CopyCat : Learning American Sign Language (ASL) through a Gesture-Based Computer Game

For

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ABSTRACT

CopyCat is a research prototype combining an interactive computer game with sign language recognition technology. This paper presents the development process of the game. CopyCat allows deaf children to communicate with the computer using American Sign Language (ASL) and encourages them to practice ASL in an enjoyable way. Focusing on a user-centered design method, we performed several pilot studies in collaboration with the Atlanta Area School for the Deaf (AASD) to develop compelling game play that also accounts for the limited accuracy of the sign recognition system. The resulting game shows promise: the children continued to play beyond what we required for our pilot studies; our ASL linguist consultant observed improvement in the children's signing clarity, and the initial results from the sign recognition system suggest that it will perform at the required level of accuracy.

Insert video1 here: CopyCat Introduction Video

KEYWORDS

ASL, language acquisition, computer game, user-centered design, gesture recognition, Wizard of Oz test

BACKGROUND

Ninety percent of deaf children are born to hearing parents who do not know or are not fluent in sign language (1). Often these children's first exposure to native signing is at school. Since early childhood is a critical period for language acquisition, early exposure to ASL is a key for deaf children's linguistic development (2,3). Learning a language and developing a cognitive model through active interaction relies on the exchange between learner and model which synergically affect each other (4). Children construct their own understanding through interaction with their environment (5). When designing educational applications concerning how children think and learn, it is important to provide them with environment allowing them to think about thinking and learn about learning (6).

A 1999 Kaiser Family Foundation report estimated that seventeen percent of children ages two to seven and thirty-seven percent of children ages eight to thirteen play computer games everyday (7). However, since many educational computer games rely on spoken or written English, the educational benefits of these computer games are rarely accessible to deaf children whose native language is ASL.

RESEARCH QUESTION

ASL is a structured language complete with linguistic features that are distinct from English. Based on the characteristics of ASL, the object of this study is to verify the instructive benefits of the game which allows deaf children to improve their linguistic skill while playing the game. In addition, since the data acquisition process of the prior sign language recognizer was time-consuming and laborious, we expect to accelerate the development process of our sign language recognizer by obtaining sufficient

signed data in faster and easier way from children's input while they participate in the pilot test.

Another objective of this study is to inspect the effectiveness of the Wizard of Oz (WOz) method for this user-centered development approach. In several on-site simulations, the research team used this method to evaluate participants' performance in qualitative ways for game interface development and in quantitative ways for sign language recognizer development.

DESCRIPTION

CopyCat aims to assist young deaf children's language acquisition by interactive tutoring and real-time evaluation. Children practice ASL in a fun an enjoyable way while interacting with animated character. Unlike many educational games relying on English grammar skills or spoken audio files, CopyCat provides text-free interface supported by gesture recognition system which allows deaf children to transfer knowledge through their native language. While playing the game, the player wears colored gloves with wrist-mounted accelerometers to control the action of the game.

The title CopyCat refers to Iris, the main character of the game. Iris is a white cat who knows ASL and whose kittens are hiding in the backyard. The player's role is to help Iris find her kittens by signing a phrase such as "Black kitten under the chair." The game interface includes picture buttons, a push-to-sign button, a video tutor, a live video feed, and character animations. The push-to-sign button activates the gesture recognition system before the child begins signing and deactivates after signing. This process allows the system to filter unnecessary gestures and capture only pertinent signing.

Insert photo1 here: Colored Gloves and Accelerometers

To help Iris, the player first clicks a picture button. The video tutor demonstrates the phrase that the player should sign to Iris. The player can see the video tutor as many times as he wants. Before signing to Iris, the player clicks the push-to-sign button to activate the gesture recognition system. Once the recognition system is activated, the player signs to Iris letting her know how to find her kittens. The player can watch himself signing through the live video feed in the game interface. After finishing the sign, the player clicks the push-to-sign button again to deactivate the gesture recognition system. While the gesture recognition system is activated, a video camera captures the vision-based data and accelerometers capture location-based data. Data obtained from these sensors is transmitted to the gesture recognition system that analyzes data, triggers real-time evaluation, and forwards the result to the game interface. If the sign is correct, Iris will understand and go save her kittens. Otherwise, she will look puzzled and encourage the player to try again.

Insert photo2 here: ASL Game Interface

METHOD

Focusing on user-centered design, the research team has iterated the game interface and development strategy through several studies with deaf children at AASD. From November 2004 to March 2005, seven deaf children at AASD participated in the tests. A method called Wizard of Oz (WOz) was used for our pilot studies. While the child plays the game, a human Wizard simulates the computer recognizer and evaluates the correctness of the player's sign manually. The WOz method allows the research team to develop the game interaction and gesture recognition system separately. The first and

second trials explored the game design alone, while the third and fourth trials required the children to wear the gloves needed to recognize the sign.

Insert photo3 here : AASD Pilot Test Setting
Insert photo4 here : Interaction Diagram for Pilot Test (November ~ December, 2004, 1st and 2nd trial)
Insert photo5 here : Interaction Diagram for Pilot Test (February ~ March 2005, 3rd and 4th trial)

RESULTS AND DISCUSSION

The feedback from the children illustrates both the effectiveness of game-based ASL tutoring and suggests improvements for the next design. Although the children sometimes omitted a sign or mis-signed part of the phrase, they were willing to use the video tutor multiple times to correct their signs to communicate with Iris. In attempting phrases multiple times, the children showed more persistence and clarity in signing than we had expected. We also discovered several signs which appeared very similar to our recognizer (e.g."go", "green", and "blue") due to the children's disfluency. Our recognition system needs to be developed with stricter evaluation criteria to encourage more precise signing.

