Gestures with Speech for Hand-Impaired Persons

Darren Guinness
Dept of Computer Science
Baylor University
Waco, TX 76798 USA
darren_guinness@baylor.edu

G. Michael Poor
Dept of Computer Science
Baylor University
Waco, TX 76798 USA
michael_poor@baylor.edu

Alvin Jude
Dept of Computer Science
Baylor University
Waco, TX 76798 USA
alvin_jude@baylor.edu

ABSTRACT
Mid-air hand-gestural interaction generally causes a fatigue due to implementations that require the user to hold their arm out during this interaction. Recent research has discovered a new approach to reduce fatigue related to gestural interaction, by allowing users to rest their elbow on a surface, and calibrate their interaction space from this rested position [1]. Additionally, this approach reduced stress on the hand and wrist compared to the mouse, by shifting much of the load to the forearm and shoulder muscles. In this paper we evaluated gesture and speech multimodal interaction as a form of assistive interaction for those with hand impairments. Two participants with hand impairments were recruited to perform the evaluation. We collected qualitative and quantitative data, which showed promising results in using this method for assistive interaction.

Author Keywords
Gestural Interaction; Speech-based input; Assistive interaction;

ACM Classification Keywords
K.4.2 Social Issues: Assistive technologies for persons with disabilities

INTRODUCTION
Our previous work attempted to solve the gestural fatigue problem known as "Gorilla Arm Syndrome," which causes arm and shoulder fatigue over prolonged periods of interaction. To reduce this fatigue, we developed the Personal Space approach to gestural interaction, which allowed the user to rest their elbow on the table during the interaction [1]. This rested gestural interaction also attempted to reduce repetitive wrist movement compared to the mouse, which has been strongly associated with hand impairments [2]. This was achieved by shifting primary motions from the wrist and hand to larger muscle groups such as the forearm and shoulder areas. Several studies were conducted using this approach and uncovered interesting results; fatigue was greatly reduced, performance degradation when switching hands was minor when compared to the touchpad and mouse, and pairing gestural cursor navigation with speech based selection yielded no significant loss in throughput.

Each result by itself was interesting, but the combination showed promise for those with hand impairments. To evaluate gestures with speech as an assistive interaction we conducted a small case study using two participants with hand impairments and the new gestural approach. Hand impairments reported were fibromyalgia, osteoarthritis, and carpal tunnel syndrome. Participants performed an experimental task designed to reflect normal computer usage using 4 different interaction styles: mouse hover, mouse click, gesture hover, gesture multimodal. Initial results were promising with both participants expressing that the reduction of wrist movement was beneficial when using the gestural multimodal interaction. Several improvements were also discovered in the study with the help of participants and a speak-aloud procedure. These findings are detailed in the evaluation section.

EXPERIMENT
Participants
Two participants (both female) between 50 and 65 years of age with hand impairments were recruited to participate in the study which lasted approximately 1 hour.

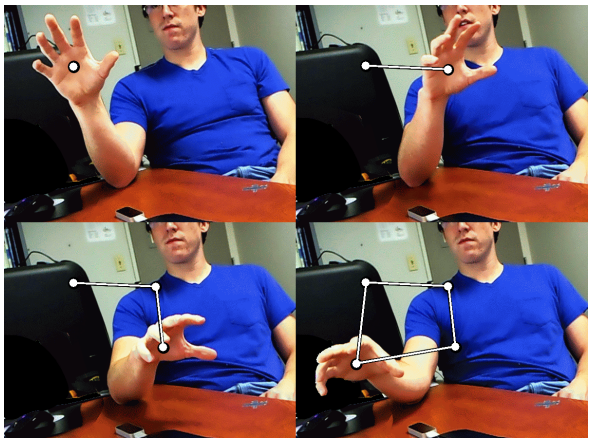
The Interaction


Figure 1. During calibration, the software guides users to position their hand at the 4 corners. Users can then rest their elbow on the table during the task, which reduces fatigue.

In tasks that use a mouse, a regular off-the-shelf mouse (LogitechM-U0032-O) was employed. Gesture-based navigation implemented the Personal Space approach using the

ASSETS '14, Oct 20-22 2014, Rochester, NY, USA
ACM 978-1-4503-2720-6/14/10.
http://dx.doi.org/10.1145/2661334.2661398

Leap Motion Controller [1]. This approach allows users to define their own interaction space through a calibration step, as shown in figure 1. This step creates a quadrilateral flat plane in 3-dimensional space which is then affine-mapped to the display screen. A 2-minute training video detailing the use of gestures and the calibration was shown to the participants. Speech recognition was done with commercial software called "e-Speaking" version 4.1.1 and a pre-trained speech recognition model.

