CHAPTER 13

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The Design and Development of a Usage Tracking and Analysis Facility for an Augmentative Communication System

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INTRODUCTION

Many communication systems allow for flexible configuration of the vocabulary set by the clinician. Generally, selection and positioning of lexical units within the vocabulary set is done by the clinician through consultation with the patient and through his or her own common sense choices. However, since the clinician has a limited number of sessions with the patient, rarely is a vocabulary set chosen from scratch. Usually, the clinician augments the vocabulary set supplied with the communication system with additional words and phrases. Two problems exist with this method.

The first problem is that of vocabulary choice. Initial selection of lexical items could preclude inclusion of a frequently used word, causing the patient to have to repeatedly form it from its letters, significantly decreasing his or her communication rate. A less serious, but related problem is the inclusion of a word that is rarely used. A large number of superfluous words contributes to an increased search and selection time for the patient and, consequently, a decreased communication rate.

The other problem is that of search and selection time for a lexical item. In a communication system, items that are used more frequently should be placed where they can be selected quickly. If a frequently selected item is inconveniently positioned, this results in an increased search time.

A facility that monitors real-time patient usage of the device and provides a detailed report of selection behavior would aid the clinician in choosing an appropriate vocabulary set and better placement of lexical units for their patient's communication needs.

TECHNICAL DESCRIPTION

The system was developed as an extension to the Meta-4 communication system1. Meta-4 is a communication system being developed at the Applied Science and Engineering Laboratories of the University of Delaware and A.I. duPont Institute. Currently in beta-test stage, Meta-4 is designed to be used on a portable IBM-PC compatible computer. The overall philosophy of the system is to be as flexible as possible. Currently, Meta-4 supports several input strategies and devices as well as fully user configurable vocabulary and page layout. The tracking and analysis system consists of two logical components, an interface to the run-time of the communication system known as the tracker and a separate software system for analyzing the usage data produced by the run-time interface known as the usage analyzer.

The methodology of the system is as follows: The communication system is used by the patient in a normal manner. While the communication system is being used, the run-time interface records the patient's selections and the elapsed time between selections in a file. This file is referred to as the history file. The history file is used as input to the analysis system. The analysis system uses the data from the history file along with additional files which define the vocabulary set of the device, to produce a detailed report summarizing the patient's communication activity.

Tracker

The tracker was implemented as an event called from the main loop of the Meta-4 runtime. The tracker's first task is to open the current day's history file and initialize the record for the current session. Once the session record is initialized, the tracker is called after each selection the user makes. A timer is maintained, and it measures the elapsed time between selections in one-hundredths of a second. Each selection is recorded in the data-file along with the elapsed time taken to make the selection. The tracker maintains a buffer of the three most current selections, and the file is updated when either the buffer fills up, or ten minutes elapses between selections.

Usaae Analvzer

The usage analyzer was implemented as a batch-orientated facility which is run after the Meta-4 session(s) are completed. The analyzer uses the history files created by the tracker and Meta-4's vocabulary files as input and generates output in a format compatible with ***Borland Sprint,*** a text processing and formatting package which uses a Scribe-like command set.

Initialization

When initialized, the analyzer first loads in all of the data files that specify Meta-4's current vocabulary set. This vocabulary set is known as the book. The book is organized into separate pages, with each page being a separate data-file in the book directory. The items in the page files are loaded into a database which is implemented as a hash-table. The hash-table is implemented as a linear array of buckets with chained slots. A simple hashing algorithm is used, where the hash value is computed from the modulus of the sum of the ASCII values of the characters in the hash key by the number of buckets in the hash-table. The hash-key is formed from the concatenation of the literal and function-list fields of the item and the current page name. The concatenation of these three fields results in a unique identifier for each item. As the items are loaded in, a separate record in the hash-table is created for each item.

