# Student Project Aimed at Helping the Visually Impaired Take Notes in Class Wins Prize at Microsoft Imagine Cup

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## Abstract

Students with low vision typically use an assistive technology (such as a monocular) to see the front of the classroom. Switching between sitting erect to view the front of the room through the monocular, hunching down to take handwritten notes, and then sitting up again greatly slows down note-taking. In a fast paced class (with a lot of board work) this delay can cause the student to fall behind in note-taking, compared to his or her fully-sighted peers. The Note-Taker is designed to allow students with low vision to hover over a Tablet PC laptop to simultaneously view a zoomed-in video of the front of the classroom and take handwritten notes on the Tablet PC surface with a stylus.

## Introduction

In the Fall of 2007 at Arizona State University (ASU) undergraduate David Hayden added a mathematics major to his Computer Science major, and registered for 3 senior-level math classes. In doing so he found that none of these math classes used a textbook. All of the material was presented at a very fast pace on whiteboards at the front of the classroom. In fact, it was common to have a dozen white boards filled during a single 45 minute lecture.

David is legally blind, and depends on a monocular to see the front of the classroom. To take notes he must repeatedly switch back and forth between sitting erect to view the board through his monocular, and hunching down to within a few inches of his desktop, to take handwritten notes. This repeated switching back and forth caused a cumulative board-note-board delay that prevented him from keeping pace with the class in his note-taking, and he was forced to drop all 3 of his math courses.

### Solving the Problem

David contacted John A. Black, Jr. at the ASU Center of Cognitive Ubiquitous Computing (CUbiC) whose research was focused on the development of assistive technologies for people who are blind or visually impaired. He and John discussed the problem, envisioned a potential solution, and then David was challenged with building that solution for himself. David mounted a conventional digital camcorder onto a USB-controlled pan-tilt mechanism, connected these to his Tablet PC laptop, and then developed application software to control the pan, tilt, and zoom of the camera with on-screen buttons.

This camera and Tablet PC combination allowed him to hover a few inches above the surface of his Tablet PC to simultaneously see a zoomed-in video of the front of his classroom, and take handwritten notes on a OneNote electronic notepad with a stylus,

thus eliminating the board-note-board delay. This software and hardware became the first-generation (1G) Note-Taker prototype.

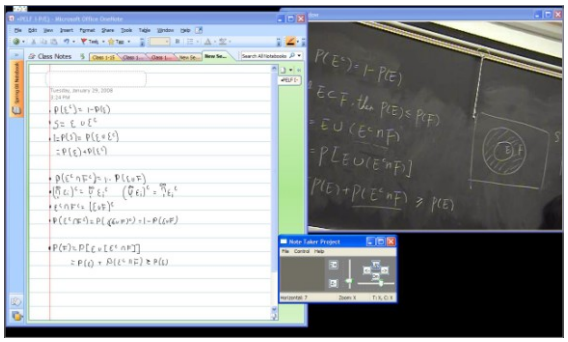

Figure 1. The interface of the 1G Note-Taker software. Visible are Microsoft OneNote, the live video stream, and a control panel for controlling pan, tilt, and zoom.

Figure 2. David using the 1G Note-Taker

Using this rather crude Note-Taker prototype, David then re-enrolled in the 3 math courses and finished all 3 courses with grades of "A". He referred to the first time he used it as an "emotional experience", and said that it was the first time he was able to leave the classroom, having fully understood the entire lecture, without any need for supplementary study outside the classroom.

**Creating a Team**

David and John then applied for funding from the National Science Foundation (NSF), winning a grant under the Research in Disabilities Education (RDE) program. This provided support for additional students to join the development project, to refine the software and hardware. Added to the team were Qian Yan from Industrial Design, Shashank Srinivas from Computer Science, and Michael J. Astrauskas from Electrical Engineering. The team designed a more precisely controlled pan-tilt-zoom (PTZ) video camera using hobby servos, and a Sony industrial block camera. The resulting second-generation (2G) camera prototype was called the "Skippycam" because it was housed in a Skippy peanut butter jar. This camera was able to pan and tilt faster and more precisely, and it provided 36x optical zoom.

The 2G Note-Taker software was also refined, to allow the user to quickly aim and zoom the camera by simply tapping, dragging, and pinching on the video that was displayed

on the Tablet PC surface. The user sees a split screen view, where the video is in one half of the screen, and the electronic notepad is in the other half of the screen. The electronic notepad was provided by Microsoft OneNote software, which allows notes to be either typed or handwritten with a stylus.

