

CHAPTER 13
UNIVERSITY OF ALABAMA AT
BIRMINGHAM

Department of Biomedical Engineering
1075 13th St. S.
Birmingham, Alabama, 35294-4461

Principal Investigator

Alan W. Eberhardt, PhD

(205) 934-8464

ESSENTIAL TREMOR MEASURING DEVICE

*Designers: Kailash Bohra, Jonathan Cayce, Eric DuBois, Ingrid Menegazzo
Client Coordinator: Dr. Leon Dure, Division of Pediatric Neurology
Supervising Professor: Alan W. Eberhardt, Department of Biomedical Engineering
University of Alabama at Birmingham, Birmingham, AL 35294*

INTRODUCTION

Essential tremor (ET) is one of the most frequently occurring tremor disorders and is commonly observed in limbs or the head during performance of an action, and in certain postures. When observed in children, diagnosis is crucial to improve the quality of life and ensure the ability to develop needed skills. A device was developed to measure ET in children and to create a database for comparative analysis. This will help further investigate and improve diagnosis for the disease.

Design requirements were to measure ET of the hand and arm (5 to 12 Hz) and physiological tremor (up to 30 Hz). It is to be used in small examination rooms (12 ft by 12 ft); therefore the device was to be simple, compact, portable, and easy to set up. Based on these constraints, the client required the device to interface with a laptop system. Due to the patients' range of ages (5-18 years) it also had to be adjustable to different sized arms. The device was to have a shock resistant rating of at least 1000g to ensure adequate protection from misuse or fall, and to ensure sustainability of the device. It had to be made

of materials that can be cleaned using antiseptics to ensure sterile use for each patient.

The software was to provide graphs of frequency, display the value of the tremor frequency, and store data to be used for later analysis.

SUMMARY OF IMPACT

The resulting design is compact, portable, and easy to set up. The system measures ET of the hand and arm (5 to 12 Hz), is adjustable to different sized arms, and is shock resistant. The software is user friendly, displays the value of the tremor frequency, and stores the data to be used for later analysis. This will allow the client to perform routine exams on patients with ET and ultimately may improve his ability to diagnose and treat the condition. The ability to extract a dominant frequency will also permit the clinician to compare the condition of the patient before and after taking medications, and to perform comparative studies of patient response to physical therapy.

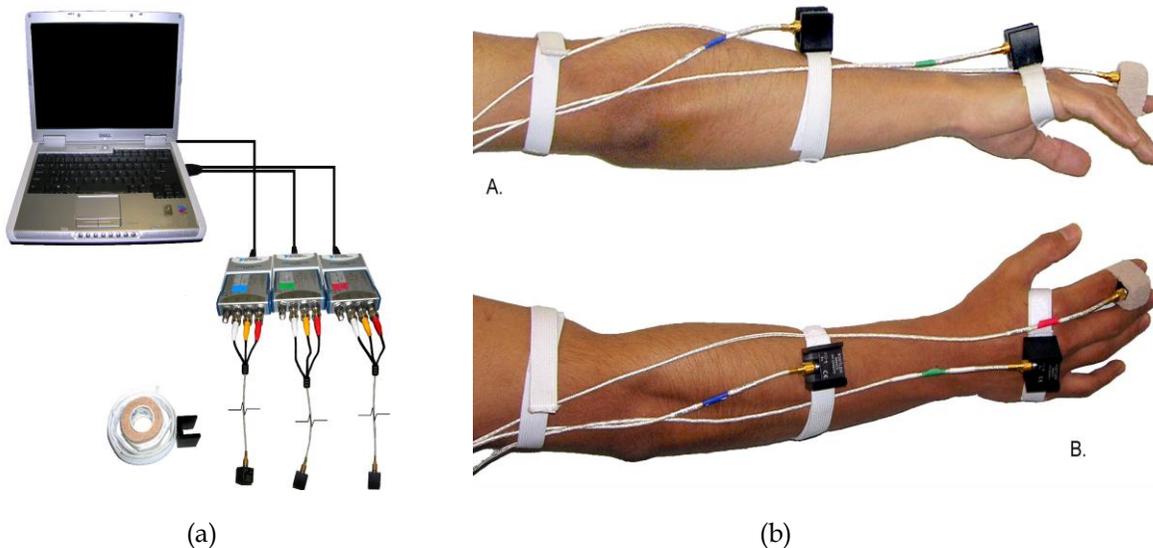


Fig. 13.1. [a] Laptop, Data Acquisition Modules, Accelerometers, Clip, Velcro Straps and Non-Adherent Bandage; [b] Views of Mounted Accelerometers on the Arm.