Analvsis

Once the book is loaded into the database, the history files are opened and read in item by item. Each item is found in the hash table from the hash-key which is the same as the first field in the item record. Once the item is referenced, the selection counter, times list and total-ticks fields are updated. In addition, the function-list field is parsed, and if the function changes the state of the current page, the current page global variable is updated accordingly. This variable is used in constructing the hash-key for each item in the history file. In addition, a buffer is maintained for the construction of new lexemes. Any group of letters deliminated by a space, punctuation, an existing word, or a page-change command is considered by the word-builder function as a word. Once a word is recognized, its existence as a new item is checked in the hash-table. If it is found, its state variables are updated, otherwise it is added to the table. This process is repeated until all the history files are read.

Sortinq

Once the analysis is complete, the entire contents of the hash-table are copied into a dynamically allocated linear array. The array is then sorted, using the quicksort algorithm. The elements are sorted into non-decreasing lexical order on two keys: the primary key is the page name and the secondary key is the literal field of the item. The quicksort algorithm is extremely efficient, and is able to sort the array with an average case time complexity of $O(N \log_2 N)$.

Report Generation

The sorted linear array is then passed to the reporting function which generates the output. For each item, the following pieces of information are printed in a table like format:

1. Frequency of occurrence
2. Average selection time
3. Selection rate
4. Literal Field
5. Function List
6. Location in the vocabulary set

The final output of the analysis facility is a text file which can be interpreted by the Borland *Sprint* typesetting package. The prototype's output was designed to be printed in landscape format on a PostScript compatible printer.

References

1. Demasco, et al., "The Implementation of a Software Methodology for Communication Aids," RESNA Proceedings, 1987, pp. 745-747.

High Stability Walker for Child Patients with Cerebral Palsy

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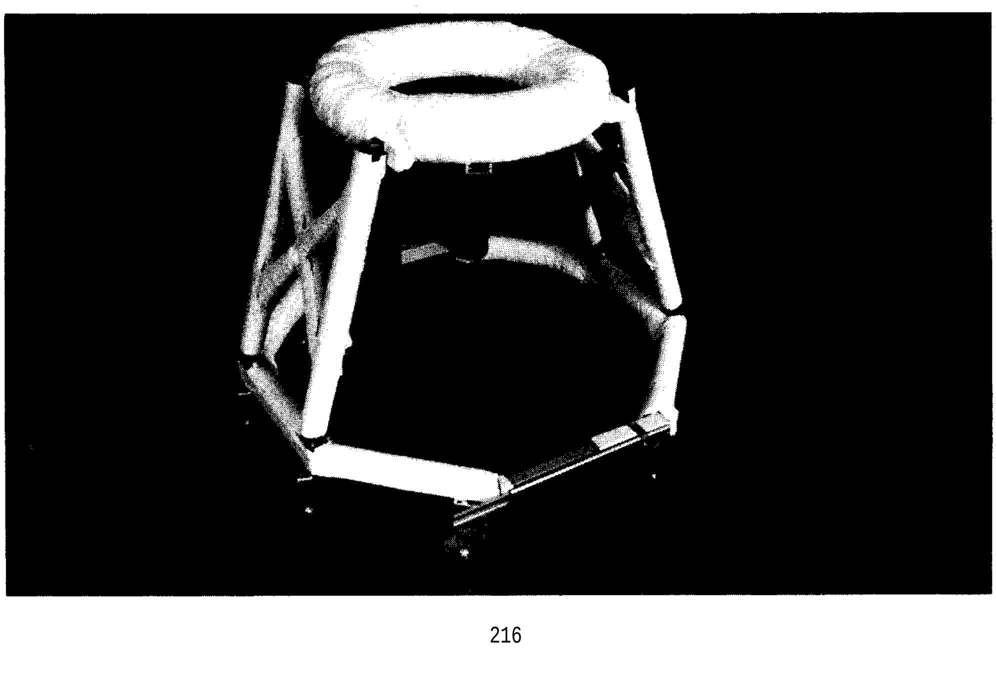
INTRODUCTION

The high stability walker is a wheeled device which both supports the cerebral palsy patient and allows for mobility while providing high stability. The patient sits on a bicycle type seat which is suspended from a swivel ring which is in turn supported by vertical members that attach to the wheeled base. All wheels are castered and the device is easily moved by the patient "walking" along the floor. The swivel ring allows the seat to rotate about a vertical axis so that motion in any direction is simplified. The wide base provides for high stability. In addition, telescoping members in the base ring allow the ring to partially collapse to pass through typical doorway.

