Note-Taker 3.0, An Assistive Technology Enabling Students who are Legally Blind to Take Notes in Class

David Hayden,
Michael Astrauskas
CUbiC
Arizona State University
Tempe, AZ 85281

dshayden@asu.edu

trevie@asu.edu

Qian Yan,
Liqing Zhou
School of Industrial Design
Arizona State University
Tempe, AZ 85281

qian.yan@asu.edu

lzhou29@asu.edu

John Black
CUbiC
Arizona State University
Tempe, AZ 85281

john.black@asu.edu

ABSTRACT
While the Americans with Disabilities Act [2] mandates that universities provide visually disabled students with human note-takers, studies have shown that it is vital that students take their own notes during classroom lectures. Because students are cognitively engaged while taking notes, their retention is better, even if they never review their notes after class. However, students with visual disabilities are at a disadvantage compared to their sighted peers when taking notes - especially in fast-pace class presentations. They find it more difficult to rapidly switch back and forth between viewing the front of the room and viewing the notes they are taking. Currently available assistive technologies do not adequately address this need to rapidly switch back and forth. This paper presents the results of a 3-year study aimed at the development of an assistive technology that is specifically aimed at allowing students with visual disabilities to take handwritten and/or typed notes in the classroom, without relying on any classroom infrastructure, or any special accommodations by the lecturer or the institution.

Categories and Subject Descriptors
K.3.1 [Computers in Education] Computer Uses in Education
I.4.1 [Image Processing and Computer Vision] Digitization and Image Capture

General Terms
Design, Experimentation, Human Factors

Keywords
Note-Taker, Note Taker, note-taking, legally blind, low vision, Tablet PC, pen computer, classroom accessibility, STEM

1. INTRODUCTION
Education research has shown that secondary and post-secondary students benefit from taking notes, even when they don't subsequently review those notes [1]. However, students with visual disabilities, are at a severe disadvantage when taking notes in a classroom. Note-taking requires rapid switching between a near-sight task (viewing a writing surface and taking notes) and a far-sight task (viewing a distant board at the front of the room). For low-vision students, one or both of these tasks will usually require magnification. However, commercially available assistive technologies provide magnification for near-sight tasks, or for far-sight tasks, but are not designed to support rapid transitions between these two tasks.

2. THE NOTE-TAKER PROJECT
To allow students with visual disabilities to take notes in their classrooms, we have iteratively designed, prototyped, and tested, three generations of a portable, hardware/software assistive device that we call the *Note-Taker*. The first Note-Taker proof-of-concept Pan/Tilt/Zoom (PTZ) camera prototype was built from off-the-shelf components, and employed a rudimentary software application to display the video on a Tablet PC. The touch-sensitive surface of the Tablet PC provided incremental up/down/left/right buttons for aiming the camera, and a zoom slider for zooming in and out. The split-screen interface allowed students with visual disabilities to rapidly glance back and forth between the board and their notes, like their fully sighted peers. The Note-Taker 1.0 user interface is shown in Figure 1, and the Note-Taker 1.0 PTZ camera is shown in Figure 2.
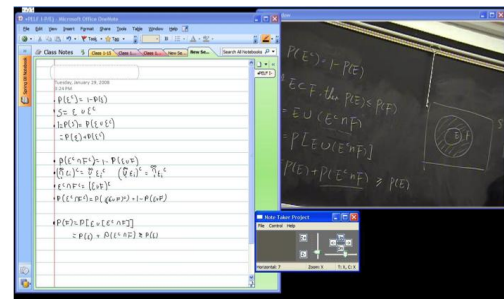

