CHAPTER 13
UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL

Department of Biomedical Engineering
Room 152 Macnider Hall, CB #7575
Chapel Hill, NC 27599-7575

Principal Investigator:

Richard Goldberg (919) 966-5768

PILLOWCASE FOLDING AID

Designers: Meghan Hegarty and Theresa Forshey
Client Coordinator: Cyeteese Garrett
Supervising Professor: Richard Goldberg
Department of Biomedical Engineering
Room 152 MacNider, CB # 7575
University of North Carolina at Chapel Hill
Chapel Hill, NC 27599

INTRODUCTION

Orange Enterprises is a community rehabilitation program that employs people with disabilities to perform a variety of jobs. One of their jobs is to fold and package pillowcases into a plastic sleeve. In general, the individuals selected for this job are not physically impaired, and thus the actual folding action does not present a challenge. Instead, the problem lies in remembering how to orient the pillowcase, the direction in which to fold it, and ensuring that the ends meet and that it is wrinkle-free. The goal of this project is to develop an aid that guides employees throughout the task and enforces proper technique, leading to increased productivity, improved quality, and greater independence.

SUMMARY OF IMPACT

According to the client coordinator, "The pillow case device will be used as a training device for clients as well as a guide for others that may need additional cues to complete all steps of task. At this time we have a limited number of clients who can fold the pillow cases appropriately. With the device, clients will show an increase in productivity. We are also confident that this device will enable more clients to perform the task of folding the different shapes of pillow cases."

TECHNICAL DESCRIPTION

The Pillowcase Folding Aid consists of an acrylic work surface and a center-divide rod (Figure 13.1). The work surface is easily be cleaned, and is hinged at the center for compact storage and simplified transportation. The center-divide rod provides a central axis for folding, and it permits both right- and left-handed operation. The rod is held in place by a magnetic that is mounted into the work surface, and the client can move the rod out of the way when necessary. A vertical side wall is also included to help guide the user in positioning the rod over the magnet in the central location.

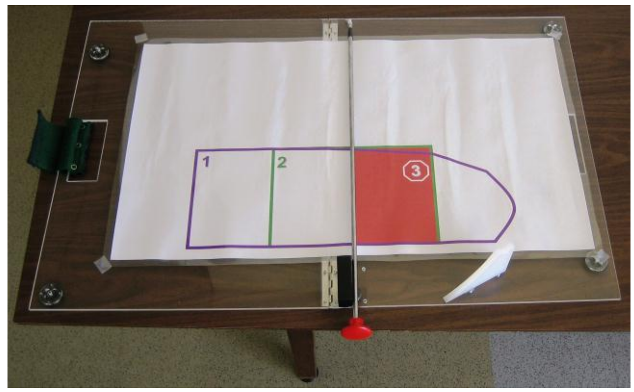
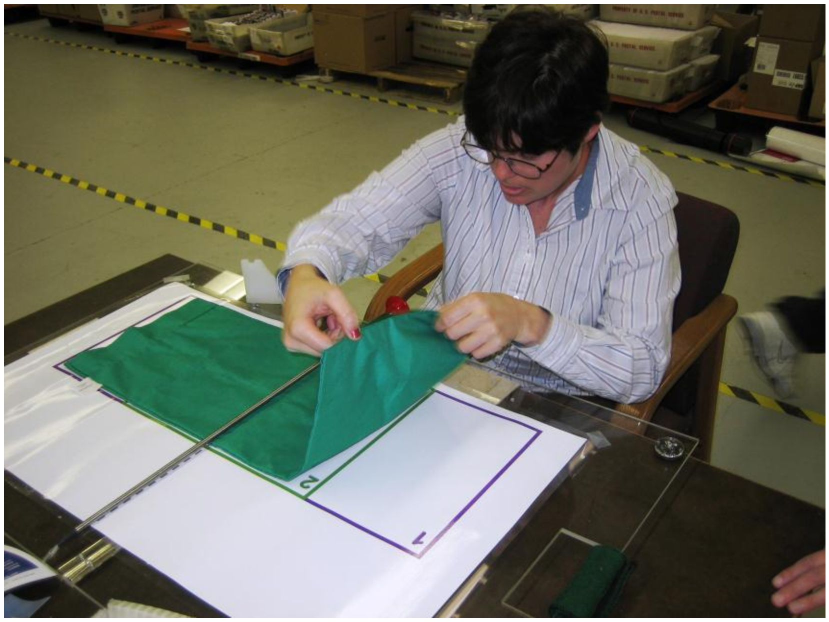


Fig. 13.1. The pillowcase folding aid, which includes the acrylic work surface, a center divide rod that provides a central axis for folding. One of the folding templates is shown on the work surface, which outlines the different steps for folding a particular pillowcase.

