Usability Testing of Computer Animation of Fingerspelling for American Sign Language

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Abstract

Usability tests have been conducted to obtain early feedback on animated computer graphics being developed to present translations of English into American Sign Language (ASL). These animations are part of development of a personal digital translator for the deaf. Since ASL is a visual language, it is particularly important that the animations be visually realistic, recognizable, and comprehensible. It is also important to ensure that the components of the translator are usable by the deaf community.

1 Introduction

American Sign Language (ASL) is a natural language used by members of the North American Deaf community and is the third most widely used language in the United States [1][2]. For the deaf, lack of access to spoken English is a significant barrier to participation in the hearing world. At present, deaf people rely on sign language interpreters for access to spoken English. Interpreters are trained professionals who must be compensated for their work. The expense of hiring a translator along with the planning required to ensure that one is available for an event, make it less likely that a deaf person will have an interpreter available in many situations where one would be beneficial.

The development of closed captioning for television was a pioneering effort in making English accessible to the deaf community. However, this is an incomplete solution since ASL is very different linguistically from English. [3][4]. Because of the huge differences in grammar, the average reading ability of deaf adults in the United States is between the third and fourth grade level [5]. Consequently, the intended benefit of closed captioning is often lost.

We believe that a technology that translates English into ASL, especially for conversation, would provide greater freedom and privacy for the deaf. For example, medical and legal matters could be transacted doctor-to-patient or attorney-to-client

without the need for an interpreter. A personal digital translator would better bridge the gulf between deaf and hearing worlds.

This project presents a variety of challenges, including the use of animated three-dimensional computer graphics (CG), the linguistic distinctiveness of ASL, and the assurance of product usability for a large and varied population. This paper explores the role of early usability testing as a tool for evaluating possible solutions to the technical challenges. Usability testing was conducted during development of a prototype for the handshape animator, a key component of the digital translator.

2 The nature of ASL

American Sign Language is a rich and varied natural language. While ASL shares some vocabulary with English, it is not a direct translation of English words and sentence structure. It presents many of the same challenges of any language translation process, but adds the complexity of changing modality from aural/oral to visual/gestural [6]. Since ASL is meant to be seen, visual clarity is a critical factor [7].

Word/phrase signs in ASL can express an extraordinary range of meaning by using facial expressions and the natural geography of the body, in addition to the hands. As practiced by fluent signers, word/phrase signs are economical and of endless variety. Positioning and facial expression convey differences in sentence type (e.g. question vs. exclamation), as well as level of intensity. Word/phrase signs account for the majority of a typical ASL conversation [8].

Another component of ASL is fingerspelling. Fingerspelling is the use of the hands to spell out English words letter-for-letter. It is used for proper nouns, technical terms, acronyms, initialized signs, loan signs**,** and in situations where no word/phrase sign exists [9]. Fingerspelling slows ASL conversation, but is necessary for complete communication.

Although word/phrase signs and fingerspelling have very different roles in ASL communication, they share a common physical building block, the shape of the hand. All signs and fingerspelling are composed of one or more handshapes. Additional information is conveyed by facial expression, hand orientation and position, but the handshape is a key component.

3 Computer graphics technology

We believe that computer graphics is the most appropriate technology choice for presentation of ASL on a digital translator. Its support for immediate creation of new animations based on both existing rules/conditions and changing input from outside sources provides the flexibility necessary for ASL sign translation. We believe that CG has the potential for:

- Conveying the grammar of ASL more fully, e.g. questions, verb tenses.
- Supporting translation beyond “phrase book” type, scripted applications.
- Providing support for more combinations of signs and development of new signs based on combinations of handshapes and physical positioning.

While CG best supports a broad spectrum of the users' communication needs, it carries with it two major challenges, which are:

Development of representations of the fine motor movements of the hand. CG has been used frequently to emulate body physiology for movie work, where the appearance of gross motor movement has been the only requirement. Any acceptable representation of ASL requires small subtle movement of the hands and other parts of the body.

Lack of physicality – objects can pass through each other. This problem, called "collision avoidance" is similar to the challenge presented to virtual reality applications when virtual objects must be grasped while the hand is constrained by the implied boundary of the object.

4 Usability concerns

Usability is a central concern of the ASL project. In concept, the personal digital translator could become a constant resource for the deaf as they carry out day-to-day tasks. The user would see an animated figure signing/fingerspelling to translate any conversation or input document that was encountered. ASL presentation would be based on observation of a figure that has the capabilities and constraints of a human body. Realism is an important goal, to the extent that it contributes to accurate handshapes, expressions, and body position. It is also crucial that the user not be distracted by oddities of the representation of the body.