Removal of four bolts allows the entire device to be packed flat for ease in transportation. All frame members are padded to minimize patient injury.

SUMMARY OF IMPACT

The primary goal of the device is to provide a highly stable unit which allows the patient to propel himself with few limitations to overall mobility. The wide base makes tipping nearly impossible while the collapsing design limits restrictions to mobility. Patient support is accomplished through the use of the suspended seat and also by the enclosing swivel ring. Patient placement into the unit is somewhat difficult; however, once in place the patient is quite secure. Padding of all members reduces the possibility of patient injury from contact with frame members.



TECHNICAL DESCRIPTION

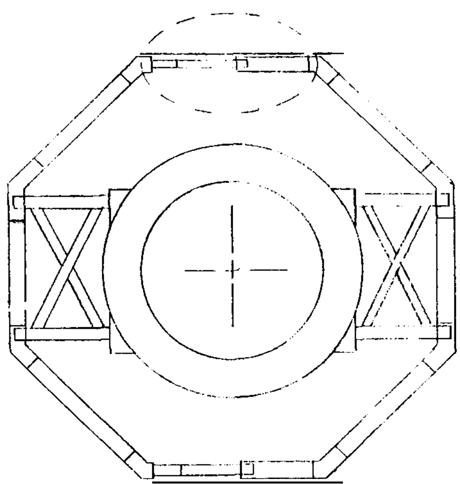
Critical design constraints for this prototype were: stability, maneuverability and comfort. In addition, it was necessary that the unit be relatively easily transported and that it not be cost prohibitive. Several design concepts were developed and analyzed before the given design was chosen.

As shown in the top view and the photograph, the walker consists of two rings separated by two side braces. The top ring has an inside diameter of fourteen inches; and, supports the seat and allows it to pivot about a vertical axis. The cross-section of the ring member is basically a box with a through slot through the middle of the bottom surface. On the interior of the box is a second ring, concentric to the first, which is connected to several wheels which ride on the inside of the bottom surface of the box section. The seat is supported from this second ring at three places. This arrangement allows the seat to rotate freely yet keeps the relative positions of the seat straps fixed so that the seat does not tip. To the outside of the box section are affixed four limited motion pivot blocks. These allow the angle between the plane of the side braces and the swivel ring to change when the base is collapsed for passage through doorways. Motion at these hinges is limited to reduce tipping of the swivel ring. For the prototype, the swivel ring was constructed of wood but testing revealed that future designs require a stronger material at the hinge points.

Each side member is constructed of two vertical members rigidly connected by an X-brace. The parallel, vertical members are twenty-four inches long and are separated by twelve inches. To reduce weight, the vertical pieces were constructed of pultruded one inch square, fiberglass box beams while the X-braces were 1" x 0.1" fiberglass bar stock.

The base ring is octagonal with each side having a nominal length of fourteen inches. Inch and one-half square, pultruded fiberglass, box beams were used for each side with aluminum inserts for each joint. The front and rear sections of the octagon were made using common drawer slides which were adjusted to allow a maximum side length of fourteen inches yet permit the octagon to collapse to a maximum width of twenty-eight inches. Limited motion hinges were again used to connect the side supports to the base ring. Six inch diameter hard rubber casters were attached at each apex of the octagon.

The total price for the construction of the walker prototype, excluding labor and design costs, was $300.