We developed instructional templates that guide the user step-by-step through the folding process. They contain numbered outlines of a particular pillowcase at various stages of folding. To keep the process simple for our clients with cognitive limitations, there are no more than 5 numbered steps, and the outlines of the shapes are color-coded to assist with easy matching. Different templates are available for each type of pillowcase. The job coach must tape the appropriate template to the work surface before the client begins using it.

To fold the pillowcase, the client simply needs to match and align it with the appropriate outline on the instructional template. Then, they fold the pillowcase over the center-divide rod axis, which acts as an indicator of the folding direction and ensures that the pillowcase is folded completely in half (Figure 13.2). This matching, aligning, folding sequence is repeated until the pillowcase fits completely within the last shape, which is designed to resemble a 'Stop' sign; the client is easily able to relate to this analogy.

The total cost of the device is approximately $78.



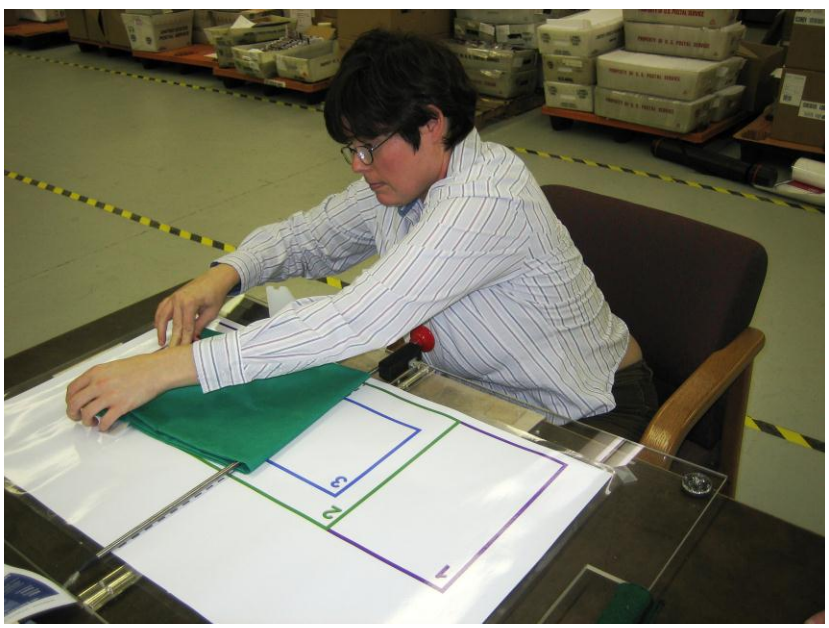


Fig. 13.2 (Top and Bottom). Client folding a pillowcase over the center-divide rod. After completing the fold, the client moves the rod out of the way, realigns the pillowcase on the next pattern on the template, and folds again.

WAFER SEALING AID

Designers: Theresa Forshey and Meghan Hegarty
Client Coordinator: Cyeteese Garrett
Supervising Professor: Richard Goldberg
Department of Biomedical Engineering
Room 152 MacNider, CB # 7575
University of North Carolina at Chapel Hill
Chapel Hill, NC 27599

INTRODUCTION

Orange Enterprises is a community rehabilitation program that employs people with disabilities to perform a variety of jobs. One of the jobs commonly performed requires employees to place a clear, round sticker, called a wafer seal, along the edge of a folded piece of paper to hold it together for mailing. Currently, employees are handed a roll of wafer seals, the mailings, and a cardboard template. A roll of wafer seal is similar to a roll of tape, but with the stickers mounted to a backing. However it is difficult for anyone, with or without a disability, to remove the stickers from the tape. The client then must slide the mailing into the template, which has semi-circles cut out on the edges to indicate where the wafer seal should go, and attach the wafer seal.

