CHAPTER 12
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NAVIGATION AID WITH TACTILE FEEDBACK

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INTRODUCTION

The Tactile Navigation Device will be a hands-free technology that can be used to navigate visually-impaired and blind people through high traffic areas where directions cannot be conveyed by voice commands, therefore, making tactile directions necessary to guide the user. Such a system will also be useful for people with Usher Syndrome, which results in both hearing and vision impairment. This device is being developed in stages; the first stage, now complete, involved the development of a tactile interface device (Figure 12.1) and a computer-based navigation system. The next step will be to integrate the two pieces into a single wearable system.

The system architecture for the tactile interface device is shown in Figure 12.2. It includes a keypad that enables a user to input a destination, a set of servo motors to indicate direction, a vibration motor to indicate proximity, and interfaces designed to work with the building navigation system and a bus locator system being developed as part of two separate projects (identified as P11016 and P11015, respectively). The device is capable of relaying instructions to go forward, back, left, and right. Those directions will be computed on the navigation side of the system and relayed through the microcontroller to the servo motor-driven pegs that provide the actual tactile feedback to the user.

The navigation side of the system is designed around a network of RFID (radio-frequency identification) tags and a tag reader carried by the user, along with a compass to identify the user's bearing. Based on identification of RFID tags visible to the tag reader, the user's current location can be identified and compared to his or her final destination, and directions can be computed. The second floor of the engineering building is being used as a test scenario, and the navigation team has defined this floor as a series of areas, each containing its own network of tags. The software uses Dijkstra's routing algorithm to determine the best sequence of areas to traverse to get from the user's current location to the final desired destination.

Fig. 12.1. Tactile interface for navigation aid.

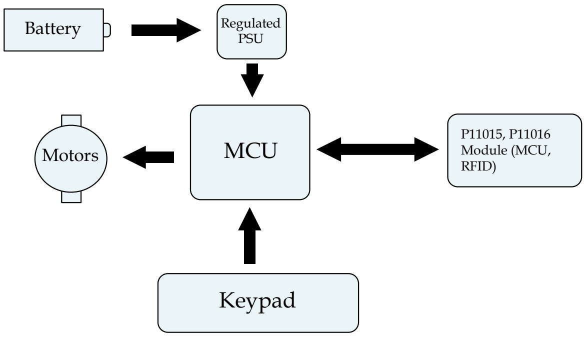


Fig. 12.2. Tactile interface device system architecture.

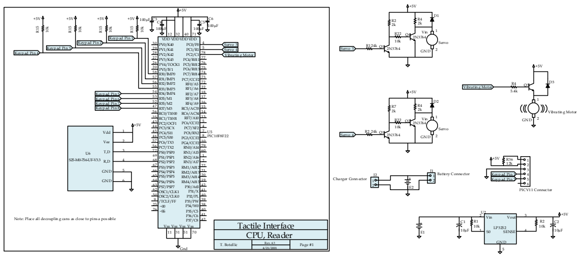


Fig. 12.3. Circuit schematic for microcontroller, keypad, and RFID tag reader; motor control; and power electronics.

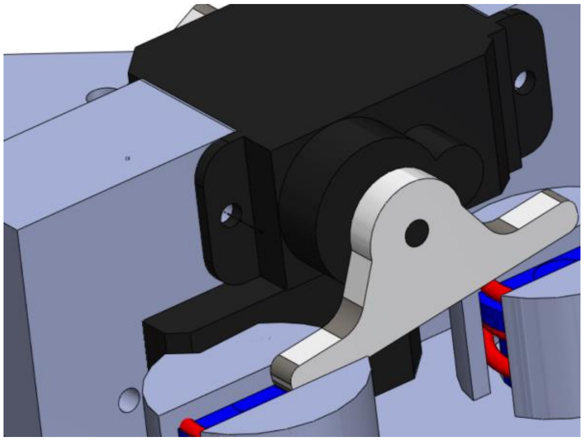


Fig. 12.4. Servo motor mechanism to provide tactile feedback. The motor arm (silver) rotates and engages one of two pegs (blue), depending on the direction of spin.

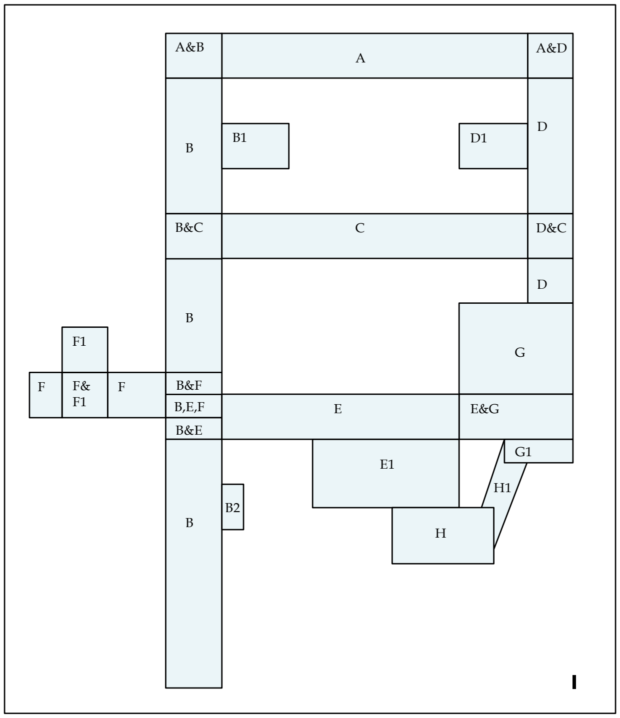


Fig. 12.5. Graph layout of the 2nd floor of the James E. Gleason Building.

SUMMARY OF IMPACT

Since this system is in Phase 1, the full capability has not yet been demonstrated with the end users. The tactile interface device was tested with some volunteers, and they were able to correctly identify keys on the keypad to input information (98% success) and were able to correctly interpret directions from the device 94% of the time. The most significant impact of this project is that it has been selected to be used as a model multidisciplinary design project within the college and the next iteration will be run with multiple teams, each seeking the best solution.

TECHNICAL DESCRIPTION

The tactile interface is driven by a PIC18F8722 microcontroller. It was chosen because it is capable of operating at the +5 Volts required for the navigation team's RFID tag reader, has enough pins to control the motors, can receive inputs from the keypad, is low cost, and can be programmed in C. The microcontroller software was developed using the PICDEM PIC18 explorer board, MPLAB IDE, and the C18 compiler. A 2″x2″ PCB was designed to be housed within the tactile interface. The PCB contains the MCU, control circuitry, voltage regulator, and connection pins that interface with the keypad, motors, battery charger, battery, and PICKIT programmer. Circuit board schematics are shown in Figure 12.3. The device is powered by a 6V 2200mAh rechargeable NiMH battery pack, and the device is charged by plugging a wall charger into a charging port on the device. This eliminates the need to remove and replace batteries frequently.