Motorized Mobility Device for Handicapped Children

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INTRODUCTION

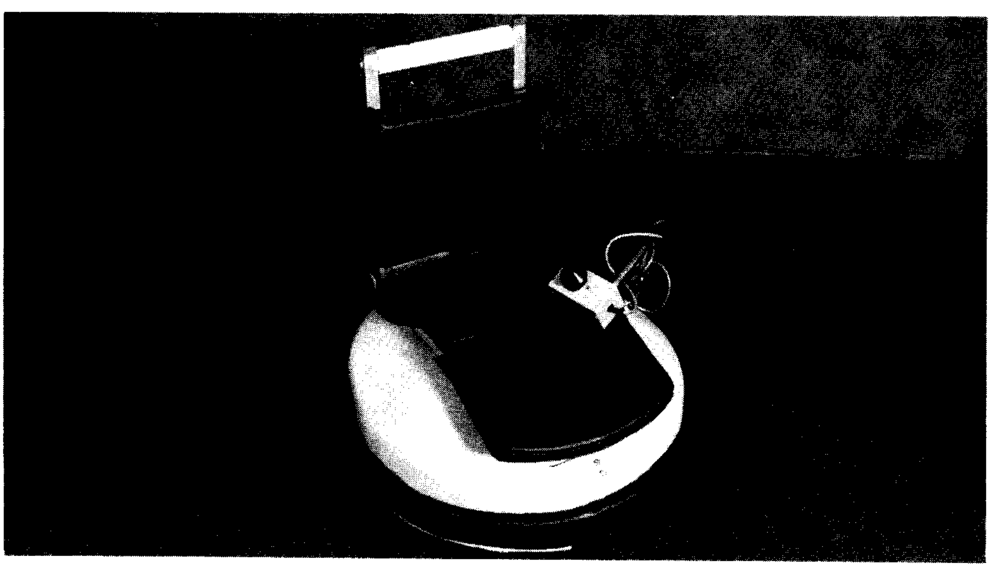
The motorized mobility device is a saucer like, electrically powered, "wheelchair" designed for use by **small** children. It is principally targeted for children between the ages of 1 and 3. The device is powered by two, rechargeable, gel-cell batteries which drive two independent motors connected directly to the drive wheels. Directional control is done via a joystick which activates a proportional controller similar to that used on electric wheelchairs for adults. The joystick can be replaced by other switching devices appropriate to a particular child's handicap. The child rides atop the saucer in a modular seat which can be easily altered to suit the needs of the individual.

The device will be used by therapists as a means of evaluating certain motor skills which aid in the transition to typical wheelchairs. The design is also usable within the household environment to maximize the mobility of a handicapped child.

SUMMARY OF IMPACT

The motorized mobility device was designed to aid therapists in evaluating the motor skills of handicapped children and to provide a "child size" device to increase their mobility. For evaluation purposes, the controls and seating are modular. As such, they can easily be removed, altered and replaced. This provides an easy method for judging the ability of a child to adapt to other mobility devices.

From a mobility aspect, the device is designed to place the seated child at eye-level with his or her peers. The conventional drive mechanism coupled with the round body style promotes maneuverability and handling. Further, the device is low to the ground allowing for the possibility of mounting from the floor by a child with good upper extremity function and mobility. As such, the unit gives the child the ability to freely interact with peers. Maximum speed of the unit can be set by adult and a tethered control box can be used to override the child's input.