Our client is an employee with poor vision, limited motor control, and use of only one hand to perform this task. It is difficult for him to remove the wafer seal from the roll and to use the template correctly. Furthermore, it is hard for him to see the clear wafer seal sticker. As a result, he cannot effectively do this task independently.

Our goal is to develop a Wafer Sealing Aid so that our client can perform this task at work. This will lead to: (1) greater productivity due to faster sealing times, (2) a decrease in the number of rejected mailings resulting from misplaced wafer seals, and (3) greater independence due to a decrease in the need for supervision and help. Overall, this will serve to increase the number of units completed per hour, resulting in greater income for the client.

SUMMARY OF IMPACT

The client coordinator states that, "The wafer seal device will allow opportunities for clients with vision impairments, limited range of motion, and/or fine motor skills to perform the task of wafer sealing.

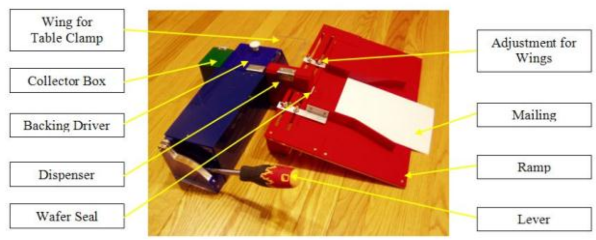


Fig. 13.3. Identifying the parts of the wafer seal device.

The wafer seal device may be used as a training tool as well."

TECHNICAL DESCRIPTION

Our device, shown in Figure 13.3, uses a ratcheted lever system to dispense a single wafer seal for each pull of the lever. The client then slides a mailing into place under the exposed seal, using a ramp and guide arms for alignment, and sticks the wafer seal onto the mailing.

With each pull of the lever, the wafer seal roll is pulled a fixed distance through the dispenser. A ratcheting system pulls the roll in only one direction for each pull/push cycle of the lever. As the backing is pulled through a 180 degree turn just in front of the ramp, the wafer seal becomes partially detached from the backing, making it easy for the client to access it. The empty backing is then collected in the collector box. The client places the mailing on the ramp, right under the partially exposed wafer seal, and the alignment wings allow for correct placement relative to the wafer seal dispenser. At this point, it is easy to stick the wafer seal onto the mailing and complete the operation.

With this device, the client can repeatedly execute the same steps for this task. The steps are: turn the lever, slide the mailing up the ramp, push the wafer seal onto the mailing, slide the mailing back down, and fold the wafer seal over onto the other side of the mailing. While this process consists of many steps, the client is able to perform the task effectively.

The device is safe, adjustable and easy for the job coaches to setup. There is a hinge door with a handle that makes loading the tape into the backing driver easy. The box for this mechanism is long in order to increase stability and allow the lever to be easily reached. The device is stable without a table clamp, but the wing can be clamped to the table as extra precaution. The job coach can adjust the wings, depending on the mailing size and orientation.

The device is made from colored acrylic to provide a professional look as well as making it easy to remove misplaced wafers. The total cost of the project is $183.