In order to guide the user to his or her destination, two servos were used to push the pegs gently down onto the user's forearm in order to indicate direction. One of the servos pushes the pegs to indicate forward and backward, and the other pushes the pegs to indicate left and right (Figure 12.4). The servos respond to pulse-width modulation (PWM) signals, and move to different positions based on the duty cycle of the PWM received. There are six different PWM signals that could be sent to the servos: four correspond to forward, backward, left, and right, and the other two rotate the servos back into their neutral positions. The PWM signals correspond to the four different movements that are contained within the MCU memory space.

The servos are driven via a network of bipolar junction transistors (BJTs). These serve not only to amplify the relatively small current that the MCU is able to provide (around 10mA) to a level that is adequate to move the servo, but also to isolate the MCU from any back EMF that the servos produce. The high resistance seen from the base terminal of the BJT effectively buffers the sensitive pins of the MCU from any harmful electrical spikes that the servos emit. The BJTs themselves are protected from back EMF by a fly back diode connected from the collector to the upper supply. This sinks excess current in response to a voltage spike back into the power supply instead of the transistor. The PWM signals are sent out through an I/O pin on the MCU and into the base of a BJT through a 10k Ω resistor resulting in an inverted PWM signal at the output of the first transistor. By chaining the output of the first transistor to the input of the second, the signal is inverted again, so that it is in phase with the original output coming from the MCU. Resistors were chosen so as to keep the BJTs in saturation. While in saturation mode, the transistor effectively acts as a switch. This reduces the power being dissipated through the transistor by lowering the voltage across the collector-emitter junction.

A vibrating motor is used to signal to the user that he or she has arrived at the destination. It is also used to give feedback to the user as certain buttons are pressed on the keypad. A single BJT is used to isolate the motor from the MCU which provides the control signal, and also to amplify the current to the proper levels. The base resistor was chosen so that the current flowing through the motor would cause it to vibrate at a level noticeable to the user without damaging the motor. Once again, a fly back diode was connected from the emitter terminal of the BJT (where the motor is connected) to the upper supply to prevent against damage caused by back EMF.

All of these components are housed in an enclosure manufactured in three parts. The base, shown in Figure 12.1, was rapid prototyped in RIT's Brinkman Lab, using ABS polymer. This was done to accommodate the complex geometry required to fit the user's forearm and support the various electrical and mechanical components. The housing walls were machined out of plastic and the cover of the case, holding the keypad, was machined from HDPE. The enclosure is designed to accommodate not only the input and tactile feedback mechanisms, but also the RFID tag reader that will be integrated in the next phase of the design.

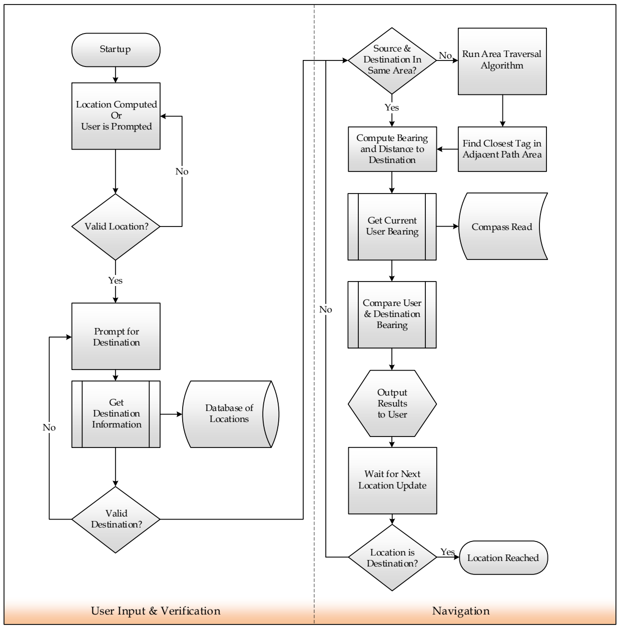


Fig. 12.6. Navigation software flowchart.

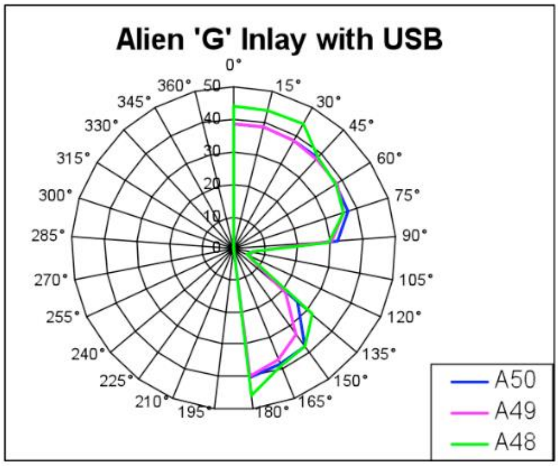
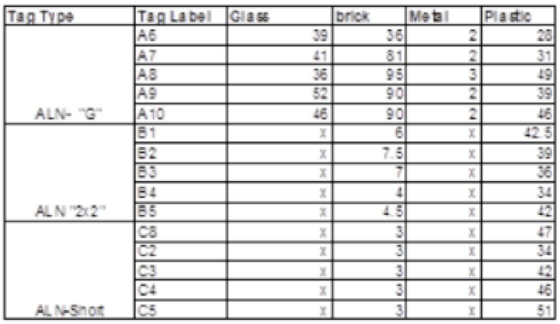


Fig. 12.7. Test results for the Alien "G" inlay tag. Measurements in inches.

The navigation software uses a two-level scheme. The top level is simulated by a graph, where each of the larger areas of a building are defined (Figure 12.5). These areas can be hallways, hallway intersections, stairwells, and large rooms such as conference areas. Within each of these large areas, locations are defined. Each tag ID corresponds to an x-position and y-position, the area containing the tag, and a brief description of the landmark the tag identifies. These two levels allow for a robust and expandable navigation algorithm. The algorithm itself uses

Dijkstra's routing algorithm to define the path of areas that need to be traversed. Dijkstra's is a greedy algorithm, which means the algorithm makes the optimal path choice at each stage. For instance if a point has 2 edges outwards with weights 4 and 10 the path with 4 will be traversed first. The path traversal using Dijkstra's forms the logical operation that guides the user through the building's highest level of organization. After the path of areas is computed, the algorithm will look for the closest location, which is a tag, in the adjacent area along the path. Computation of this bearing forms the method of traversal between the high level areas that Dijkstra's search has returned. The program computes the bearing necessary between the 2 points. The program reads the current bearing that the user is showing from the compass, which with a comparison to the desired bearing, allows the direction of travel to be output in human terms. A flow chart for the navigation software is shown in Figure 12.6.

