2008 International Tech Symposium
Instructional Technology and Education of the Deaf
National Technical Institute of the Deaf (NTID)

Utilizing Lifelike, 3D Animated SigningAvatar Characters for the Instruction of K-12 Deaf Learners

Jason Hurdich, Team Leader, Sign Language Projects
Vcom3D, Inc.

Vcom3D, Inc. is a leader in research and development related to the instruction of K-12 Deaf and Hard-of-Hearing (Deaf/HH) students. Our SigningAvatar® characters provide a striking increase in many children's attention span, their level of engagement, and academic results. During an evaluation at the Florida School for the Deaf and Blind, the increase in comprehension when shifting from *text-only* to *text accompanied by sign language* by use of the SigningAvatar technology was 17% to 67%.

Part 1: National Science Foundation Research Project: "Lifelike, Expressive Avatars for the Instruction of K-12 Deaf Learners"

Vcom3D, Inc. received funding from the National Science Foundation (NSF) to conduct a research project whose goal was to identify signing styles of teachers of both genders communicating in American Sign Language (ASL) with young students. This project, conducted in partnership between Vcom3D and the Laurent Clerc National Deaf Education Center at Gallaudet University from January 2007 through December 2007, was based on the "Shared Reading Project" principles created by David Schleper (1997).

Mr. Schleper has identified fifteen important principles that effective teachers and parents use for reading to Deaf children using ASL. These ASL readers go well beyond strictly interpreting English text so Vcom3D identified several of these principles as those that could be addressed using our Sign Smith Studio authoring tool:

- Deaf readers re-read stories on a storytelling to story reading continuum.
- Deaf readers make what is implied explicit.
- Deaf readers adjust sign placement to fit the story.
- Deaf readers adjust signing style to fit the story.
- Deaf readers connect concepts in the story to the real world.
- Deaf readers use attention maintenance strategies.
- Deaf readers engage in role-play to extend concepts.

During the same project, researchers found that appropriate use of facial expressions is an important communicative skill for teachers working not only with Deaf/HH, but also with hearing students. Although the importance of facial expression is recognized, more research is required in order to develop a comprehensive language model of how the face is used to communicate in different contexts and in different "registers".

In order to enhance the expressiveness of our Virtual Tutor (also known as SigningAvatar characters) simulations, Vcom3D is researching the nuances of how the face and body are used in communication - in ASL, and teaching in general.

The outcome of our research, based on videotaping teachers, is to improve the quality of our Virtual Tutors in areas such as modeling of facial expressions, connection of these expressions with their meanings, and to support the instruction of children and teachers using our Sign Smith Studio product.

The result of additional funding, for which we have applied, will allow Vcom3D to continue development of our Virtual Tutors and Sign Smith Studio authoring tool. We are developing detailed simulations of the face and body animations, and will evaluate the effectiveness of these simulations in interactive multimedia environments designed for Deaf/HH students.

Another key result of this research will be to improve our Sign Smith Studio authoring tool, which allows the ASL author to add the context, nuances, and explanations that might not be explicit in the English text, and further explain them for the Deaf student.

We will research added interactivity in which the Deaf child can respond to questions signed by the Virtual Tutor, allowing the Virtual Tutor to act as language arts and reading coach.

Currently, Vcom3D is implementing proof-of-concept software for simulating variations in facial expressions and signing styles that appear to be the most effective in the reading sessions derived from videotaped activities at the Clerc Center.

Part 2: U.S. Department of Education funded research: "Mobile Language Reference for Deaf and Hard-of-Hearing K-12 Students"

Relevant to our "Lifelike, Expressive Avatars" project, Vcom3D is also researching and will show evidence of the initial success in utilizing mobile devices, such as the Apple® iPod, in terms of making information accessible via the means of portable and mobile delivery in ASL within K-12 educational settings.

The Phase I proof-of-concept mobile language reference prototype, funded by U.S. Department of Education (October 2006 - March 2007), includes definitions and explanations of idioms, scientific terms, multi-sense and unfamiliar terms which Deaf/HH students often have trouble understanding.

Evaluation of the Phase I proof-of-concept has been highly favorable, with the following average evaluations by upper elementary and middle school educators of Deaf/HH students (Hurdich and Sims, 2007):

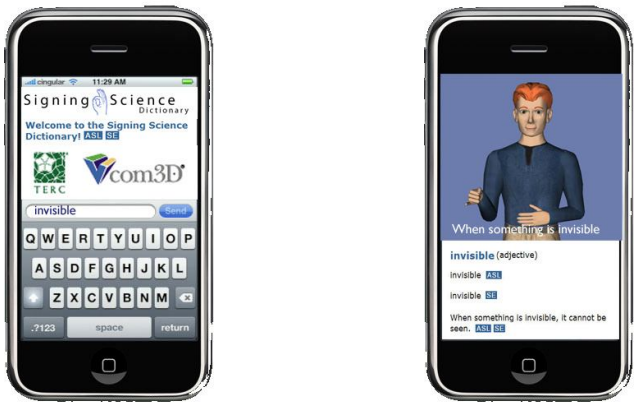
- Ease of Use: 8.3 out of 10
- Supported Reading Comprehension 7.7 out of 10
- Motivation 10 out of 10

In October 2007, Vcom3D, Inc. began the Phase II SBIR project (which runs through September 2009) to develop an exemplar Mobile Language Reference for Deaf/HH K-12 Students using the Apple iPod Touch.