The user will also have to be able to recognize signs and fingerspelling at a high presentation speed in order to carry on conversation. Transitions between handshapes and body positions also must be recognizable.

Signs and fingerspelling combinations must be comprehensible. Comprehensibility refers to the user's ability to recognize the signs/fingerspelling and the ability to assemble them into meaningful words, phrases, or sentences.

5 Fingerspelling as a prototype application

In order to find solutions to the technical problems noted above and to ensure that those solutions would meet user needs, the team decided to choose a limited domain, fingerspelling, for prototyping. Creation of a fingerspelling prototype would be an opportunity to develop a scale model of the problem set and iteratively refine solutions that would apply to the animation of hand shapes used in ASL. It would also provide the opportunity to get user feedback on the resulting representation of fingerspelling, with respect to its realism, recognizability and comprehensibility.

As discussed previously, fingerspelling is a small but essential portion of ASL. The handshapes used in fingerspelling are derived from the same basic set of handshapes that form word/phrase signs. Solving the problems of accurately portraying fine motor movement and collision avoidance for fingerspelling will lead to a breakthrough in animating entire sentences in ASL.

Furthermore, fingerspelling is one of the first things that people typically learn about ASL, so users would be very likely to know the handshapes presented and the meaning of each should be clear. Fingerspelling would generate specific words that could be verified, vs. signing, where interpretation could vary slightly from user to user. Differing results based on individual differences in sign interpretation could then be confused with variance due to incorrect handshape. Finally, verification of fingerspelling results would be relatively straightforward.

The prototype development process itself led to improved technical solutions. When creating the handshapes, we developed a more accurate hand model than those previously available [10]. When animating the hand, we developed a simplified collision avoidance approach that capitalized on a data-driven solution instead relying on a general brute-force technique [11]. The next step was evaluation of the results of the technical solutions from a user perspective.

6 Usability testing

Usability testing is an evaluation technique frequently used in the field of Human-Computer Interaction. It provides empirical data as a result of product testing by representative members of user communities and has been found to be an effective way to identify problems with minimal time and effort by a small number of testers [12]. Quantitative and qualitative results are typically studied using cluster analysis techniques.

We conducted an exploratory usability test to evaluate the fingerspelling prototype. Exploratory usability tests are conducted early in the development cycle when the design of the product is still very fluid. Such tests are one type of formative evaluation. Other types include assessment and validation.

Formative evaluation is conducted while the product is still in development, during its formation. This contrasts with summative usability tests which are conducted to compare existing products and to summarize their similarities and differences. In a light-heartedly analogous situation, a dinner party, the chef conducts formative testing, while the guest performs a summative evaluation.

The goal of formative usability testing is to identify and resolve usability issues during product development. This contrasts with scientific experiments which are performed to determine whether a null hypothesis about a set of variables should be rejected or not. Usability testing is particularly well suited to support iterative problem discovery and resolution. [13]. The goal of our usability test was to gather feedback on the realism, recognizability, and comprehensibility of the sign images and animation created using the team's CG approach.

One of the basic requirements of usability testing is that its participants be members of the user population [13]. That is especially true for this project. Skilled signers, especially deaf signers, are very sensitive to the subtleties of the handshapes, positions, and expressions that make up ASL. These same subtleties would be lost on most of the hearing population. However appealing the animations might appear to a hearing person, we knew it was imperative that the usability testing be conducted with deaf people who would be likely to use the translator.

7 Usability testing of fingerspelling animations

The ASL team determined that evaluation of realism, recognizability and comprehensibility of the CG-based handshapes would best be accomplished by showing the test participants the handshapes in multiple formats. This would give the testers a variety of views of the handshapes and lead to richer results. The testers would be asked to view animated fingerspelling to provide feedback related to realism, recognizability, and comprehensibility. The testers would also be asked to view still images of the handshapes underlying the animations to cross-validate the feedback on realism and recognizability. Testers would also be asked to comment on preferences for color and hand details.

The team also decided that the fingerspelling animations would have to spell out words, not nonsense syllables, in order to test comprehensibility. The words would be commonly used and would have an equivalent word/phrase sign that could be used to give feedback to the test facilitator.

In addition, the team wanted to evaluate the speed of presentation and whether various rates of speed had an impact on recognizability and comprehensibility.