The navigation team chose to use passive RFID tags for location tagging, due to their lower cost and ease of maintenance. Active tags offer a wider read range, but they are considerably more expensive and would require periodic battery replacement. The tags selected, with 64-bit identifiers, were purchased from Alien Technologies. The team also selected the Skyetek Module M9 RFID reader and a low-profile antenna, which resulted in some sacrifice in antenna gain, but meant that device size could be kept smaller. Since the RFID tags were going to be placed in a variety of different environments, on a variety of different surfaces, extensive tag testing was done to determine the read range of the available tags. Based on the building landmarks being tagged, the team determined that they would need to test tags mounted on glass, metal, painted cinderblock, painted drywall, paper, wood, and plastic. Since the antenna will be placed on or around the user's arm when in use, the team determined that the tags should be placed at slightly higher than waist level on building landmarks for optimal readability. The team also determined that the speed at which the user walks by the tag has no effect on the read range. Representative test results are shown in Figure 12.8. There is an ongoing issue with tagging elevators, and the team was unable to determine whether the issue was the large amount of metal in and around the elevator or interference from electromagnetic brakes, but this is an issue that must be addressed in the next iteration of the project. Figure 12.9 shows the reader, antenna, and primary tags selected for use in this project based on the team's testing.



Tag Type	Tag Label	Glass	brick	Metal	Plastic
ALN- "G"	A6	39	36	2	28
	A7	41	81	2	31
	A8	36	95	3	49
	A9	52	90	2	39
	A10	46	90	2	46
ALN "2x2"	B1	x	6	x	42.5
	B2	x	7.5	x	39
	B3	x	7	x	36
	B4	x	4	x	34
	B5	x	4.5	x	42
ALN-Short	C8	x	3	x	47
	C2	x	3	x	34
	C3	x	3	x	42
	C4	x	3	x	46
	C5	x	3	x	51

Fig. 12.8. Test results (in inches) for various tags with the reader held 1 foot above and below the plane of the tag.

The total cost of the project was approximately $651.39 for the navigation unit, with an additional $300 worth of RFID tags donated by the Alien Company, and $428.31 for the tactile interface unit

More information is available at http://edge.rit.edu/content/P11016/public/Home and http://edge.rit.edu/content/P11017/public/Home

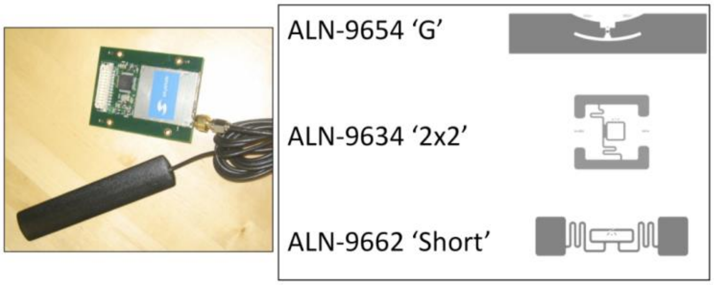


Fig. 12.9. Reader, antenna, and tags selected based on testing.

CAMPUS BUS IDENTIFICATION

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Computer Engineering Designers: Michael Delles, Irem Gultekin
Mechanical Engineering Designers: Mohamed Mandeel (Project Manager)
Client Coordinator: Franklin LeGree
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INTRODUCTION

The primary goal of this project was to design a portable device that assists visually impaired and blind people to select a desired bus and find the exact location of that bus at a bus stop, particularly when multiple buses are present at one time. These passengers typically have to get on the bus and ask the driver for the route number, and may need to exit the bus and board another, and repeat the process until the correct bus is boarded. This project will ultimately enable the end users to board their chosen buses with minimal outside assistance. Two bus stops are of particular interest in this project: Gleason Circle, a stop on the RIT campus where many buses often arrive at the same time, and a bus stop in the city of Rochester located at the Association for the Blind and Visually Impaired (ABVI)-Goodwill Industries, which employs a large number of people who are blind.

SUMMARY OF IMPACT

Due to delays in setting up communication between RGRTA and campus, the system has not been fully implemented at this point, but the client coordinator is extremely interested in seeing the results of this project when it is continued next year. Further, a successful project will be useful to people without visual impairments, since it will enable anyone to receive a notification that their bus is about to arrive.

TECHNICAL DESCRIPTION

The overall system architecture is outlined in Figure 12.11. The four key steps to that need to be completed are (1) identify user location, (2) identify bus location, (3) create navigation vector, and (4) user path correction. The user location is identified using an Radio Frequency Identification (RFID) tag placed at the bus stop. The user will be notified when he or she is within range of the tag, approximately 1-2 ft. This tag has a known GPS coordinate for each bus stop.

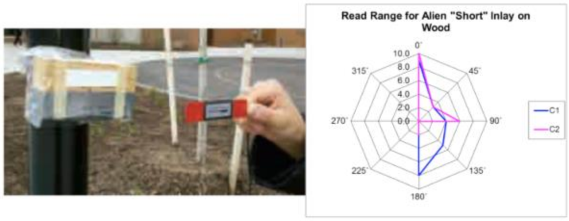

Fig. 12.10. RFID tag testing at Gleason Circle bus stop and sample test results.

The bus location is determined through access to the RGRTA GPS database, and the navigation vector is calculated based on the GPS coordinates of the bus and the user location.

To test the effect of attaching the RFID tags to metal bus stop poles, five different Alien RFID tag types (“G”, “2x2”, “Short”, “Squiggle”, and “Squiglette” inlay) were mounted to wood and plastic plaques, and these assemblies were then attached to the bus stop pole. Read range angles and distances were recorded. When mounted to a 1.5” thick piece of wood, the “G” and “Squiggle” tags were detected throughout the entire testing range of 0° to 180° at an average distance of one foot. Both of these tags were also consistently read at a 30° angle above and below the point parallel to the tag height. When mounted to a 1” thick piece of plastic, only the “G” tags were detected. Representative test results are shown in Figure 12.10. The final recommendation from the team was to mount the Alien G tag on wood at the bus stop.

The software to acquire information from RGRTA and calculate navigation vectors was written in C# and created in Microsoft Visual Studios 2010. The entire project consists of six classes: two threaded classes to gather data from RGRTA, named timepointData.cs and Busdata.cs; three object files to hold and organize this data, named Bus.cs, TimePoint.cs, and GPSCoord.cs; and a main program to run the guidance algorithm, named vipbGuidance.cs. One of the complicating factors in this software is the fact that, on any given day, a single bus may be running a number of different routes. This means that the software needs to be able to link the mapping of different buses to their routes to the GPS information gathered by bus.