TECHNICAL DESCRIPTION

Three tri-axial accelerometers (Kistler 8690C5 PiezoBEAM) were interfaced with three separate Dynamic Signal Acquisition modules (National Instruments USB-9233), which connected directly to the laptop (Dell Inspiron 680m). The assembly of the prototype can be seen in Fig. 13.1a.

The materials used for the strapping system were elastic bands with Velcro strips sewed to them. The finger accelerometer is attached the patient's finger using bandaging tape. A third elastic band was constructed to hold wires running from the accelerometers against the patient to allow more patient mobility. Accelerometer mounting brackets were mounted to the hand and forearm straps using fabric glue to create a firm interface between the straps and the accelerometers. The set-up of the strapping system can be seen in Fig. 13.1b.

The Dynamic Signal Acquisition module contained built-in filtering. Filters consisted of a passband filter, stopband filter, and alias free filter. The software design incorporated LabVIEW (National Instruments), which uses block diagram programming to build user-defined applications. There are numerous tools and functions predefined to acquire and analyze data, called Visual Interface modules (VIs), within this program. The prototype's software was initialized using a visual interface, named Introduction, where the user can select to test the patient, compare data, cancel, or quit the program by clicking on the appropriate VI button. When the Test patient or Compare data buttons are pushed, a new visual interface is displayed to the user where two separate sets of code are used to accomplish appropriate tasks.

The test patient interface functions by first prompting the user to enter information. The user then selects the type of test (postural, finger to nose, or nose to target) and then clicks start in the visual interface window to begin data acquisition. A built-in module in LabVIEW (called data acquisition assistant module) collects data from the accelerometers three times at a rate of 2,000 samples per second. It then converts the signal from volts to acceleration. The data acquisition assistant module outputs a clustered signal that contains data for the x, y, and z axes of the accelerometer, which allows for easier processing in the LabVIEW environment. The acceleration data are plotted onto three separate viewgraphs and are sent to the FFT spectral analysis module for frequency measurements. The frequency spectrum is then sent to three separate viewgraphs to display the peak frequencies of the data set to the user.

The acquired data are saved using a built-in write-to-file module. The module creates an Excel data sheet containing patient and test information, including the mean frequencies for each axis of the three accelerometers. A second method uses LabVIEW's built-in database connectivity to transfer data collected in the Test Patient VI to an Access Database named Acceleration data. Once the data have been entered into the database, the user can then perform other tests on the patient or exit back to the introduction interface.

To protect the device during transport, the design team purchased a hard case (Pelican) with foam padding.

The total cost associated with the system was \$9,199.

COMPUTER TABLE

Designers: Jonathan Byers, James Posey, Christine Wood

Client Coordinator: Michael Smith, UCP Hand-in-Hand

*Supervising Professor: Alan W. Eberhardt, Department of Biomedical Engineering
University of Alabama at Birmingham, Birmingham, AL 35294*

INTRODUCTION

The goal of this project was to design and construct a multi-purpose computer table, to accommodate the children with cerebral palsy at a daycare center.

The table was to accommodate children ages two through five. For those children who use wheelchairs, the table had to be adjustable to different heights (21 - 30 in.). It had to support a number of loads, including a touch screen monitor (39 lb), computer processor (32 lb), printer and other accessories (~25 lb).

The monitor was to be easily adjustable within the horizontal plane to suit the sight and arm ranges of the children. A large keyboard tray able to adjust to various heights and tilt, which could slide under the table when not in use was needed. To prevent the children from tampering with the computer tower (processor), it had to be concealed and locked. Also, the various accessories used with the computer required a storage area for organization. The system was to be easy to use by the staff, quiet, child-proof, safe, and cleanable. The client requested that the table surface be made with a light wood laminate top, and that the complete system have blue accents to go with the existing daycare center decor.