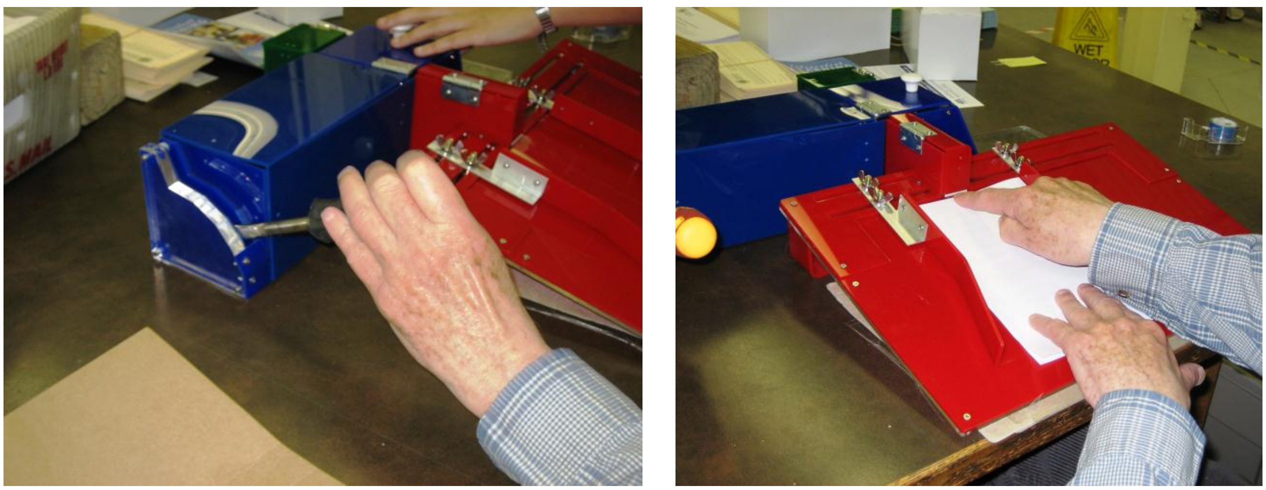


Fig. 13.4. The client is pulling the lever to dispense the next wafer seal, and then sticking the wafer seal onto the folded mailing.

KARAOKE TRAINER

Designers: Swarna Solanki and Omar Aman
Supervising Professor: Richard Goldberg
Department of Biomedical Engineering
Room 152 MacNider, CB # 7575
University of North Carolina at Chapel Hill
Chapel Hill, NC 27599

INTRODUCTION

Our client is a 19 year old male who has severe mental retardation. He has limited dexterity, visual impairment, and limited verbal capabilities. The client has become motivated to practice vocalizing through music therapy, whereas other forms of speech therapy were ineffective. A music therapy session involves the client's therapist singing a familiar song and stopping before the end of a phrase, for example, "Take me out to the ball…" Once the client verbally finishes the phrase, "game", the therapist will continue singing the next line of the song. If he does not respond, the therapist encourages him to do finish the line before moving on.

The goal of our project is to develop a device that simulates these music therapy sessions so that he can practice vocalizing independently. Voice detection is necessary so that the device knows when the client has vocalized. However, his voice is difficult to understand, so speech recognition is not necessary. As long as he is vocalizing, he is meeting the therapist's goals. In addition, a simple interface is required, preferably one comparable to an Apple iPod shuffle, which he is already familiar with, so that he may use it without supervision.

SUMMARY OF IMPACT

The device successfully motivates the client to practice vocalization by singing along with his favorite songs. The client learned very quickly that the device continues playing the song if he vocalized appropriately. Thus, if he mumbled or whispered the word and the device could not register his voice, the client makes another attempt that is louder and clearer. The positive feedback from the device puts a smile on his face as he claps and listens to the music. This result is exactly the type of influence his family and therapist hoped for. After using the device for a short amount of time, there was an obvious increase in the client's ability to respond verbally to those around him, just as he experiences after a session with his music therapist.

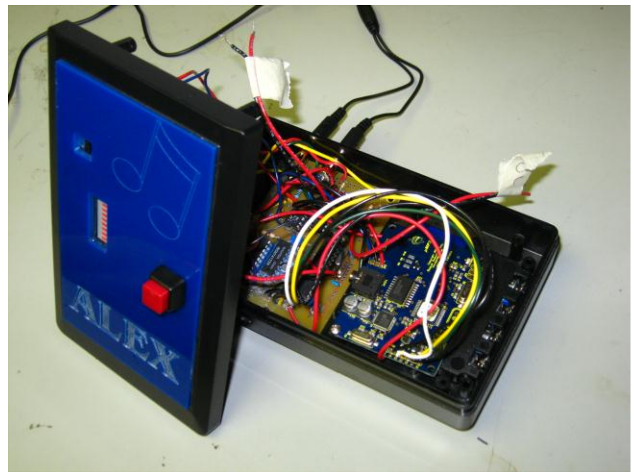


Fig. 13.5. Photo of the device with cover removed to reveal the circuitry inside.

The client's mother stated that the device is simply "Great!" after she saw it in action for the first time. She continued, "there are very few times in Alex's life that somebody can actually make a difference for him. I feel like this device is going to be a huge success!" The client's father stated, "I am so happy, I feel like I am going to cry!"

TECHNICAL DESCRIPTION

The device is based on the PIC 16F876 microcontroller (Microchip, Inc, Chandler AZ). Other major components are the music player, the user interface, and the voice detection circuit. The music player is a Rogue Robotics (Toronto, ON) uMP3 Playback Module. This uses a Secure Digital (SD) card to store MP3 files, and interfaces with the microcontroller to select which song to play. Each song is stored in a folder on the SD card. Each folder contains the song broken into separate tracks according to the client's expected responses.