The first threaded file, timepointData.cs, gathers only the specific time point that each bus hits on the RIT route. The second, Busdata.cs, gathers the information of the regular GPS signal that each bus sends out at a rate of once per minute. This information is stored in two Dictionary objects, one that stores each Bus according to its route, which is determined by the time-points it hits, and another that stores the bus by its identification number with its most current GPS location. The Bus.cs object stores the ID number of the bus, the bus's last GPS location, the route it has been assigned to and the last time point it hit. The TimePoint.cs object stores each time point as a String for its name and a GPSCoord of its location. The GPSCoord object is made up of two double precision numbers, for latitude and longitude. The vipbGuidance.cs class works by first prompting the user for a destination until a valid destination is entered. Then that route is searched for until the correct bus is identified. Once it has been identified it waits for the arrival of the bus to the user's timepoint. Once the bus arrives a new GPS signal is sent a minute after it arrives from which the Haversine Formula is used to compute a direction vector to guide the user. If the user deviates from the path a new vector is calculated. The program exits when the bus leaves the timepoint.

The total cost of the project was approximately $408.91

More information is available at http://edge.rit.edu/content/P11016/public/Home

Detailed Flowchart

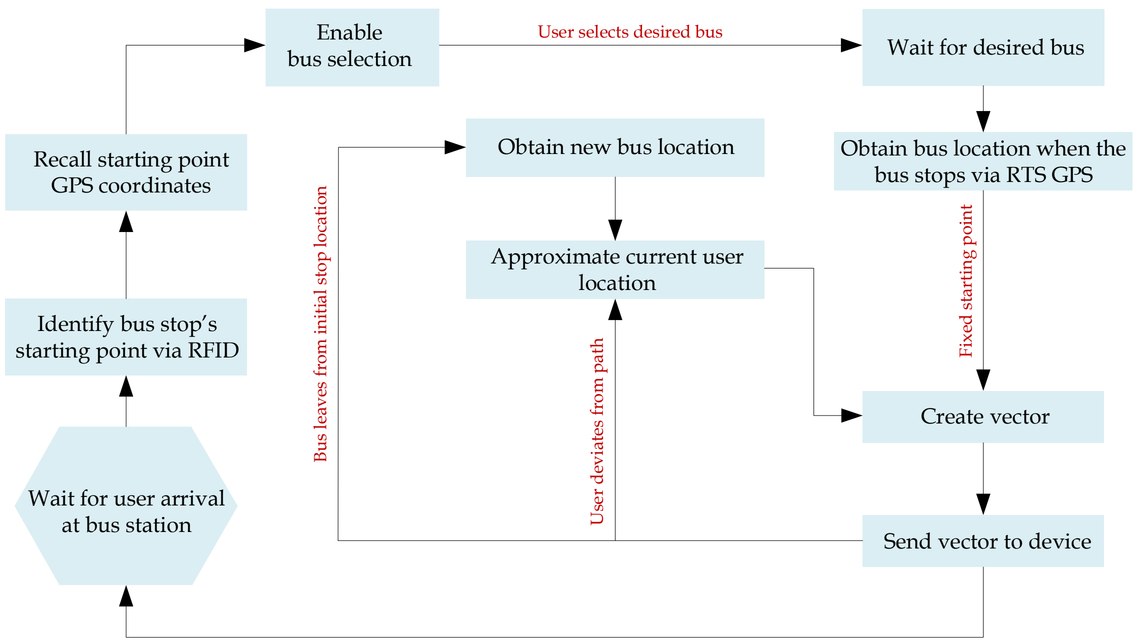

Fig. 12.11. Flow chart for bus identification system.

BALANCE TRAINING BICYCLE

Electrical Engineering Designer: Lawrence Grant
Industrial Engineering Designer: Wesley Seche
Mechanical Engineering Designers: Kyle Benesh (Project Manager), Marc Sciarrino
Client Coordinator: J.J. Mowder-Tinney, Ph.D., PT
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INTRODUCTION

The Physical Therapy clinic at Nazareth College engages a variety of clients in need of balance training, and looking for a challenge. The balance training bicycle introduces some controlled instability similar to that experienced on a freestanding bicycle without the risks associated with actual bike riding. Clinic clients in need of balance training are those who have had strokes, or those who have other neurological conditions that cause an imbalance in strength between the left and right sides of their bodies. This device is a refinement of a prior senior design project, with specific goals of achieving a more realistic pedaling “feel”, better control over the bike’s tilt, and an improved user interface.

SUMMARY OF IMPACT

The redesigned system is shown in Figure 12.12. The therapist noted that the pedal mechanism provides a much improved feel, and that the tilt resistance is much more consistent and easy to adjust. The team was able to accomplish this while retaining the positive features from the prior iteration, namely the seat, handlebars, frame, and ability to lock the bicycle in an upright position.

TECHNICAL DESCRIPTION

The design was broken into three subsystems: 1) frame and pedal resistance, 2) tilt mechanism, and 3) display/feedback. The team was tasked with improving the pedal resistance and tilt mechanism without significantly redesigning the frame, seat, handlebars, and upright-and-locked position mechanism, and they chose to incorporate commercial off-the-shelf components for the pedals and the tilt mechanism.

The new pedal mechanism relies on magnetic braking to provide pedal resistance, which gives a much smoother and more realistic feel than the prior friction-resistance pedal system. The pedal mechanism is a magnetic eddy-current-brake pedal exerciser, similar to those in commercial exercise bicycles, which works by taking the rider’s rotational force input and using it to spin a large ferromagnetic disk between two opposite polarity magnets. This creates swirling currents of electricity in the disk around the areas crossing the magnetic flux, in the direction opposite of the pedaling motion. This creates a velocity dependent resistance against the rider’s input and avoids the stick-skip issues previously experienced with the prior friction braking mechanism. A portion of the frame was removed to make room for the pedal mechanism, and stress and fatigue analysis done to the modified frame indicated that the new static factor of safety is approximately 6 and the new factor of safety on infinite fatigue life is 5.4.

Fig. 12.12. Balance Training Bicycle.

The prior balance bike design relied on a collection of elastic Therabands to provide tilt resistance. While this concept was appealing to the clinicians because of its simplicity, the Therabands proved to be difficult to attach and remove. The new design relies on a commercially available bicycle shock absorber, which contains a spring and damper acting in parallel. The shock absorber has a nominal spring constant of 350 lb./in and a damping coefficient of approximately 500 N-sec/m. Figure 12.13 shows the prior and current tilt resistance designs. The tilt resistance mechanism functions by using a pair of the bicycle shock absorbers, along with a pair of fabricated “sliders” consisting of a male and female part that slide together concentrically. These two pairs of components are linearly connected to each side of the bike to affect tilt resistance in both directions. The sliders act as a release when the bike tilts in the opposite direction of a given shock. This way, the shock is not placed in tension and the bike is allowed to tilt in either direction without interference. Analysis done on the tilt mechanism showed that, with a 300lb client on the bike at full tilt of 10°, a therapist guarding the client would need to apply a force of 38lb to bring the rider back up to a vertical position, ensuring safety for both the client and the therapist. Tests with a 200 lb. user showed that a rider allowed to tilt to one side would not fall quickly, but would take slightly more than 1 sec to fall up to 10°. Additionally, stress analysis on the brackets added to support the shock absorber indicates a static factor of safety of 1.56 and a factor of safety on infinite fatigue life of 1.32.