SUMMARY OF IMPACT

The adjustable computer table meets all the design constraints. It permits children of varying size and ability to access the computer and use the keyboard or touch screen monitor. The result is an increase in computer use by children who previously were not able to access the computer. The system is safe and

portable, and allows the staff to control the use of the system and position the table for each user. Storage units for the computer tower, cords and accessories prevent undesirable access by the children.

TECHNICAL DESCRIPTION

The tabletop was made of light wooden particleboard laminate. The keyboard tray (Versa Products, Inc) met ANSI/BIFMA standards and was rated to support a maximum load of 70 lbs, which exceeded the design load for the largest child (weight = 55 lbs) supporting his or her weight entirely on the keyboard tray. A flat panel, touch-screen monitor (PLANAR) and fully adjustable monitor arm (Neoflex, Ergotron) were purchased.

For the table adjustment, two lifting columns (LINAK) were chosen, which provided support against bending moments resulting from the monitor being mounted at the rear of the table. LINAK donated two DL1 lifting columns as well as the control box and button control. The minimum height of the actuator was 17.5 in. and it had a maximum stroke length of 11.8 in., satisfying the adjustability constraint.

A basket that could slide under the table was attached to hold various computer accessories. A work surface on a gooseneck arm provided an additional surface for accessories. All work surfaces were coated with polyurethane. The final table design (Fig. 13.2) met ANSI/BIFMA Standards x5.5-1998.

The total cost was \$1,371.



Fig. 13.2a. Adjustable Computer Table.



Fig. 13.2b. Ergotron Neo-Flex Monitor Arm.

BABY CARRYING SYSTEM

Designers: Idris Lawal, David Sewell, Asaf Stein

Client Coordinator: Michael Papp, Alabama Department of Rehabilitation Services

*Supervising Professor: Alan W. Eberhardt, Department of Biomedical Engineering
University of Alabama at Birmingham, Birmingham, AL 35294*

INTRODUCTION

A child carrying system was built to assist a client with paraplegia who uses a manual wheelchair in transporting her toddler during daily activities. The product had to safely support and restrain the toddler who at the time was 12 months old, weighed 22.5 lb and was 30.25 inches tall. Also, the device had to be versatile enough to allow for his growth over the next two years. The carrying system could not impede the mobility of the wheelchair; it could not bind or hit the sides of the wheel chair when performing turns or backing up. The product was to be lightweight (<25 lb), and sufficiently collapsible in order to fit into the client's vehicle (width of standard door = 32 in). Once unfolded, the product was to be self-standing. While seated in her chair, the client should be able to easily attach and detach the device to and from her wheelchair. The product had to withstand the stresses resulting from both the torque created from turning the wheelchair, as well as the weight of the frame and child combined.

ASTM standards for strollers stipulate child restraints as well as folding and latching mechanisms that involve a two-step process. The stroller should support a static load of 100 lbs. in the center of the seat.

SUMMARY OF IMPACT

The baby carrying system satisfied the client's needs by allowing her to transport her toddler. Its lightweight design minimized the total amount of added weight. The product did not compromise the mobility of the wheelchair and was found to be easily attached to and detached from the wheelchair, and easily stored in or removed from the back seat

of her vehicle. The final product met all of the design constraints and operated fluidly. The device allowed the client to conveniently and independently transport her toddler without assistance, thereby providing her with greater independence and improved quality of life.

TECHNICAL DESCRIPTION

The final design consisted of the main stroller frame (Maclaren Stroller, which met all design specifications and came with desired accessories, such as a rain cover) and rear swivel wheels (Sportaid Wheelchair & Stuff), which were purchased from commercial vendors. A ball and socket "trailer hitch" included a 1 7/8 in. diameter stainless steel ball and allowed for ample rotation about three axes. A one-half inch cylinder was bored out of the trailer ball to reduce weight. The receiving socket was attached at the stroller's front, and the hitch attached to the rear of the wheelchair via existing open-ended tube receptacles. Aluminum tubing was chosen for the connector components because it is lightweight and strong. Polyurethane swivel wheels were chosen for good traction and optimal wear properties.

The resulting device (Fig. 13.3) adheres to the ASTM safety standards. Bending, bearing and shear stress calculations were performed; the design was predicted to withstand the stresses resulting from turning the wheelchair and travel over uneven terrain given the weight of the frame and child. All results fell well below ultimate and fatigue strengths of aluminum. The total weight of the product was 21 lbs.