7.1 Usability test preparation

The following steps were completed in order to prepare for the usability tests:

- A high-level test plan was prepared.
- Six common words, TRY, MAD, TEST, COKE, DEAF and BICYCLE, were chosen for the prototype. Each has a word/phrase sign equivalent.
- An animation was developed for each word using the CG techniques developed by the project team.
- Three versions of each word animation were developed from the base animation. Each version presented the same fingerspelling, but at a different speed. The three speeds were consistent across the six words.
- Still images of each of the “letter” handshapes were produced with a grey background. These were printed and mounted on poster board.
- A detailed test protocol was prepared.
- Opportunities to conduct usability tests with appropriate users were identified.

7.2 Usability test participants

We identified potential sources of test participants through contacts with the deaf community. We determined that it would be more efficient to take our usability test to gatherings of deaf people who would be potential participants rather than to try to attract deaf individuals who would be willing come to us to perform the tests. The materials required for the tests, a portable PC, still images on heavy paper stock, and data log forms, were very easy to transport and setup at the test sites

In most usability tests a written background questionnaire would be used to gather information about each participant prior to the test. A post-test questionnaire would also be administered after the test to solicit feedback. Participants would complete the

questionnaires in writing. In recognition that many deaf people do not like to write in English, the questions on the questionnaires used for this test were signed to each participant by the facilitator and the signed responses were noted.

Many deaf people are particularly reluctant to give criticism of the work of others. Extra attention was given to assuring the test participants that their comments would help to improve the product and were no reflection on those who had made the comments..

We were able to conduct our usability tests with two different groups: deaf high school students and participants at Deaf Expo, an annual conference that explores many of the issues and needs of the deaf community. Both tests took place in November 1999.

A deaf facilitator conducted the test and a data logger noted observations. An ASL interpreter was also present since the data logger did not know ASL and did not understand the communication between the facilitator and the test participants.

7.3 Usability test protocol

The usability test protocol for both groups was the same with one exception (noted below). Each participant was:

1.Given a brief background test/interview by the facilitator using ASL. (ASL skills were evaluated by the facilitator and conveyed to the data logger during this conversation.) This included questions about education how long the participant had been deaf.

2.Shown an animation (on the laptop PC) which presented fingerspelling of one of the six test words.

a. The participant was asked which word the animation represented.
b. The participant signed back the word, if possible. In some cases it was fingerspelled back.
c. The response was noted by the data logger.
d. If the participant did not recognize the word, the animation was repeated.
e. If the participant still did not recognize the word, an animation at a different speed was shown.
f. If different speed animations were shown, the participant was asked which one they preferred.
g. The above steps (a.- f.) were completed for six word animations (TRY,MAD,TEST,COKE,DEAF,BICYCLE). The words were presented in this order for all subjects.

3.Asked about the background color(white) of the animations.
Depending on the response, Step #4 below might be omitted.

4. Shown four images of the same handshape with four different background colors (BLUE, GREY, PINK,MAROON).

a. Asked which of the four background colors they preferred.
b. Feedback was noted by the data logger.

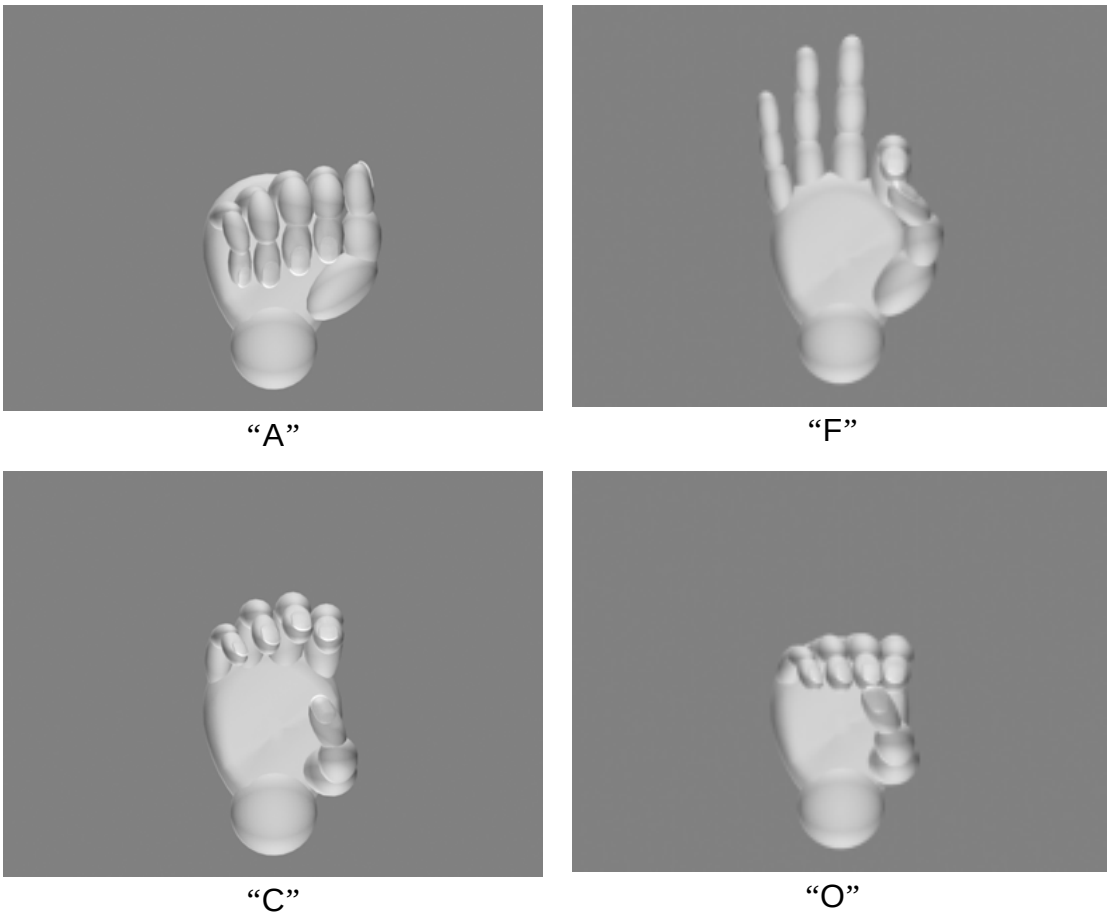
5. (For Deaf Expo only) Shown two "Fingernail" still images. These were images with “moons” at the base of the nail or “no moons”.
   a. Asked which they preferred.
   b. Feedback was noted by the data logger.