TECHNICAL DESCRIPTION

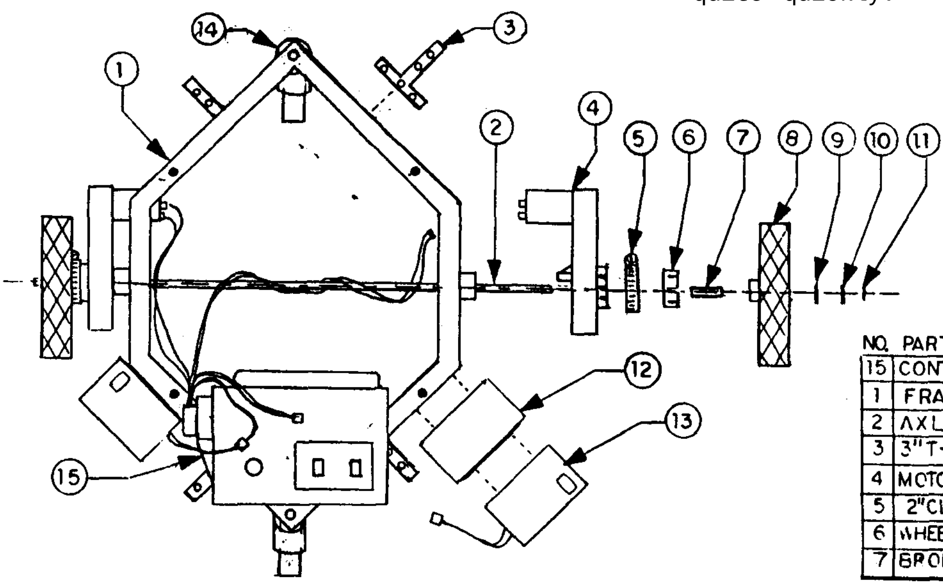
The design of the mobility device can be divided into three principal areas: the frame and drivetrain, the electronics, and the body and seating. The frame provides the base upon which all other systems are attached. As shown in the figure, it is a welded, hexagonal structure made from one inch square, one-eighth inch wall aluminum tubing. The frame measures twenty-four inches from front to back and sixteen inches from side to side. Four eight inch long, one half inch diameter aluminum rods are welded normal to the frame (these are shown as black dots on the angled sides of the frame) and extend vertically through the body to support the seat. The axle is made of seven-sixteenths drill rod and extends through the frame. It does not rotate but merely supports the wheels. Also attached to the frame are four T-plates to which the body is bolted, and two pans to which the batteries are strapped in place. The drive for the wheels is provided by two gearmotors used on the "Quadrunner" car built by Powerwheels. These units weigh approximately one half pound each, include a 110 to 1 gear reduction, will run under variable voltage control and can be bought off-the-shelf. The gearmotors are affixed directly to the frame and a special hub was constructed to mate the gearbox output to the wheels. The wheels are seven inch diameter hard rubber wheels with bushings inserted to minimize wear.

The electronics system is based on an ABEC proportional controller. The controller was modified to provide for a remote location of the joystick and on/off power switch. The centering springs in the joystick were also replaced to correspond with a child's strength. Power for the controller is provided by two six-volt gel cell batteries wired in series. On a full charge, the batteries can operate the unit for approximately three ours. The battery charger was not mounted on the unit.

The body of the unit was constructed of kevlar cloth and polyester resin which was fabricated over a male mold. The diameter of the shell is twenty-eight inches and it is eight inches deep. L-brackets, which attach to the T-plates on the frame, are affixed to the inside surface with through bolts. A bucket type recess was placed in the top of the body to provide for a child with tetraphocomelia. An access door in the front of the shell allows access to the controller and the on/off switch was placed on the back of the shell out of the child's reach. For demonstration purposes, an aluminum frame seat was constructed which attached directly to the seat support posts. A foam "bumper" was placed around the entire shell to reduce collision damage.

The prototype of the motorized mobility device cost a total of three hundred sixty ($360) dollars to construct. This price did not include the cost of the proportional controller which was provided by the A.I. duPont Institute.

Initial testing of the unit was done with 2- to 3-year-old non-handicapped children. All children seemed to enjoy the device and adapted to the controller quite quickly.



NO.	PART	REQ'D	NO.	PART	REQ'D
15	CONTROLLER	1			
1	FRAME	1	8	7" WHEEL	2
2	AXLE	1	9	NYLON WASHER	2
3	3" T-PLATE	4	10	STEEL WASHER	2
4	MOTOR/GEARBOX	2	11	7/16" SNAP RING	2
5	2" CLAMP	2	12	BATTERY TRAY	2
6	WHEEL-HUB	2	13	6-V BATTERY	2
7	BRONZE BUSH'G	2	14	3" CASTER	2

VALENTA