The user interface consists of a "next" button, similar to the next song button on an iPod Shuffle. This button is active at the beginning of a song, but at the therapist's request, it becomes inactive once the client starts singing a song. This forces him to complete a song once he starts it.

The voice detection system identifies when the client vocalizes, while ignoring when he claps or grunts, as well as other ambient noises. According to our studies, actual vocalization results in a signal of greater amplitude than background noise or grunts, and of greater duration than hand claps or finger snaps. Thus, the circuit identifies vocalization as signals that are above a minimum threshold duration and amplitude.

In our vocalization detection system, the microphone is connected to an instrumentation amplifier, which is then input to a comparator. This outputs 5 V when the amplified microphone signal exceeds the reference voltage. The comparator output is sent to a retriggerable one shot, which outputs a 5 V pulse for a short time period when the comparator output goes high. Because the one shot is retriggerable, it maintains a constant 5V output as long as the input signal has peaks more often than the output pulse duration of the one shot. This signal is fed to a PIC, which measures the duration of the one shot output, and determines if it is long enough to represent vocalization. The system effectively filters out clapping, finger snapping, grunting, and other short or quiet sounds.

The reference voltage for the comparator is adjusted by the parent or therapist. An LED array shows the relative strength of the reference. Using a potentiometer, the user sets this reference voltage between 0 and 1 V, based on the response of the microphone. The LED array allows a visual comparison between the output signal of the instrumentation amplifier and the reference voltage at input of the comparator.

Our final device employs an external speaker and headphones. The sensitivity control is intentionally difficult to access to avoid accidental adjustment. The next button and LED array, volume control, audio jacks, and on/off switch are all made accessible. The enclosure is custom made of blue acrylic. The total cost of the device is $396.

Fig. 13.6. Photo of client using the device.

TRACE AID

Designers: Elliot Greenwald and David Zilber
Client Coordinator: Chris Wensil, Mariposa School for Children with Autism
Supervising Professor: Richard Goldberg
Department of Biomedical Engineering
Room 152 MacNider, CB # 7575
University of North Carolina at Chapel Hill
Chapel Hill, NC 27599

INTRODUCTION:

The ability to write is a skill essential for natural progression in an academic setting. However, for children with autism, traditional methods for developing this skill are less effective. Typically, the precursor to writing is the development of fine motor control with the dominant hand, which is accomplished via tracing. Even with the one-on-one, personalized instruction and positive reinforcement offered at The Mariposa School, a school for children with autism in Cary, North Carolina, most of their students are not motivated to develop tracing and handwriting skills. The goal of the project is to develop an aid that provides positive feedback when the student is tracing properly over large, printed letters.

SUMMARY OF IMPACT

Our client coordinator at The Mariposa School, Chris Wensil, is excited about the device and its ability to help many children at the school. In particular, he is impressed with the device's immediate impact with several children; they quickly learned that proper tracing keeps the music playing and thus they continue to practice a proper tracing technique.

TECHNICAL DESCRIPTION

The purpose of the device is to provide musical feedback when the child is tracing properly. A photodiode sensor is mounted in the tip of a pen, and the client uses this pen to trace over a piece of paper with a large printed letter (see Figure 13.7). The paper rests on top of a commercial light-bed. Light shines up from the bed, through the paper and the light level is detected by the photodiode sensor. When the sensor is over a dark area on the page, the black ink on the paper blocks a significant amount of light, resulting in a low voltage output from the photodiode. Accordingly, when the sensor is over a blank area on the page, more light reaches the photodiode sensor, its output voltage increases.

Fig. 13.7. Photo of the device, with a letter A as the tracing area.

If the desired tracing area on the page is solid black, then the device cannot differentiate between a moving pen and a stationary pen positioned over the black areas on the page, because both scenarios results in a low voltage on the photodiode. In addition, low light levels within the ambient environment provide similar signals as the black tracing area. A simple solution is to make the tracing area consist of a checkerboard pattern (note the "A" on Figure 13.7). As a result, when the user is properly tracing over the checkerboard, the photodiode signal is roughly sinusoidal. The microcontroller looks for a sinusoidal signal of a certain minimum frequency, and triggers the musical feedback accordingly.