The display mechanism is based on an Arduino Mega 2560 microcontroller. This microcontroller will be in charge of operating all of the relevant displays, using inputs from an inclinometer to sense tilt and multiple switches. The signal from the inclinometer will be run directly into the microcontroller for processing. An array of LEDs will be used to relate to the rider the current angle of tilt. The LED will be “selected” to be lit using a four bit control signal from the microcontroller which will run into a demultiplexer. A pair of seven segment displays serve to tell the rider how many times they have “fallen” (i.e., hit the maximum tilt angle set) to the left and to the right. Every time they reach the max angle for their riding settings the counter will increment. These can be reset to zero on powering off or by pressing the reset button. The buzzers will sound every time that the rider reaches maximum angle to add an audio feedback to their 'fall'. The volume for these buzzers will be controllable using the potentiometer. There is a power switch and a mode switch to allow the user to select the maximum angle setting (either 5 or 10 degrees).

The total cost of the project was approximately $770.23

More information is available at http://edge.rit.edu/content/P11001/public/Home

Fig. 12.13. Left: old tilt resistance mechanism. Right: new tilt resistance mechanism.

ALERT NOTIFICATION DEVICE

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Electrical Engineering Designers: Stephen Berus, Athena Turner
Client Coordinator: Prof. Gary Behm, National Technical Institute for the Deaf
Supervising Professor: Prof. George Slack
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INTRODUCTION

A missed alert for a deaf or hard of hearing person can have serious consequences. Even if the event is not life-threatening (such as a fire alarm), missing vital information can negatively affect the quality of life for deaf and hard of hearing people, as it restricts their independence. Most home and hotel alert systems are audible, thus neither convenient nor practical for these people. Products with non-audible functions exist on the marker, but are cumbersome for travel or may require permanent installation. This project aims to create a portable device that combines visual and tactile cues that an alert is present, with a nominal usage scenario of an alarm clock to wake a sleeping person.

SUMMARY OF IMPACT

The final device functions as an alarm clock that can be set from a computer and then operates independent of the computer to wake the user. It fits in the palm of the user's hand and uses high power LEDs on either side of the box as well as a bed shaker to provide both visual and tactile alerts. The finished device is shown in Figure 12.17 mounted on a tripod to elevate it.

TECHNICAL DESCRIPTION

Work on this design project was broken into three parts: driver electronics, software, and housing. The driver electronics (Figure 12.14) consist of controls for the external bed shaker, controls for the LED array, and power regulation. The 12 LEDs were arranged as shown in Figure 12.14 with 6 parallel pairs of 2 LEDs in series, in order to reduce hat through power dissipation (384 μW v. 768 μW for 12 LEDs in parallel). The bed shaker was protected by a diode and the Toothpick 2.1 Bluetooth Transceiver, used to communicate with a PC, was protected by a fuse. The final PCB layout is shown in Figure 12.15.

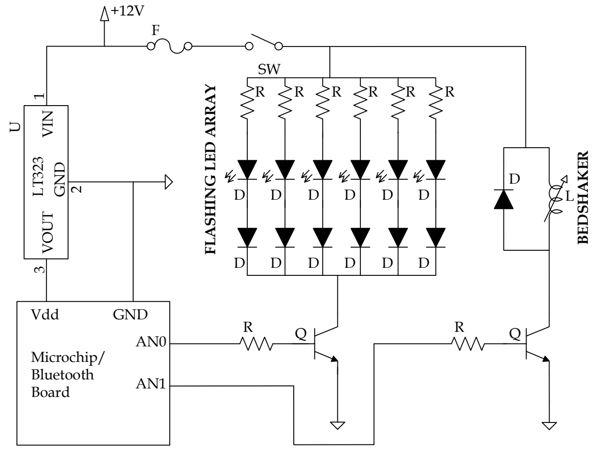

Fig.12.14. Circuit Diagram.

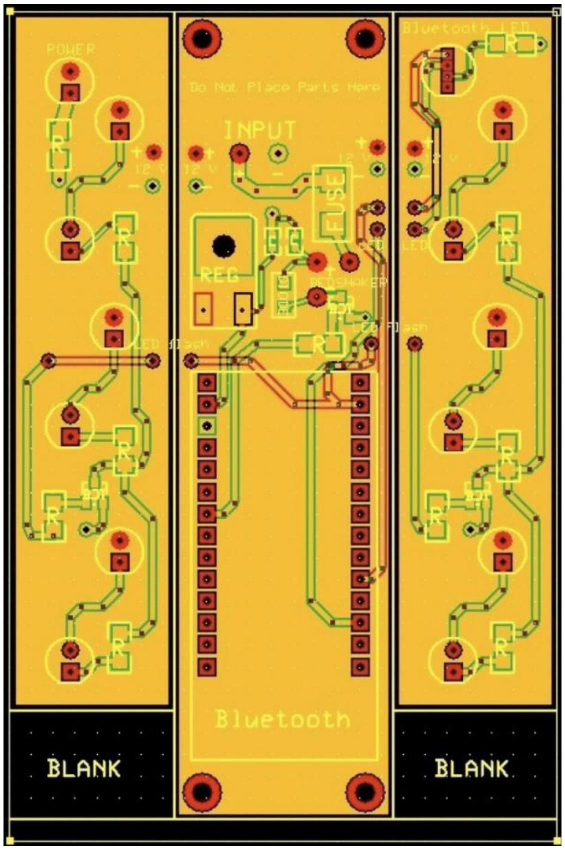

Fig. 12.15. PCB Layout

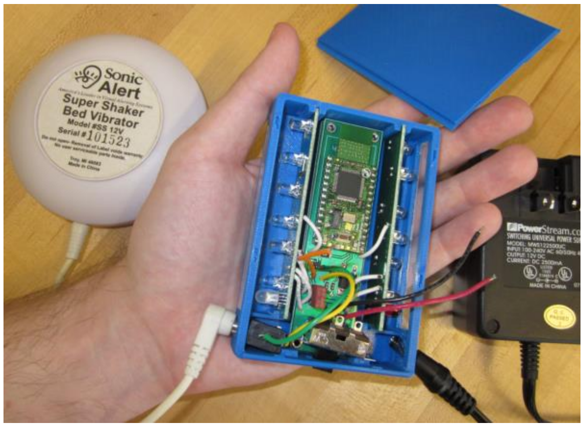

Fig. 12.16. View of inner workings of device, including bed shaker and power adapter ports.