The total cost was \$1260.



Fig. 13.3a. Rear View of Client's Wheelchair Shows the Open-ended Tubes Used to Attach the Trailer Ball Connector.



Fig. 13.3b. Adapted Stroller with Trailer Hitch and Trailer Ball Connector.

INDEPENDENTLY-OPERATED LAPTOP MOUNTING SYSTEM

Designers: Jonathan Dennis, Peserai Chinoda

Client Coordinator: Michael Papp, Alabama Department of Rehabilitation Services

*Supervising Professor: Alan W. Eberhardt, Department of Biomedical Engineering
University of Alabama at Birmingham, Birmingham, AL 35294*

INTRODUCTION

The Independently-Operated Laptop Mounting System was designed for a male in his early twenties who pinal muscular atrophy (SMA). This condition is characterized by muscle fatigue and muscle pain. The client had a laptop mounting system that permitted him to use the laptop, and that stored the laptop in a rear position during normal operation of his wheelchair. The system required an aid to change the laptop position for use or storage. As a result, the client's independence was restricted.

The design was required to be detachable in order to ensure the original manual system would still be usable in case the new system was to malfunction. The device was also required not to exceed a clearance of four inches from the side.

SUMMARY OF IMPACT

This device eliminates the need for an assistant each time the client wishes to use or store his laptop, thereby providing him with greater independence and improved quality of life.

TECHNICAL DESCRIPTION

The system was designed using a CAD program (Pro-Engineer) to establish the necessary stroke lengths and attachment points for system actuators. A CAD image of the final design is shown in Fig. 13.4. The approved design for the laptop system involved new structural stainless steel tubing with an inner diameter of 0.7 in., an outer diameter of 0.9 in., and a yield stress of 75,000 psi. Two linear actuators (Firgelli Automations) were attached to move the arm holding the laptop (3 in. actuator) and

the main arm (4 in. actuator). The linear actuators are controlled by a timing system and two micro-light switches. The actuators are resistant to splash and dust damage. The maximum force produced by the linear actuators is 110 lbs, which was determined to be more than enough to move the laptop from the rear storage location to the front of the wheelchair for use. The actuators move at 1 in. per second, which translates into a total movement time of 10 seconds from storage to use position of the laptop. Each one of the actuators was attached to the tubing using special brackets (Firgelli Automations) that allow movement of the arms in an arc.

The torque required to lift the laptop lid was calculated to be 32 in-oz. A small dual-direction rotary motor was used to open and close the laptop (Herbach and Rademan), which produces a maximum torque of 40 inch-oz.

The motor was attached to the laptop cover by a small rod with a bracket attached at the end. This bracket was attached to two thin strips of acetal-delrin plastic that hold the cover in place while it is moving. A control system composed of a programmable logic controller, relays, one micro-light switch (Tash, Inc.), and three limit switches, was used in order to move the arms of the mount. The arms move to open and close the laptop. The switches were mounted next to the joystick, which controls the wheelchair. Both the actuators and the motor run on the 24-volt source that powers the client's wheelchair.

This device cost approximately \$900.