6. Shown posters containing images of each of the “letter” handshapes (See Figure 1 for some examples).
   a. Asked to identify each.
   b. Responses and comments were noted by the data logger.

7. Interviewed for post-test feedback and overall comments.

8. Asked not to discuss the test with other prospective testers.

9. Thanked and given a souvenir.



“A” “F”

“C” “O”

Figure 1: Fingerspelling images

7.4 Usability test results

Seven deaf high school students, all members of a class for deaf students at Prosser Academy, a Chicago high school, tested the images and animation first. Before each test began the student participant went to an area of the classroom that had been screened from the other students. The test was conducted in this area. The ASL proficiency of the high school student participants was generally moderate. While their ASL skills varied, most students could recognize the fingerspelled word on first or second presentation. Most preferred faster animation speeds. The teacher of this group, a highly skilled ASL signer, also tested the images and animation. She also strongly preferred the fastest animation speed.

Based on the usability tests by the deaf high school students and teacher, an animation that fingerspelled at an even faster speed was created and used during the tests at Deaf Expo. The fastest speed presented at Deaf Expo was 2.5 letters per second. This is comparable with studies of recognition rates for fingerspelling [14].

Seventeen Deaf Expo attendees also evaluated the fingerspelling animations and images. The attendees were solicited for participation through a public announcement by the test facilitator, who was making a presentation at the conference. All of the test participants came to a booth that had been setup at the conference by the ASL team. The tests and image reviews were conducted at the booth. All participants at Deaf Expo were highly proficient in ASL.

The following items were findings from tests with both the high school student participants and the Deaf Expo participants.

- Most users were able to read the fingerspelled words in one or two presentations (comprehensibility).
- Most users were able to read the words at high speeds of presentation (comprehensibility).
- There was specific feedback that the fingerspelling handshapes “C”,”O”, and “E” were hard to distinguish (recognizability). This had a negative impact on the comprehensibility of some words, specifically COKE.
- Some users commented on the unusual appearance of the thumb, which was particularly apparent in “Y” and “L”(realism). Users also had difficulty recognizing and reading the word containing “L” and “Y”. However, this word was the longest of the six words presented, so the effect of unusual appearance may have been confounded with word length.
- Participants preferred a blue background for the handshape images over grey, pink or maroon.
- All participants were enthusiastic about the potential development of the personal digital translator.

8 Conclusions and Related Work

We are proceeding with fine-tuning of the handshapes, based on user comments on the realism of specific components, particularly the appearance of the thumb in some handshapes and the letters “C”, “O” and “E”.

The results of the usability test and user comments gave a clear indication that the approach we are using for hand animation is a promising first step toward a usable product. We will continue to use this approach in our future work--development of a sentence animator.

The positive response of the participants to the usability test itself and the valuable information gathered during the test sessions also support our continuing use of usability testing as a part of the development of the digital translator.

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