Effective Animation of Sign Language with Prosodic Elements for Annotation of Digital Educational Content

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1. Introduction

Computer animation of American Sign Language (ASL) has the potential to remove many educational barriers for deaf students, because it provides a low-cost, effective means for adding sign language translation to any type of digital content.

Several research groups [1-3] have investigated the benefits of rendering ASL in 3D animations. Although the quality of animated ASL has improved in the past few years and it shows strong potential for revolutionizing accessibility to digital media, its effectiveness and wide-spread use is still precluded by two main limitations: (a) low realism of the signing characters, which result in limited legibility of animated signs and low appeal of virtual signers, and (b) lack of easy-to-use public domain authoring systems that allow educators to create animated ASL annotated educational materials.

The general goal of our research is to overcome both limitations. Specifically, the objective of the work reported in the paper was to research and develop a software system for annotating math/science digital educational content for grades 1-3 with expressive ASL animation with prosodic elements. The system provides educators of the Deaf with an effective means of creating and adding grammatically correct, life-like sign language translation to learning materials such as interactive activities, texts, images, slide presentations, and videos.

2. The ASL Authoring System

The system has been iteratively developed with continuous feedback from teachers and students at the Indiana School for the Deaf (ISD). It includes 3 components:

3D Model Support Component. This component allows importing 3D models of characters and background 3D scenes.

Animation Support Component. This component enables the user to (a) import signs from a sign database, (b) create new signs, (c) create facial articulations, (d) smoothly link signs and facial articulations in ASL continuous discourse, and (e) type an ASL script in the script editor and automatically generate the corresponding ASL animation. (a) The system includes an initial database of animated signs for mathematics for grades 1-2; more signs can be added to the library. (b) If a needed sign is not available in the database, it can be created by defining character hand, limb, body poses. (c) Facial articulations are created by combining morph targets in a variety of ways, and applying them to the character. (d) The animation support module computes realistic transitions between consecutive poses and signs. (e) The ASL system includes a tool that understands ASL script syntax (which is very similar to ASL gloss): the ASL Script Editor. The ASL script editor enables a user with knowledge of ASL gloss, to type an ASL script including both ASL gloss and mathematical equations; the script is then automatically converted to the correct animations with prosodic elements.

Rendering Support Component. This component implements advanced rendering effects such as ambient occlusion, motion blur, and depth-of-field to enhance visual comprehension of signs. It exports the final ASL sequences to various movie formats.

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3. ASL animation with prosodic elements

Although various attempts at animating ASL for purposes of deaf education and entertainment currently exist, they all fail to provide regular, linguistically appropriate grammatical markers that are made with the hands, face, head, and body, producing animation that is stilted and difficult to process (as an analogy, try to imagine someone speaking with no intonation). That is, they lack what linguists call 'prosody'. Prosodic markers (e.g. head nod, hand clasp, body lean, mouth gestures, shoulder raise, etc.) and prosodic modifiers (e.g. sign lengthening, jerk, pauses, etc.) are used in ASL to convey and clarify the syntactic structure of the signed discourse [4]. Research has identified over 20 complex prosodic markers/modifiers and has measured frequencies of up to 7 prosodic markers/modifiers in a two second span [5]. Adding such number and variety of prosodic elements by hand through a graphical user interface (GUI) is prohibitively slow.

Our system includes a novel algorithm that automates the process of enhancing ASL animation with prosodic elements. The algorithm interprets the ASL script entered in the Script Editor (described in section 2) and identifies the signs and the prosodic markers/modifiers needed to animate the input sequence. The prosodic elements are added automatically from ASL prosody rules. Example prosody rules automated by our algorithm are:

- *High-level sentence structure*. Appropriate prosodic modifiers are added to mark the beginning (i.e. blink before hands move) and end (i.e. longer last sign) of the sentence. Periods and commas are automatically translated to their respective prosodic modifier (longer and shorter pauses, respectively).
- *Sentence type.* Interrogative, imperative, and conditional sentences are detected based on punctuation marks (?, !) and key words (e.g. "wh-words", "if", "whether") and appropriate prosodic markers (i.e. raised eyebrows) are added.

The final animation is assembled by retrieving the required signs from the sign database and by translating the identified prosodic elements to corresponding animation markers/modifiers. A multi-track animation timeline is populated with the animated signs and animation markers/modifiers. Most prosody markers are layered on top of the animated signs. Some prosody markers, such as e.g. hand clasp, are inserted in between signs. Prosody modifiers are layered on top of the signs they modify. The supplementary video includes examples of ASL animated sequences enhanced with algorithmically generated prosodic elements.

4. Discussion and Conclusion

The system described in the paper is the first and only animation-based sign language program that produces fluid ASL animation enhanced with automatically generated prosodic elements. The problem of advancing Deaf education decisively can only be solved if the process of increasing ASL animation quality is automated. Scalability to all age groups and disciplines can only be achieved if educational content can be easily annotated with life-like, grammatically correct ASL animation by teachers with no computer animation expertise. Our system provides a solution to this problem because it enables users with no technical background to create high quality ASL animation by simply typing an ASL script.

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