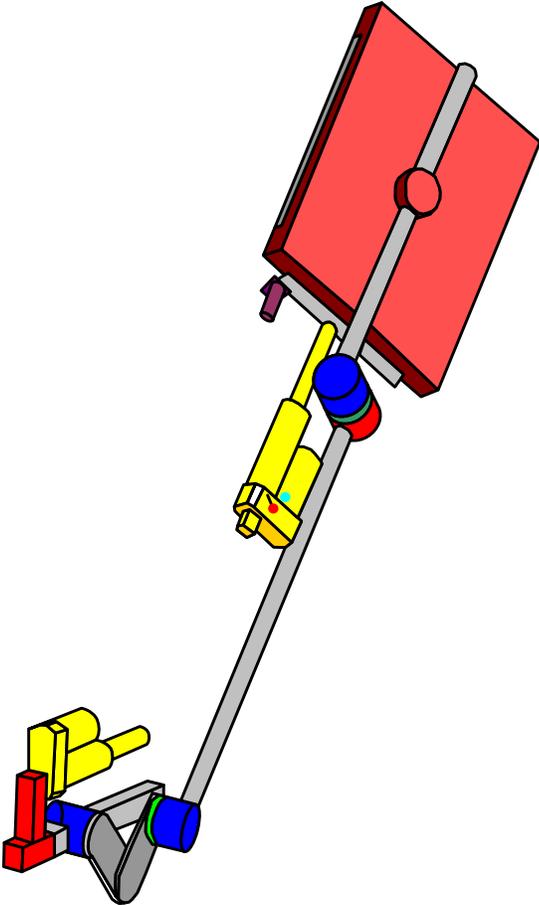


Fig. 13.4. Pro-E Drawing of the Independently-Operated Laptop Mounting System.

MODULAR COMPOSITE WHEELCHAIR RAMP

Designers: Genevieve Martin, Donald Pritchett, Jessica Robertson, Regina Scarber

Client Coordinator: Alan Eberhardt, Department of Biomedical Engineering

*Supervising Professors: J Barry Andrews, Gregg Janowski, Uday Vaidya, Department of Materials Science and Engineering,
Tina Oliver, Department of Mechanical Engineering*

University of Alabama at Birmingham, Birmingham, AL 35294

INTRODUCTION

A non- or semi-permanent wheelchair ramp was requested. Careful consideration was given to the potential clientele and observation of housing subdivisions in the surrounding area. It was concluded that the ramp would not be custom-designed for one specific home. Instead, it would be sufficiently flexible in design to accommodate nearly all dwellings that use stairs to gain entry.

The ramp had to comply with the American Disabilities Act (ADA). ADA compliant ramps cannot have slopes exceeding a ratio of 1:12. The maximum rise for any ramp run is 30 inches. The ramp landing had to be at least 60 inches long and at least as wide as the ramp run. Both ramp runs and landings must have handrails, which must extend 34-38 inches high. Handles must be easy to grab and remain rigid in their fittings. Handrail edges must be rounded; if they are circular, the outer diameter must be between 1.25 and 2 inches. They must extend horizontally above the landing a minimum of 12 inches. The width between handrails must be at least 36 inches wide.

Curbs are required on the ramp and landing and necessitate a minimum two inches in height. The ramp must have edge protection, by means of either extended floor or curb/barrier protection. Other factors and project limitations included sensitivity to ultraviolet light, water absorption, corrosion, and supporting the live load of a person whose weight is in the 99th percentile, and who is in a motorized wheelchair. Modularity was also required, such that the ramp should be easily maneuvered by two average adults.

SUMMARY OF IMPACT

There are a variety of ramps on the market today; however, most are very expensive. Many people who use wheelchairs cannot afford a very expensive

ramp system. The current ramp system has the potential to be an improvement over commercially available ramps by providing an affordable and safe means to enter a home from a wheelchair. It helps the user to be more independent.

TECHNICAL DESCRIPTION

The prototype system was comprised of two pieces: one sloping and one landing platform made from a sandwich composite which would minimize weight. The legs of the structure contained a mechanism for height and slope adjustments to provide maximum flexibility. The rails were prefabricated and held in place by custom-made aluminum brackets.

The ramp deck was built of carbon fiber, a polypropylene honeycomb core, 1-inch square steel tubing, 0.75-inch square steel bar, epoxy resin, and polyurethane stiffeners coated with fiberglass. The ramp and landing were constructed by hand. The steel bar was cut to length and ground to form a tight fit in the ends of the steel tube when driven into place. The tubing was then welded to form the outside dimensions of the ramp deck. The railing was made from 6061 aluminum and connected with couplings fitted with set screws. Post testing included testing the deflection of the deck and strength of the legs and bolts. The result was a composite ramp system that was modular, but heavier and more expensive than desired. The manufactured platform pieces were too large for easy assembling. The ramp landing was not as strong as desired, but corrections in manufacturing errors promise to increase stiffness in future designs. For future work on this project, stainless steel tubes will be replaced with fasteners. Vacuum Assisted Resin Transfer Molding (VARTM) will be used instead of hand lay-up. Materials will be ordered much earlier to extend the period needed for revisions.



Fig. 13.5. Composite Modular Ramp System.