Figure 3. The "Skippycam"—the 2G Note-Taker camera

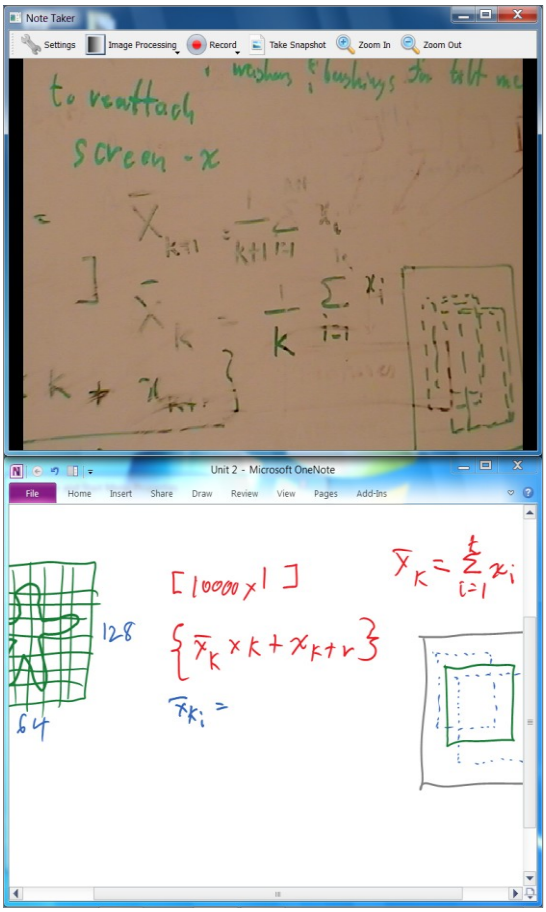


Figure 4. The Note-Taker software sharing the screen with OneNote.

After creating the second-generation Note-Taker prototype, the team used it to conduct user studies with ASU students who have visual impairments. Overall reactions were positive, with all of the participants saying that they would like to use the Note-Taker in their classrooms. However, they also requested several refinements to both the software and the hardware.

These user studies led to the creation of third-generation (3G) software and hardware. The 3G PTZ camera was better balanced, to make camera movement more precise and predictable, the mechanical noise was reduced, and a more attractive plastic camera body was designed, and fabricated with 3D printing. Additional features were added to the software. One example is a *lookback* feature, which allows the student to view video frames that were cached over the last 10 seconds whenever the professor blocks the view of the board. Video and audio recording were time indexed to allow playback of the video, along with the notes that were taken as the video was recorded, to allow for after-class review of the lecture, and further augmentation of the notes.

In the Spring of 2011 the team entered the 3G Note-Taker prototype into the US Imagine Cup Competition – an annual software design competition sponsored by Microsoft. Microsoft encourages students to choose one of the United Nations Millennium Development goals, so the Note-Taker team chose the goal of universal education. "Team Note-Taker" won first place in the US competition, earning the right to represent the US in the Imagine Cup World Finals in New York City, along with National teams from over 100 other countries. After 6 days and 3 rounds of competition in New York, Team Note-Taker won second place in the competition.

Figure 5. The Note-Taker team at the Imagine Cup World finals. From left to right: Industrial Design graduate student Qian Yan, Computer Scientists David Hayden and Shashank Srinivas, Michael J. Astrauskas, mentor John A. Black, Jr.

## Conclusions

The team views this win in New York as a starting point, rather than an endpoint. While the 3G Note-Taker camera is fully functional, it is not readily manufacturable, as it is too expensive and tedious to build. Based on ongoing user testing with the 3G prototype, and using their cash award from the Imagine Cup competition, Team Note-Taker is

developing a 4G camera prototype. This camera will employ a single embedded microprocessor, reducing its bulk, making it smaller, lighter, and less expensive.

No one, especially David, expected the Note-Taker project to take off as it did. Throughout the project, the team has learned much about designing software and hardware, while working as a team. Our user studies have taught us that what looks good in the lab, and what may be a good solution for one person, might not be ideal for everyone.

Although the project started 3 years ago, the team's enthusiasm and confidence has continued to increase with our recent successes. What started as a single proof-of-concept prototype for a single student to use in class has turned into a world-recognized project with real-world implications. The team hopes to eventually see the Note-Taker made available to students as a commercial product.

**Acknowledgements**

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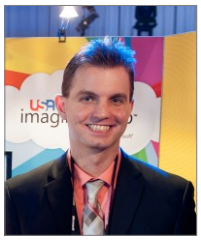
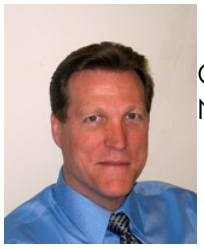
**About the Authors:**



Michael J. Astrauskas is an undergraduate studying Electrical Engineering at Arizona State University. He has been a member of the Note-Taker team since 2009, focusing on electro-mechanical aspects of the Note-Taker camera, as well as helping conduct user studies.

David Hayden is pursuing a PhD in Computer Science at Massachusetts Institute of Technology. His research interests are in computer vision and machine learning, and their applications to assistive and wearable technologies.

Qian Yan is pursuing a Master of Science in Design in Arizona State University. His expertise is product design and design research.



Dr John A. Black Jr is a Faculty Research Scientist in Arizona State University's Center for Cognitive Ubiquitous Computing (CUbiC). He is the PI for the NSF Note-Taker grant, and the mentor of Team Note-Taker.