Experimental Tasks

Participants were asked to perform a point-select task over 70 randomly placed targets using each of the four different interactions: mouse hover, mouse click, gesture hover, and gesture multimodal. Index of difficulty ranged from 1-4 bits. Either the mouse or gestures was used to control the position of the cursor. Both the mouse and gesture hover tasks required participants to navigate and hover over each target for 500 milliseconds. Gesture multimodal tasks asked participants to navigate using gestures to the target and use voice commands for selection of the specified target which was either "Left-click", "Right-click", or hover. The mouse click task was used as a control in which the mouse was used for both selection and navigation.

EVALUATION

For the evaluation we collected both quantitative and qualitative data. We have provided throughput values in table 1 for comparison, but chose to focus on qualitative findings and suggestions to better highlight the needs of these individuals.

	Mouse Hover	Mouse Clicks	Gesture Hover	Gesture Multimodal
P1	3.17	3.44	2.10	2.41
P2	3.91	3.96	1.97	2.38

Table 1. Throughput (bits/sec) per task

Participant 1

The first participant has fibromyalgia and osteoarthritis. Before the experiment the participant mentioned that the hand they used for cursor input alternated with pain flares. During the gestural experimental tasks, the participant tended to move her wrist. In gestural interaction, the hand is meant to stay in an open or cupped position, and the wrist is supposed to stay in a neutral straight position for both tracking and ergonomic purposes. This is detailed in the training video. When asked about this behavior she responded that it was simply a natural tendency.

This wrist movement was recorded during calibration causing the system to expect this behavior and caused further problems in the corner regions when the hand was in a neutral position. After the first gestural round the participant requested the elbow cushion which she had previously declined at the beginning.

After the experiment the participant gave some very helpful feedback. She noted that using larger muscle groups was favored over smaller muscle group interactions such as wrist movements with the mouse. The participant also noted that holding the hand in an open position caused some pain, and encouraged the use of a brace to solve the problem. The participant also suggested that the use of the elbow cushion should be encouraged.

Participant 2

The second participant has carpal tunnel syndrome. Before the experiment she noted that she had previously used ergonomic mice for pointing, but that she had adapted to using the touchpad with her knuckles to ease pain when interacting with her personal computer. When performing the mouse click task she felt pain within less than a minute. She specifically noted that pain generally occurred during selection tasks, due to the required finger movement.

During the gestural experimental tasks, the participant again exhibited wrist movement. After the being encouraged to keep the hand in a neutral position the participant quickly adapted to the described behavior. The participant noted that fine movements took longer, and gradually got used to the interaction and relaxed her hand as the experiment went on.

When asked for feedback, the participant noted that she experienced no hand issues using the gestural interaction, and using voice commands was highly preferred to clicking.

DISCUSSION AND FUTURE WORKS

In this paper we evaluated the use of gesture and speech based input as an assistive technology for those with hand impairments. The interaction style proved to be feasible and has promising results, but certain design considerations should be addressed. First, keeping the hand in an open position can cause strain to those with hand impairments. Second, participants may move their wrist during the gestural tasks which can cause strain similar to that of normal mouse usage. Finally, strain can be experienced in rested gestures on the elbow. These problems will be addressed by using an ergonomic cushion, and an assistive brace to alleviate strain in the next study.

CONCLUSION

In this paper we evaluated gesture and speech based interaction as an assistive technology for persons with hand impairments. The evaluation demonstrated that the interaction was feasible, and uncovered improvements for the next study. We expect that this interaction style could lead to better assistive technologies for those with hand impairments.

REFERENCES

1. Jude, A., Poor, G. M., and Guinness, D. Personal space: User defined gesture space for gui interaction. In *CHI '14 Extended Abstracts on Human Factors in Computing Systems*, CHI EA '14, ACM (New York, NY, USA, 2014).
2. Wieslander, G., Norbäck, D., Göthe, C., and Juhlin, L. Carpal tunnel syndrome (cts) and exposure to vibration, repetitive wrist movements, and heavy manual work: a case-referent study. *British Journal of Industrial Medicine 46*, 1 (1989), 43–47.