Fig. 12.17. Alert notification device, mounted on tripod without power cord and bed shaker.

The software was designed using MPLAB IDE and FlexiPanel Designer, which came with the Bluetooth development kit. FlexiPanel allowed for development of an application that runs on a PC and communicates with a Bluetooth device like the alert system created for this project. The final software allows the user to set the alarm time on a PC, and cancel or snooze an alarm sequence on the portable device.

The enclosure, shown disassembled in Figure 12.16, was created using a 3-D printing system, which allowed for a custom case design with viewing panels for the LEDs, built-in ports, and PCB supports for the three-part board. The enclosure passed compression testing (341 lb.), drop and shock testing (330 g with functioning electronics, although the enclosure cracked), and vibration testing (standard shipping truck vibration profile for 15 minutes). Additionally, the enclosure and the regulator and BJT on the PCB were all instrumented with thermocouples to monitor operating temperatures. The team found that the external surface of the enclosure never exceeded 88 °F during operation, which is safe for all users. Internally, the regulator reached a maximum of 145 °F and the BJT reached 118 °F during alarm activation, but both temperatures decreased rapidly in snooze or off mode.

The next step for this project will be to attempt to build a Bluetooth RF transceiver in-house and investigate rechargeable batteries and more scalable methods of producing the enclosure. These steps will lead to this device becoming available to the deaf and hard of hearing community at RIT.

Total cost was approximately $690.69

More information is available at https://edge.rit.edu/content/P11201/public/Home

STRAW CUTTING PROCESS IMPROVEMENT

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Mechanical Engineering Designers: Ian Balbresky, Tyler Banta, Mark Vaughn
Client Coordinator: Wayne Geith
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INTRODUCTION

The primary goal of the ArcWorks Straw Cutting Device project was to design, build, and deliver a functional straw cutting device to ArcWorks which will be able to cut multiple polypropylene copolymer (PPCO) straws to desired lengths with minimal deformation and burring. The device will have to follow ISO 9001 guidelines, along with complying with OSHA standards and being accessible to employees with a wide range of developmental disabilities. These straws are used within an assembly process at the ArcWorks facility which provides wash bottle assemblies for customers like Thermo Fisher and Nalgene. The current process at ArcWorks utilizes one automated machine along with a manual process to cut the raw material straws to the appropriate lengths. With the addition of our automated machine an increase in overall productivity at ArcWorks within their wash bottle assembly process will be seen; the increased productivity will benefit workers who are paid by the piece, and will also allow ArcWorks to reduce inventory levels.

SUMMARY OF IMPACT

The current device (shown in Figure 12.21) is able to safely cut 12 straws at a time, and is capable of cutting 1400 straws/hr., compared with the existing device's 700 straws/hr. capability, meaning that employees can increase their production and ArcWorks can reduce their safety stock. Unfortunately, the quality level of the cuts is not up to the standards set by ArcWorks.

TECHNICAL DESCRIPTION

The new device is a pneumatically-driven machine that cuts 12 straws at a time, safely and with minimal physical exertion, and removes the debris from the cutting area. The straw cut is completed using a single blade with a double bevel that is angled at 45° to the direction of motion (as shown in Figure 12.18). The straw pattern was laid out to maximize blade

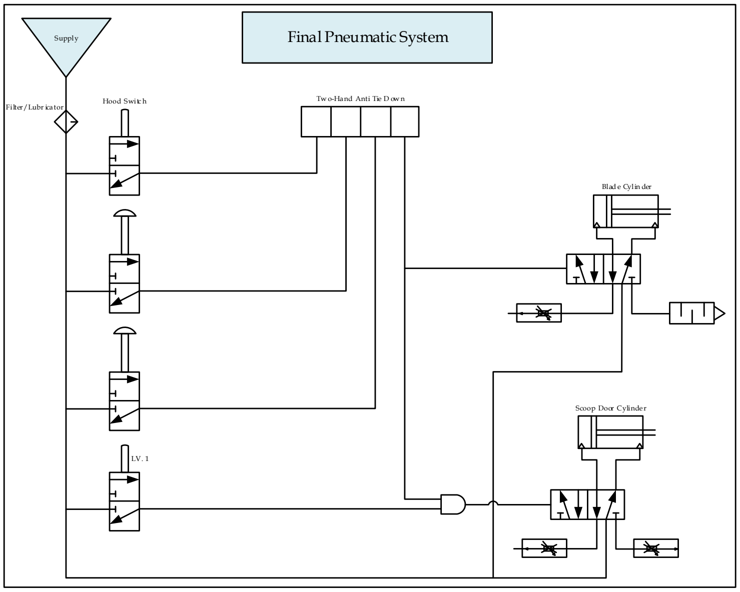

Fig. 12.18. Pneumatic system schematic.

utilization and to ensure that only one new cut is initiated at a time. The blade is mounted on a blade carriage system that is driven by a 300 lb cylinder with a 3 in stroke. The cylinder operates on a 100 psi compressed air supply, already available in the ArcWorks facility. The cylinder is triggered with a two hand anti-tie down switch, and a mechanical switch only allows actuation when the lid is closed. The pneumatic system design is shown in Figure 12.18. The cut quality does not currently meet ArcWorks's requirements, possibly due to the double bevel on the new cutting blade. The blade cuts through approximately half of the straw satisfactorily, but beyond that point, the straw bends and the remainder of the cut has the appearance of a tear, rather than a clean cut (Figure 12.19). The team has developed recommendations, including applying light pressure to hold the straw in place and prevent bending, and using a different blade; these will be investigated before delivering the machine to ArcWorks.

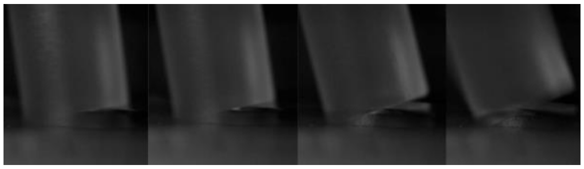

Fig. 12.19. High-speed image of straw cut.

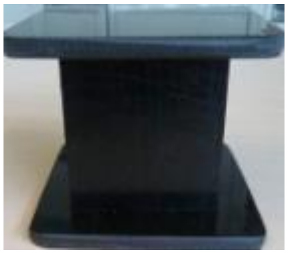

Fig. 12.20. Straw cutter support block.

The device was required to be capable of cutting 9 different straw lengths, so an adjustable trap door mechanism was designed to support the straws during cutting. The height of the trap door can be changed to any of the 9 required length settings, and after a cut is complete, a 12 lb. pneumatic cylinder, with a 1 inch stroke, opens the door and allows the cut straws to fall down for removal. The trap door does not currently function as designed, so a backup block (Figure 12.20) was created to support the straws until further work on the device can be completed. The block does not allow the 9-length adjustability, but does allow the machine to function.

