the protagonists on the strong/weak sides of the body.

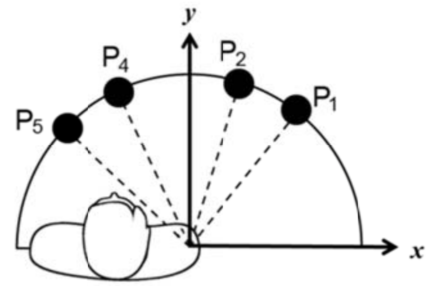

Figure 4: Loci for referents.

Given these loci, the system must manipulate the avatar to clearly indicate both the protagonist and addressee. An important aspect of this transformational model is that the avatar does not need to rigidly assume the precise position of the locus previously defined for the protagonist. All that is needed is a contrastive shift in the direction the locus sufficient to mark the transition from fixed to shifted referential framework.

The human action of turning the torso is a subtle and complex process due to the multiple participating joints involved including the pelvis, the lumbar and thoracic spinal joints, and also the sternoclavicular joints in the shoulders. In addition, the cervical spine will rotate the neck, and the eyes will shift as well. This is further complicated by the fact that, unlike most models of animation in computer graphics, these joints do not rotate in complete concert, but will cascade in a natural progression. In our motion studies of human torso movement, we found that the joints will typically begin their movement in the following sequence:

- The eyes rotate towards the direction that the body will eventually face.
- The neck rotates to facilitate the eye gaze.
- The pelvis rotates to begin the torso motion.
- The lumbar and thoracic spines follow in sequence to pull the shoulders into the desired orientation.
- The sternoclavicular joints will further rotate the shoulders to complete the transition.

Our studies of signers indicate that the eyes will turn to focus on the addressee's locus before the body rotates. In fact, this action will precede the body's rotation by up to a half second. Moreover, the actual direction that the eye gaze will assume in the role shift will depend on the addressee of the constructed dialog. Eye gaze consists of two actions that combine to orient the eyes comfortably toward a locus, namely neck and eye rotation. Ultimately, we need to take into account loci of both the protagonist and the addressee. However, when initially breaking gaze, the neck and eyes of the avatar must be turned to face the addressee, because the body has not yet turned to assume the role of the protagonist.

Since referents in signed language are indicated by direction, not by position in space, the rotation in world coordinates (fixed framework) required is precisely the angle between the addressee locus and the midsagittal plane. Thus, the angle can be computed as

$$v' = \left(P_i - S_d\right)$$
$$v = \left\langle v'_x, v'_y, 0\right\rangle$$
$$\theta = \arccos\left(\frac{v'_y}{\sqrt{\left(v'_x\right)^2 + \left(v'_y\right)^2}}\right)$$

Where P_i is the locus of referent i, and S_d is the position of the dominant shoulder. The z-coordinate is ignored here because we assume that the protagonist and the addressee are of equal height.

The actual division of this angle between the eyes and the neck will change dynamically over the course of the eye gaze shift. The eyes will move first, and then the neck will follow. As long as the angles for the eyes, neck and spine sum to θ, the eyes will maintain the proper orientation towards the addressee.

Ultimately, the rotation of the shoulders will have the dominant share of θ because they define the shifted coordinate frame. It is important to note that although the motion begins at the pelvis, it is actually the orientation of the shoulders that form the shifted coordinate frame. This action, which follows the eye and neck rotations defined above, is composed of a lean in the avatar towards the locus, and spinal column twist to orient the shoulders toward the addressee. A full discussion of this spinal algorithm can be found in McDonald, Wolfe, Schnepp, & Toro, (forthcoming).

8. Annotation to support synthesis

Both analytic and descriptive tiers are enormously valuable for synthesizing role shift. Analytic tiers give us the referent needed to synthesize narratives, while the descriptive tiers are essential for study to build the requisite mathematical models. For example, there is consensus that eye gaze contributes to marking role shift, but without analytic annotation, it is difficult to understand whether a particular eye movement coded in a descriptive tier is functioning as part of a role shift.

When generating eye gaze, sign language synthesis systems need to take into account the fact that many of the gaze codes in descriptive tiers are contrastive rather than geometrically literal. When applied literally, the codes in the ECHO conventions yield geometric interpretations of gaze that are too extreme. A “near 90º” eye gaze is difficult to produce, particularly at normal conversational speed. This is particularly true for adults -- it is not a motion that is easily performed as it requires a rotation of the neck of at least 60º with the remainder of the angle being carried by an extreme sideways glance in the eyes. This is close to the comfort limit for a human both on the neck and the eyes (Washington State Department of Social & Health Services, 2003). A total 45-60º gaze shift is more reasonable as an upper limit, and so synthesis systems should not interpret these annotations literally, but should consider the actual ranges of human motion.

However, both video and motion capture corpora can be extremely valuable for synthesis of eye gaze marking for role shift if they have certain minimal elements coded in their annotations. The protagonists in the conversation need to be identified, and if they have been specifically indexed by the signer, the referent locus for each protagonist needs to be specified in the annotation. For each role shift, both the protagonist and the intended addressee(s) need to be included in the annotation.

If these data are not supplied, then any synthesis system would be forced to estimate the best placements for the protagonists in a narrative, which could lead to inconvenient positions that yield awkward animation. Without these data, a corpus becomes less useful for building and refining procedural techniques.

9. Conclusions and future work

Efforts to synthesize role shift can benefit greatly from annotated corpora. This is true whether the synthesis uses a sparse key technique such as ours or a motion capture system such as the one described in Awad, Courty, Duarte, Le Naour, & Gibet, (2010). Motion capture utilizes large sets of captured sequences of sign that have been annotated for linguistic structure within the fixed referential framework. In contrast, the sparse key technique relies heavily on theory to make decisions on how to manipulate the keys in order to generate the shifted referential framework, and studies of corpora are essential to building the procedural algorithms.

The discussion presented here is an algorithm for producing eye gaze in role shift within a sparse-key animation system. Further study is necessary to refine the algorithm and to extend it to include facial non-manual components of role shift such as personality.

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