The WOz method allows us to observe and collect sufficient data while the children play the game. It was an effective and rapid way to perform on-site testing of both the game interface and gesture recognition system. For future work, we are working to provide richer visual and narrative content in the game interface and an expanded vocabulary set. We will also be collecting natural sign to improve the accuracy of our gesture recognition system. The eventual goal of CopyCat is to integrate all features in one application which is ready to be installed on users' personal computers.

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GRAPHICS and VIDEO PAGE

Video1: CopyCat Introduction Video

(See external video file : RESNA2005_SeungyonLee_Video.swf)

Photo1 : Colored Gloves and Accelerometers

Alternative Text Description for Photo 1: Colored Gloves and Accelerometers
Colored gloves with wrist-mounted accelerometers

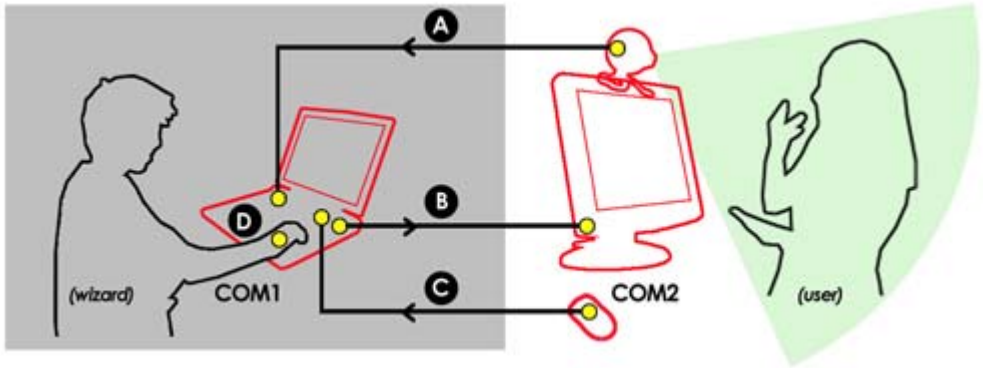
Photo2 : ASL Game Interface

Alternative Text Description of Photo2: ASL Game Interface
The ASL game interface includes A) Tutor Video, B) Live Video Feed, C) Push-to-Sign Button, D) Animated Character and Environment, E) Pictorial Buttons.

Photo3 : AASD Pilot Test Setting

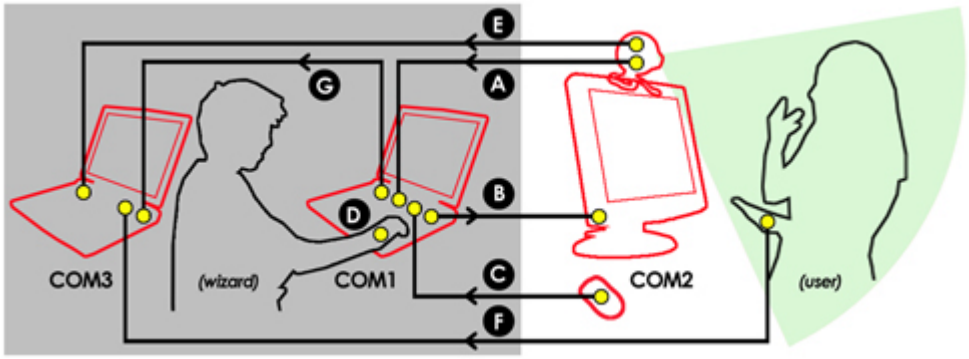
Alternative Text Description of Photo3: AASD Pilot Test Setting
The user wears colored gloves with accelerometers and plays the game using wireless mouse. A video camera is mounted on top of the monitor and transmits live video to the game and gesture recognition system at the same time.

Photo4 : Interaction Diagram for Pilot Test (November ~ December, 2004, 1st and 2nd trial)



Alternative Text Description of Photo4:Interaction Diagram for Pilot Test (November~December, 2004,1st and 2nd trial)
All equipment except monitor, camera and wireless mouse for user are hidden behind the wall. Human Wizard observes user's signing and evaluates it manually. (COM1 : Game interface, COM2 : System for user, A: Live video feed from user to game, B: External monitor for user, C: Wireless mouse for user's input, D: Keyboard for Wizard's input)

Photo5 : Interaction Diagram for Pilot Test (February ~ March 2005, 3rd and 4th trial)



Alternative Text Description of Photo5: Interaction Diagram for Pilot Test (February ~ March 2005, 3rd and 4th trial)
All equipment except monitor, camera and wireless mouse for user are hidden behind the wall. Human Wizard observes user's signing and evaluates it manually. (COM1 : Game interface, COM2 : System for user, COM3: Gesture recognition system, A: Live video feed from user to game, B: External monitor for user, C: Wireless mouse for user's input, D: Keyboard for Wizard's input, E: Live video feed from user to gesture recognition system, F: Accelerometer data from user to gesture recognition system, G: Signal synchronization from game interface to gesture recognition system)