All calculations are performed with a PIC 16F876 microcontroller (Microchip, Inc., Chandler AZ), which receives input from a simple photodiode embedded within a pen. When the proper signal is received, the microcontroller commands a Rogue Robotics uMP3 board (Toronto ON) to play an MP3 file, which is stored on an easily accessible Secure Digital (SD) card. The device is built into a commercially available children's tracing toy, the Elmer's Paintastics Light Magic. The pen housing is custom built with the use of a rapid-prototyping fusion deposition modeler and other widely available parts. The inking cartridge is from a commercial BIC ballpoint pen, and it fits snugly into the custom pen housing. The teachers easily replace the cartridge when necessary. The pen connects to the circuitry via a cable and 3.5 mm audio stereo plugs. Commercial, external speakers and headphones provide the audio feedback.

Once the Trace-Aid is activated by toggling the main power switch, the user can immediately begin tracing. As long as the pen is moved over the designated tracing area, music is heard from an audio output. However, as soon as the pen leaves the desired tracing area, or the child stops moving the pen, then the music abruptly stops. In the event that the child completes a tracing session with satisfactory results, the instructor may opt to provide an additional reward by playing continuous music. This is accomplished via a "reward" switch, activated by the instructor when appropriate.

The device is battery powered, large enough to accommodate a standard 8 ½" x 11" piece of paper, yet portable enough to fit on a wheelchair lap tray. The total cost of the device is $205.

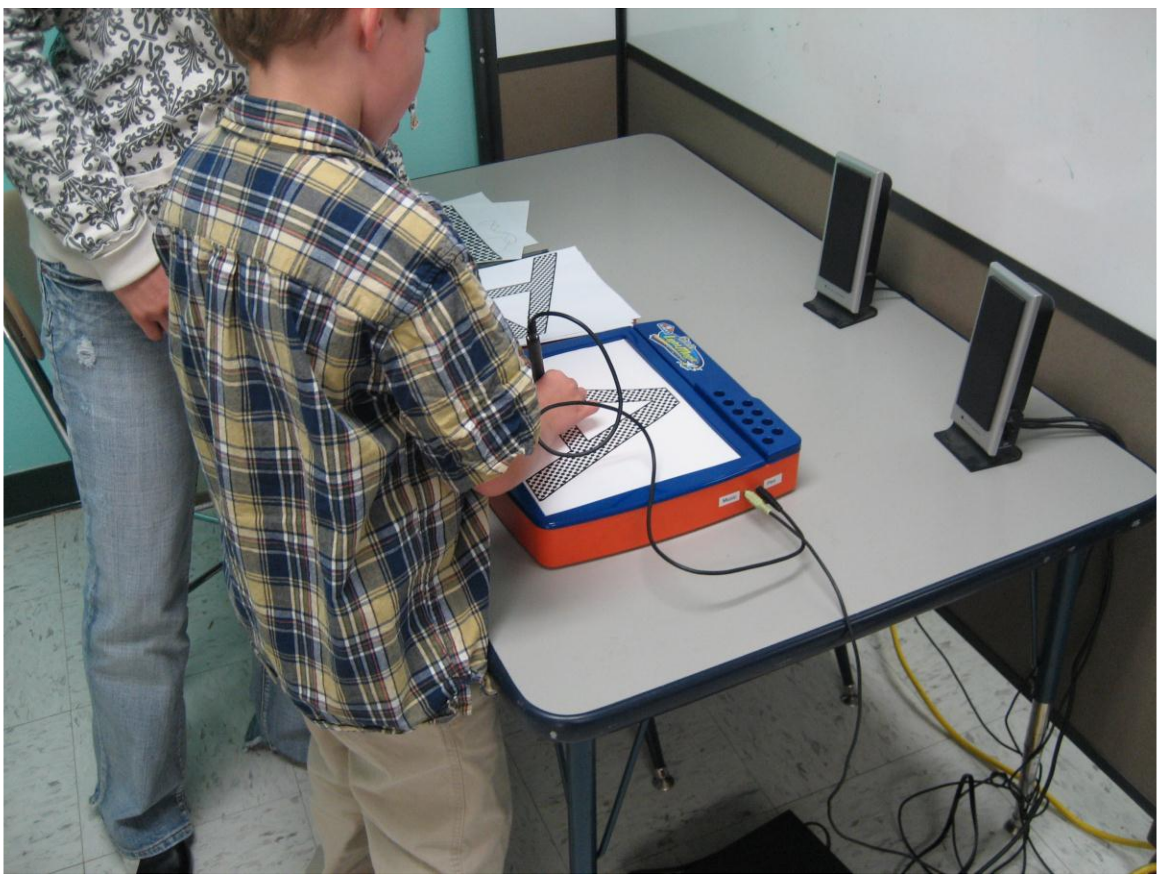


Fig. 13.8. Photo of client using the device.