Figure 1: The user interface for the Note-Taker 1.0 prototype

Figure 2: The Note-Taker 1.0 PTZ camera

3. NOTE-TAKER 2.0
Based on 150 hours of classroom testing of the Note-Taker 1.0 prototype, we then built and tested the Note-Taker 2.0 prototype [3]. One major complaint about the Note-Taker 1.0 PTZ camera was its imprecise positioning. To solve that problem we developed a servo-based camera positioner. Another complaint was that the incremental up/down/left/right buttons were tedious

to use, so we allowed the user to simply touch and drag within the video image to reposition the camera. We also allowed the user to tap on any feature of interest in the video frame to center the camera on that feature. A 36x optical zoom video camera was used to provide deep zoom, and handwritten or typed notes could be taken while viewing the zoomed video. (Typing was done with the display screen upright and the keyboard exposed, like a conventional laptop.) The Note-Taker 2.0 user interface is shown in Figure 3, and the Note-Taker 2.0 PTZ camera is shown in Figure 4. This Note-Taker 2.0 prototype won First Prize in the 2010 Microsoft Imagine Cup World Competition.
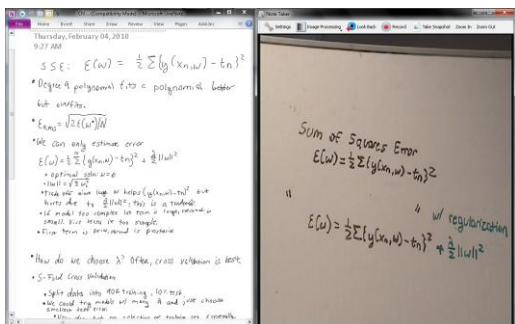

Figure 3: The user interface for the Note-Taker 2.0 prototype

Figure 4: The Note-Taker 2.0 PTZ camera

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4. FIGURES/CAPTIONS

The Note-Taker 2.0 prototype was tested in a simulated classroom setting, with tasks that would be typical in a classroom. While users liked the new direct touch camera aiming method, it was rather slow, jerky, and not accurate enough. They also found that the pinch/unpinch gestures for controlling the zoom were not always recognized, due to problems with the Windows operating system.

To solve the positioning problems, we completely redesigned the PTZ camera to pivot around its own center of gravity, and also developed camera auto-calibration software. To solve the zoom control problems, we replaced the pinch/unpinch controls with a large vertical slider, which appears along the right edge of the video screen whenever it is touched. We addtionally made the camera safer and more aesthetic by constructing, assembling, and painting a hard-plastic shell from stereolithography.

In addition to these improvements, some new features were added. Color inversion and contrast enhancement is provided, to compensate for adverse classroom conditions (such as low-light, dusty chalkboards, faded whiteboard markers, and glare) that sometimes adversely affect board visibility. In the event that a professor obstructs an important region of the board, a "look back" feature allows the user to quickly scroll through recently cached video video frames, to find an unobstructed view. Finally, screen shots of the board can be dragged into the user's notes, and video/audio streams can be recorded for later review. The entire

system is battery-operated, fits into a backpack, and can be set up on the student's desk in less than a minute [4].

The Note-Taker 3.0 user interface is shown in Figure 5, and the Note-Taker 3.0 PTZ camera is shown in Figure 6. This Note-Taker 3.0 prototype won First Prize in the 2011 Microsoft Imagine Cup US Competition [5].
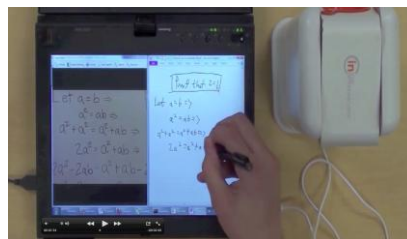

Figure 5: The user interface for the Note-Taker 3.0 prototype

Figure 6: The Note-Taker 3.0 PTZ camera and Tablet PC in use

5. CONCLUSION

The Note-Taker 3.0 prototype is undergoing additional user testing in a simulated classroom with 21 visually disabled students on the campus of Arizona State University. Three additional prototypes are under construction, and will be given to students to use in class during the Fall semester of 2011.

6. ACKNOWLEDGEMENTS

7. REFERENCES

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