The total cost of the project was $1541.63

More information is available at https://edge.rit.edu/content/P11008/public/Home

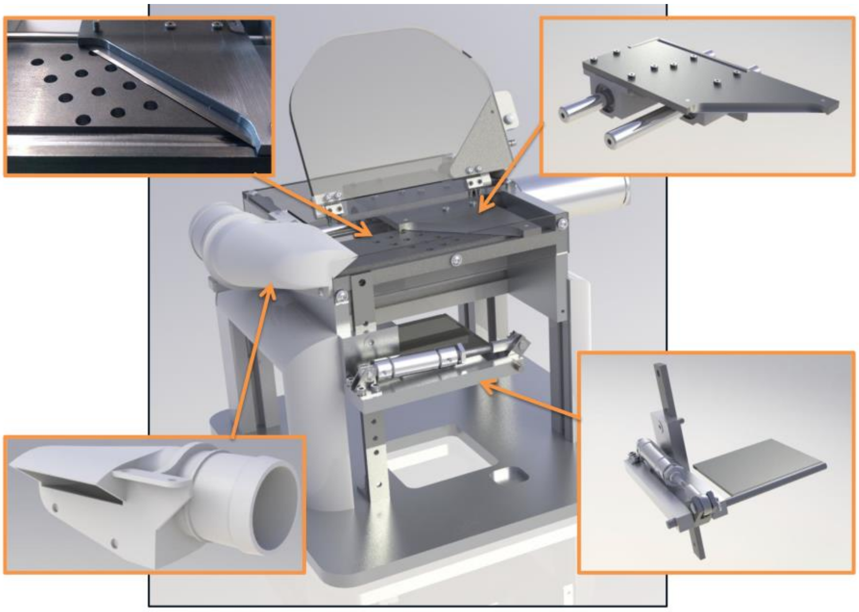

Fig. 12.21. Straw cutter design. Clockwise from top right: blade carriage, trap door/height adjustment, vacuum attachment, and cutting plate.

HANDS-FREE WIRELESS PRESENTATION REMOTE

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Mechanical Engineering Designer: Mason Verbridge (Project Manager)
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Client Coordinator/Customer: Gary Behm, National Technical Institute for the Deaf
Supervising Professor: Dr. Elizabeth DeBartolo
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INTRODUCTION

The goal of this project was to design and build a device that would allow presenters using American Sign Language (ASL) to have wireless presentation control without the need to carry around a remote device. Since ASL requires the use of both hands, the act of advancing or reversing slides interferes with the flow of the presentation and can become distracting if the remote is not easily accessible.

SUMMARY OF IMPACT

The team was able to circulate their device for use by 15 ASL users over a 10-day period, each of whom submitted a survey sheet when they returned the device. Users were given the device itself, which has a form factor that approximates a very large wristwatch, the USB dongle for communication with the computer, and spare batteries (Figure 12.23). The highlights of the device based on user feedback were its Functionality (8.5/10), Fit (7.9/10), and Overall Satisfaction (7.2/10). In addition, users indicated that they would be willing to pay an average of $25 for the device. Since the current device relies on a board that was not custom made for the system, but was modified from an existing wireless remote, the form factor of the device is fairly large and the evaluators gave lower scores for Aesthetics (5.6/10). However, the Client Coordinator noted that at the inauguration of the new President of the National Technical Institute for the Deaf at RIT, the incoming President misplaced his presentation remote and had to stop his talk to find it – if only he had had one of these devices, which would not have happened!

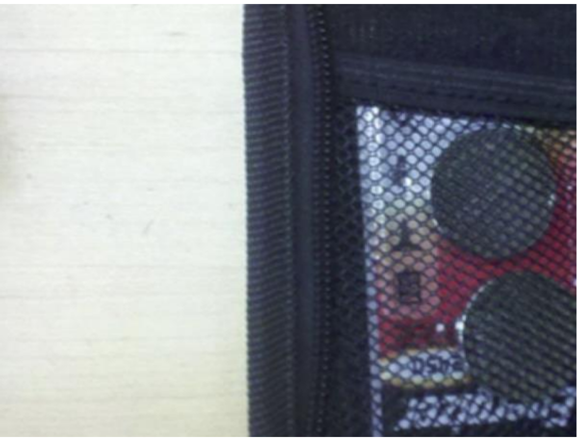

Fig. 12.22. Hands-free wireless presentation remote.

Fig. 12.23. Fully assembled device being worn.

TECHNICAL DESCRIPTION

After analyzing many different Power Point slide remotes, the team found that a pen-sized remote provided a significantly smaller board, simple functionality, and met general size and range requirements. The team decided to modify this board after some initial analysis of its functionality. The board used a single 1.5V AAA size battery, accompanied with an initial boosting circuit which raised the voltage to 5V. This 5V supplied power to the on-board micro-controller which set idle and sleep times for the transmit chip. After a single button press, which constituted the 'active/transmit' mode, the chip would idle after 0.5 seconds and reduce its current draw from approximately 60 mA during active/transmit, to 4.5mA during its idle state. The idle state would continue searching for a signal for 20 seconds, at which point it entered a 'sleep' mode if no other button activation occurred. While in this sleep mode, the circuit drew only 200uA. This fact led us to believe that our battery life spec would be met due to having a non-constant draw from the most power-hungry portion of the device. In addition, the AAA battery was replaced with a 3V CR2450. This battery is readily available for purchase at common retailers, and the specifications of the CD2450 allow for a significantly longer battery life than the standard AAA.

Portions of the board were removed to reduce the footprint and allow for the smallest possible housing. The battery contacts were removed and replaced with a CR2450 holder, and the surface-mount buttons on the board were removed and replaced with wires to allow new buttons to be attached in the desired locations. Figure 12.24 shows the board as it sits inside the device with the leads for the offset buttons. Since the enclosure severely attenuated the wireless signal, a new antenna was created and built into the system. The required antenna length was 2", so the antenna was coiled around the circumference of the case to maintain a small device size (Figure 12.24).

Finally, the team estimated the cost to make multiple devices and determined that a batch of 1000 devices, made with injection-molded cases from a rapid-prototyped mold, could be made for a cost of approximately $15.24 per piece, without labor.