ROWING MOTION COUNTING DEVICE

Designers: Deep Mehtaji, David Zilber
Client Coordinator: Julie Auker, SLP, Durham Public Schools
Supervising Professor: Richard Goldberg
Department of Biomedical Engineering
Room 152 MacNider, CB # 7575
University of North Carolina at Chapel Hill
Chapel Hill, NC 27599

INTRODUCTION

Our client is a 14 year old boy with leukodystrophy. This is a neurological disorder in which the myelin sheath, which covers central nerve fibers, progressively degenerates. This results in a variety of symptoms, including the steady loss of body tone, gait, speech, vision, hearing, and behavior.

His speech therapist requested an activity that would help him understand the concepts of numbers and counting. The goal of this project is to create a counting game that is fun and motivating for the client, and also encourages him to exercise in his wheelchair. The design accounts for his visual and physical impairments so that he can use the device independently.

SUMMARY OF IMPACT

Many individuals with disabilities cannot employ traditional means of learning due to spasticity, visual impairments, and other cognitive and physical disabilities. Our device employs rowing motion to convey the concept of quantity by counting the number of pull/push repetitions. The client's mother commented that, "Jamison is able to use it easily and pulling the handle toward him works better than pushing. He laughs at the end of the counting when you say "Yea! You did it!"

TECHNICAL DESCRIPTION

The Rowing Motion Counter teaches the client how to count by one each time that the client pulls and releases a lever arm. It provides audible feedback of the current count. Figure 13.9 shows a photo of the device. The entire device is mounted on a 0.12 inch thick plate of steel that slides easily into a slot underneath the seat cushion on client's wheelchair for quick installation / removal and portability. The lever arm is adapted from a scooter handlebar. It is connected to a residential door closer, which has an adjustable resistance so that the therapist makes it easier or harder for the client to pull the lever. A potentiometer is also connected at the axis of rotation to read the lever angle.

A Basic Stamp microcontroller (Parallax, Inc., Rocklin CA) controls the system operation. It samples the voltage of the potentiometer (that measures the position of the handlebar); this allows the device to determine when a full rowing motion (pull-release of the lever) is made by the client. By using the Stamp's onboard clock, the device has a precise timing element, which becomes useful for pause operations. Audio feedback is implemented with the Rogue Robotics uMP3 player (Toronto, CA). Audio tracks are recorded into MP3 files and stored on a Secure Digital (SD) card, which provides easy access to audio files.

There are two switch selectable operating modes for the device. In practice mode, there is no desired target. As soon as the client begins to pull, the voice feedback announces the current iteration. When the client counts to 10, the device congratulates the client and the process is reset, allowing the client to start again from 1. If the client pauses for 5 seconds, the device then prompts him to keep going. In game mode, a target is randomly generated and announced upon activation of the device. The client must reach this value through successive strokes of the handlebar. Upon reaching the destination value, the client either pushes the "engage" button or simply pauses for 5 seconds. If this occurs, the device congratulates the client, assigns a new random value, and allows the client to start again. In the case where the client overshoots the target, the device announces the user has passed the target, and requests the user to start from the beginning with the same target value. If the client pauses on a pre-target value, he hears the prompt to keep going.

As the client matures, the resistance involved in pulling the handlebar is easily adjusted by turning a screw, as the residential door closer has adjustability settings. The total cost of parts/materials is about $250.

Fig. 13.9. Photo of the device. It mounts to the client's wheelchair by slipping the horizontal bar on the right side of the photo under the seat cushion. The client grabs the handles with both hands and pulls and releases the handlebar to count. The battery-powered circuitry is mounted in the black box at the bottom of the photo, and audio feedback is provided through the two speakers.