This reference tool includes animated translations from English to ASL of multi-meaning terms, idioms and difficult words that Deaf students often face in literacy. The goal is to not only boost a student's ability to learn ASL grammar, but also to reinforce a bilingual, bicultural educational approach.

We are currently developing software authoring tools that will allow educators and educational software developers to efficiently create new dictionaries, glossaries, and other reference materials for use with the Apple iPod Touch.

Below is an example of a dictionary application that is currently being developed for Phase II, shown on an Apple iPod Touch.



Foundation of Vcom3D Research:

In previous work funded by federal grants, our team has successfully modeled the common facial expressions used in ASL, and demonstrated that these could be used to communicate language features such as questions, modifiers, and other essential meanings.

Since the initial development of our Sign Smith Studio authoring tool and SigningAvatar characters, the computational power of computers has advanced dramatically, to a point where not only the "citation form" of expressions in ASL but also fine nuances of emotional and affective displays of ASL can be simulated in real-time.

Using the developed proof-of-concept system, we created an animated version of a videotaped story signed by a male teacher at Kendall Demonstration Elementary School (KDES). The animated version of the video is 4 minutes of a story called "*The Forest*". Vcom3D analyzed the video and wrote an English transcript of the story.

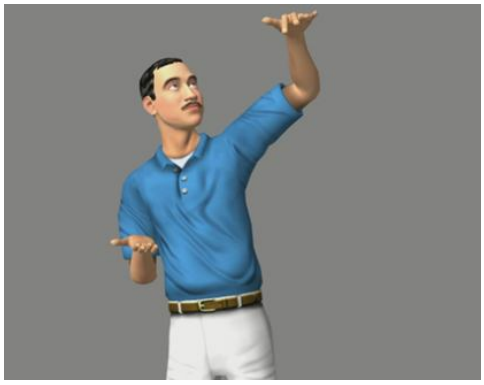
Figure 1 shows an example frame from the live video, as well as an animated version created using the proof-of-concept tool.

The result, which can be viewed at www.vcom3d.com/vault_files/forest_asl/, is a highly compelling animation that captures almost all of the grammar and nuances of the signer's performance.

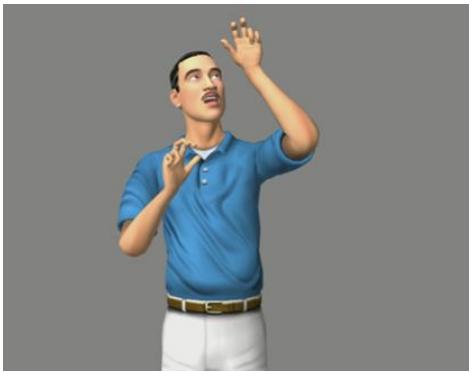
Figure 1: Real and animated version of Jason Stewart signing "disappearing into the horizon"

"Bird flying"- using head shifting and role-playing a flying bird

"Tree shaking"- used enhanced non-manual markers, body movement and puffed cheeks



"Birds soaring ahead over rotten fruit"- used eye gaze, classifiers and directionality to indicate where the items are.



"Climbing tree"- used classifiers, head tilt, eye gaze and enhanced non manual markers.

After conducting "The Forest" story evaluation, teachers responded to several questions that asked them to indicate their perception of what their students had gained from the 3D animation and avatar; the effectiveness of the interface and features. They were asked to answer the following questions listed in Table 1 on a number scale from 1 to 10, with 1 being low and 10 being high.

Table 1: Educators' Survey Data Summary

Question	Average
1. Was it easy for your student to view the life-like expressive avatar(s) for reading comprehension?	9
2. How motivated were your students to use life-like expressive avatar(s) for reading?	9.8
3. How much do you think the life-like expressive avatar(s) supported the reading comprehension of the students who used it?	9.3

Avenues for feedback from students and teachers included surveys for teachers where they could add quotes taken from the students. Participants offered a broad range of written responses to questions contained in these data collection instruments. The following is a representative sample of observations and recommendations.

From Students:

- "It helped me to correlate with the signing and reading English. It also helped me to reinforce what I was reading allowing me to compare stories. I thought the avatar looked like a real person."
- "The avatar signed clearly and I was able to fully understand the story better. I felt I was able to learn more."
- "I would much rather have the avatar sign to me over a Deaf person if I had an iPod based on the avatar's ability to show actions and expressions."
- "I would much rather view ASL than reading English, and would rather have avatars during testing. It did help me understand the questions better."
- "I felt I was able to understand the story more in depth, helped me to read better, and the avatar made no mistakes in signing. It was so cool!"
- "The avatar was funny and expressive; it does help encourage me to learn."
- "I would rather have the avatar sign stories to me than the teacher."
- "I would like to have sounds added because I am hard of hearing."
- "I would like to have seen a female avatar and would like a zoom-in feature."