The total cost of the project was $225.07

More information is available at https://edge.rit.edu/content/P11032/public/Home

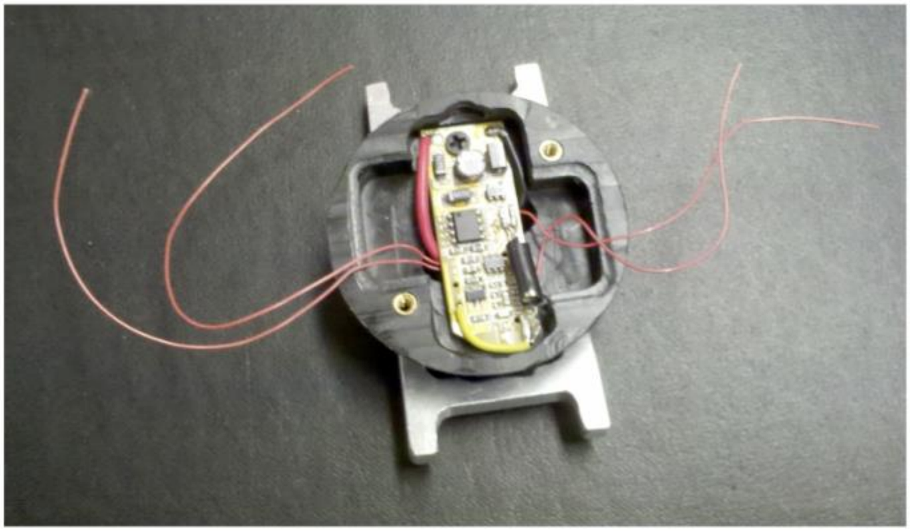

Fig. 12.24. Modified PCB placed in case, with leads for buttons shown.

MOTION TRACKING SYSTEM FOR REHABILITATION

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Industrial Engineering Designer: Maya Ramaswamy (Project Manager, Sensor Team)
Mechanical Engineering Designers: Evan Brent (Project Manager, Base Unit Team), Andrei Stihi
Client Coordinator: J.J. Mowder-Tinney, Ph.D., PT and Richard Barbano, MD, Ph.D.
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INTRODUCTION

Two local clinics, one an outpatient physical therapy clinic and the other a neurology clinic, have a need for tracking human motion. Both clinics need a quantifiable way to measure the angle in space between two rigid links: either knee flexion during walking or head tilt relative to the torso. The physical therapy clinic works with many individuals who have had strokes and who would like to have a measure of their progress in returning to a normal gait pattern, and the neurology clinic treats people with cervical dystonia.

SUMMARY OF IMPACT

Both customers were pleased with the device that was developed and were eager to use it in their clinics. The as-built system (Figure 12.25) can measure tilt (pitch and roll) to ±80° and rotation (yaw) to ±180°. Pitch, roll, and yaw can be measured to, respectively, 5°, 10°, and 8° accuracy and 2°, 6°, and 2° precision. The device can be put on quickly (less than 30 seconds), removed quickly (3 seconds), and sanitized between users, and is comfortable for users to wear. The sensors connect to a wearable base unit (Figure 12.26).

TECHNICAL DESCRIPTION

This device was separated into two sub-projects: a sensor unit and a wearable base unit. The sensor unit is comprised of a pair of Razor 9 degree-of-freedom inertial motion sensor units (9DOF IMU), each packaged in its own protective enclosure and capable of being attached to either a leg strap for collecting knee flexion angles or a head strap for collecting head tilt angles. The 9 degrees of freedom that the sensor can measure are achieved with a 3-axis accelerometer, a 3-axis gyroscope, and a 3-axis magnetometer. Each 9DOF IMU is coupled with a 3.3V FTDI breakout board for USB communication with the base unit, and one IMU is equipped with a

Fig. 12.25. As-built system being used to measure (left) knee flexion and (right) head tilt.

Fig. 12.26. Wearable, programmable base unit. Shown being used to capture knee flexion angles.

button to reset or zero out the sensors (Figures 12.29 and 12.30).

The sensors function differently depending on whether they are in head-tilt or knee-flexion mode. In knee-flexion mode, only one angle is required, assumed to be in the plane of motion of the direction of walking. The accelerometers on the 9DOF IMU are essentially used as a set of inclinometers, measuring angles of the upper and lower legs in space and finding the in-plane difference between the two. The lower leg schematic is shown in Figure 12.28 and the upper leg is similar. The angle θ is calculated by the arctan($-a_x/a_y$). For head-tilt, the 9DOF IMU is used as a pitch-roll-yaw sensor, and the magnetometers are employed in addition to the accelerometers. Since the magnetometers are very sensitive to the presence of ferrous metals, the system uses only brass fasteners.

The sensors interface with the base unit using a USB protocol, which enables vast communication, good signal integrity over the range of interest (approximately 3 ft.), minimal power consumption, and ease of implementation. A messaging protocol was developed to allow the sensors and base unit to communicate and identify themselves. The base unit is primarily comprised of a Beagle Board and Beagle Touch screen, along with a rechargeable NiMH battery pack inside an aluminum enclosure. The base unit is programmed in C. It performs a 10-number average of the sensor data and performs all necessary calculations. It also includes a graphical user interface that allows the user to select which mode (knee flexion or head tilt) to use and stores data in a comma-delimited format for export to Microsoft Excel (Figure 12.27).

The total cost of the project was $675 for the base unit and $735.76 for the sensor unit.

More information is available at https://edge.rit.edu/content/P11011/public/Home

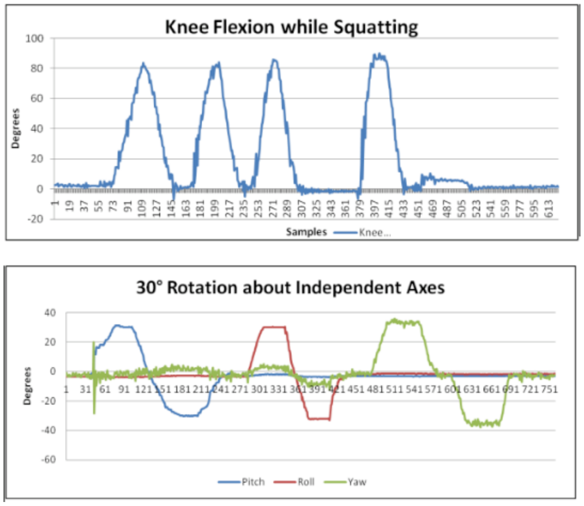

Fig. 12.27. Sample data collected using the human motion tracking system

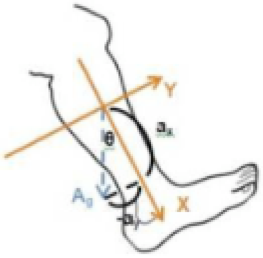

Fig. 12.28. Illustration showing the values used to calculate angle of the lower leg.

Fig. 12.29. Front and back of sensor unit with reset button, showing snaps to attach to knee or head straps.

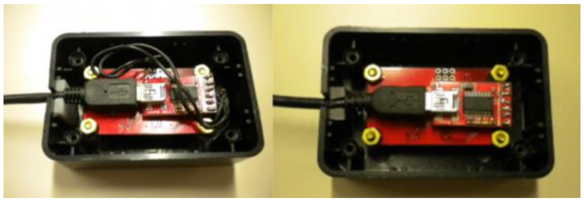

Fig. 12.30. Sensor units without reset button (left) and with reset button (right).