The Automation of Non-manual Signals of Declarative Sentences in American Sign Language

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Abstract

American Sign Language (ASL) is the preferred language of the Deaf in the United States and most of Canada. It is a dynamic set of hand positions, body movements, and facial expressions. Currently, human ASL interpreters are required to facilitate communication between the Deaf and hearing. ASL interpreters are in high demand and are not always available, which means that communication among the Deaf and hearing may be impaired or nonexistent. In these situations, a voice-activated display of ASL could help.

A prerequisite to such a voice-activated display is the ability to create well-formed, understandable declarative sentences automatically. Previous efforts have created a method for properly conjugating agreement verbs in declarative sentences [Toro 2004], however the work only addresses the motion and configuration of the hands and arms. An important aspect to the understanding of ASL are non-manual signals; signals that are not expressed on the hands [Valli 1995]. These include facial expressions and movements of the head spine and shoulders. The non-manual signals have a wide-ranging and diverse set of functions, playing a role in phonology, morphology, syntax, and semantics [Baker 1983]. Previous linguistic studies have identified eye gaze and head tilt [Bahan, 1996] but have not researched the subtler, yet important aspects of non-facial non-manual signal production such as shoulder and torso movement. This research examines the types of non-manual signals used in simple declarative sentences in ASL, and develops a methodology to portray them in 3D animations.

The goal of this research is to automate rotations of the shoulder and spine as they relate to non-manual signals. There are three main milestones of this research: a motion study of non-manual signals in simple declarative sentences, geometric characterization of the observed motions, and implementation of the mathematics as animation. The characterization of these motions must be general enough that it can be applied to any simple declarative sentence, as well as robust enough to produce correct results on any figure with human proportions.

The first step involved observing and recording motion of the head, neck, shoulder, and torso of digitized video of ASL declarative sentences. Correlations between the positions of the head, neck, shoulder, and torso were taken with respect to both the left and right hands. We found that non-manual signals are intimately linked with manual signals. The correlations lead to several generalizations of how the body moves with respect to the hands.

Observations from the motion study indicate that, in general, significant shoulder and body movements occur only when the hands are outside the ‘zone of comfort’. We define the ‘zone of comfort’ to be a rectangular area roughly bounded on the top, left, and right by the shoulders, on the bottom by the waist. The establishment of the zone of comfort facilitated four generalizations. We named these as follows: a) fingerspelling, b) two-handed raise, c) one-handed lateral, and d) two-handed asymmetry. Each of these involves positions outside the ‘zone of comfort’.

In the case of fingerspelling, the dominant hand is raised above the ‘zone of comfort’. This requires the additional rotation of the dominant shoulder upward, and the non-dominant downward to achieve natural movement. In the case of a two-handed raise, both hands are raised above the ‘zone of comfort’; this requires rotation of both shoulders upward. The one-handed signal occurs when one hand is outside the width of the ‘zone of comfort’, this case contains a twist in the body. It requires rotations in the waist, spine and shoulders in the direction of the hand position. In the case of two-handed asymmetry, both hands are on one side of the midline of the body. This situation contains a similar, but more pronounced twist in the waist, spine, and shoulders.

These generalizations were used to automate non-manual signals of the current animations. Generally, the shoulders should always be balanced with one another, except when both hands are raised. Additional observations from the motion study included observing motion of the head. The head typically tilts with the shoulders and rotates towards where the hands are pointing. Eventually, the automation will include rotations in the head and neck.

When viewing previous animations without non-manual signals, both Deaf and hearing viewers commented that the animations appeared some-what mechanical. When reviewing our initial animations using the four generalizations, viewers were strongly positive in their comments. They remarked on a more life-like quality of the motion, as well as making it easier to understand the signing.

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