From Teachers:

- "What I liked most about the avatar was he had smooth movements, clear signs, and the face was very expressive."
- "My students liked the animation -- the story became more interesting and understandable."
- "The signing of the avatar and face expressions was clear."
- "The avatar was identical to the actual signer."
- "I think over time that life-like expressive avatars could support the development of English reading comprehension for unaided reading."
- "The project was very useful for my students; it helped a student who had trouble understanding the text during the post-test."

Rationale:

Since Deaf children have difficulty developing phonemic awareness, and are often isolated from contextual information available to hearing students, teaching reading to Deaf children requires the application of several unique methods that go far beyond simply translating English text.

By providing educators with appropriate technology products, it will allow them to create curriculum content using the SigningAvatar characters as "intelligent reading tutors" or Virtual Tutors. By utilizing mobile, hand-held devices, the content will be available "anytime, anywhere" for assisting Deaf children in developing literacy skills.

Methodology:

Facial expressions are represented by deforming a 3D mesh that is an approximation of a real person's face geometry. The meshes are deformed in real-time by moving selected vertices to approximate the desired expression.

Figure 2. Comparison of current and enhanced versions of "lots" (puffed cheeks) expression.

Recent advances in the graphics capabilities of personal computers have allowed us to increase the detail of the face significantly, as shown in Figure 2, by using denser meshes to model the geometry, and by applying textures developed from photographs of real faces. Under independent funding, we have created face models that are much more expressive and that appear to be more engaging and to communicate more accurately (both in ASL and in animated speech).

As we are developing face models, we will include male and female adults and children, and will also reflect different ethnicities. For each face, we are modeling at least 60 facial expressions that can be varied in intensity, as shown in Figure 3, and can be combined to increase the range of expression.

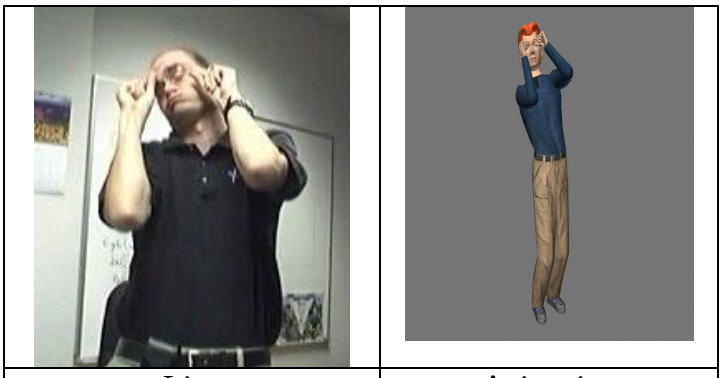
These face models and animations will be based on recent work that we have completed as part of our "Accessible Semantic Web" project, which simulates over 180 facial deformations.

Figure 3. New facial expressions can be controlled parametrically, as shown here for "surprise".

Similarly, we will use the results obtained from the Clerc Center where we identified signing styles and other body motions that are used to promote the Deaf students' understanding and engagement.

These results will be used to characterize how different degrees of facial expressions are emphasized or modified to promote engagement and understanding in literacy

As an example, Figure 4 shows a signer illustrating a response to a sudden bright light from an explosion, including squinting the eyes and leaning back away from the light. Recently Vcom3D has developed an extension to its inverse kinematics (IK) simulation of body motion that is based on a "verbs" and "adverbs" model of "action" signs (Rose et al., 2001).



Live	Animation

Figure 4. Enhanced body animation.

This animation system allows motions to be interpolated between two different "styles", while maintaining critical physical properties (e.g., touch points, floor contact) of the motions.

We are developing parametric models of key signs that can vary over a range of emphasis.

Project Findings from Evaluations to Date:

Prior research conducted with TERC, Inc. a non-profit organization located in Cambridge, Massachusetts, focuses on mathematics and science education. This includes research, curriculum and technology development, and implementation support in the form of professional development and assistance to districts and schools. An article summarizing this effort can be found at http://www.vcom3d.com/docs/ISTE_article.pdf. This provides evidence that the technology is effective.

Significance and Implications:

The NSF-funded research will result in improved, computer-based reading instruction for the 50,000+ K-12 Deaf/HH students in the U.S. whose first language is ASL. Currently, Deaf children are delayed in developing language skills, to the extent that the average reading level of a Deaf high school graduate is no greater than 4th grade.

The Dept. of Education-funded research will result in a Mobile Language Reference tool that can be taken anywhere to supplement the curriculum of the Deaf/HH student. It will contain a library of definitions that are often difficult for these students to master.