

CHAPTER 6

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SENSORY STIMULATION ACTIVITY CENTER

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INTRODUCTION

A Sensory Stimulation Activity Center (SSAC) was developed for use in the treatment of children under three with Down's Syndrome or closed head injury. Studies suggest that sensory stimulation helps to promote development in these children. The bear interacts with the child, reinforcing cause-effect relationships between a button press and sensory stimulation.

SUMMARY OF IMPACT

Most existing sensory stimulation activity centers are costly, only stimulate up to three senses, and are housed in simple plastic boxes. This activity center is housed in a stuffed bear and stimulates visual, auditory, olfactory, and tactile senses. The bear is visually appealing and fun for children of varying motor skills. It allows children to enjoy themselves while learning cause-effect relationships under the supervision of a therapist.

Therapists who use the SSAC praise its benefits:

"The Pooh is so colorful and friendly that all of my children want to keep him for their own."

"The Pooh helps the most with our physically and visually impaired children. These children are not given the normal access to exploratory play that physically normal children do. Because of that, they are unable to learn independently as other kids do. We use Pooh to stimulate the senses of smell, sight, sound, and touch."

"This is a much-needed toy. It will definitely be very useful to our therapy of these chil-

dren. Currently, similar products make the



Figure 6.1. A Child Using the Sensory Stimulation Activity Center.

kids easily bored. This toy not only keeps their attention, but is also very cuddly and fun to play with."

TECHNICAL DESCRIPTION

The active components of the device are housed in a stuffed bear. Two "C" batteries connected in series power the SSAC. A control panel on the bear provides the user interface for activation of the stimulation activities.

Activation of the functions is through momentary contact, normally-open push-button switches mounted on the control panel. The buttons have different colors and shapes. Adjacent to each button is a picture and a light emitting diode (LED) with the same color scheme as the button. Each of the four buttons, four lights, and four pictures is associated with a stimulation activity: releasing scented air, blowing air, vibrating the arm, and playing music. The picture located next to each button represents the activity powered when the button is pressed. When a button

is pressed and held the adjacent LED illuminates and the function is activated. When the button is released the function stops immediately.

Each button is connected to the power supply via the main power switch (see Figure 6.2). In parallel with each button is a 1/8" jack for an external switch. This allows either the control panel button or the external switch to activate each function. In series with each button are the corresponding LED and a current limiting resistor. The components for the stimulation

activity functions are activated in parallel to the LED circuits.

The control panel is made of plastic reinforced by 1/4" acrylic sheets. Items on the front face of the panel are mounted onto the plastic control panel and on the acrylic sheet reinforcement. All circuitry is housed within the control panel box. Circuit components are soldered onto a perforated circuit board.

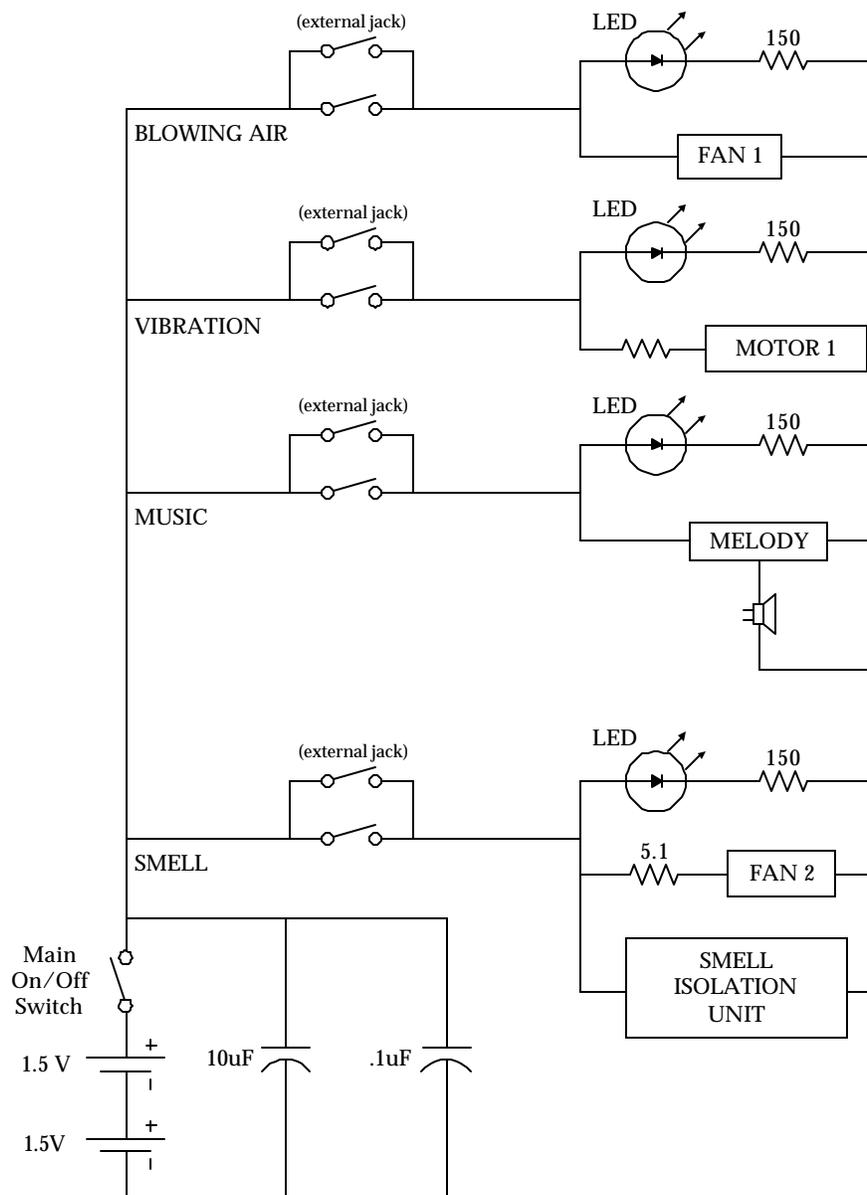


Figure 6.2. Circuit Diagram of Main Activities.

For the smell activity, a forked tube allows the passage of air from the box to the outside of the mouth. A removable air freshener cartridge housed in an isolated chamber provides scented air. While the activity is not on, a plastic flap blocks the smell from the tube leading to the mouth. When the button is pressed, a voltage pulse from a monostable multivibrator (74HC221A) causes a motor to raise the flap, exposing the tube. A fan then blows the scented air out to the mouth. When the button is released, the multivibrator emits another pulse, the motor returns the flap to its closed position, and the fan turns off. This circuit is shown in Figure 6.3.

A box located inside the bear's head contains the components for the smell and air blowing functions (see Figure 6.4). A centrifugal fan was built to maxi-

mize airflow through the bear's mouth. A vibration unit was constructed using a motor spinning an off-center mass in order to produce a shaking effect when mounted in the bear's arm. The unit is housed entirely in PVC plastic to increase robustness and safety.

The musical component comes from a commercial toy that plays a melody for a specific time when squeezed. The component was modified to play continuously when powered by the button. A piezo speaker from the same toy is mounted near the surface of the bear's fur.

The approximate cost of the Sensory Stimulation Activity Center was \$340.

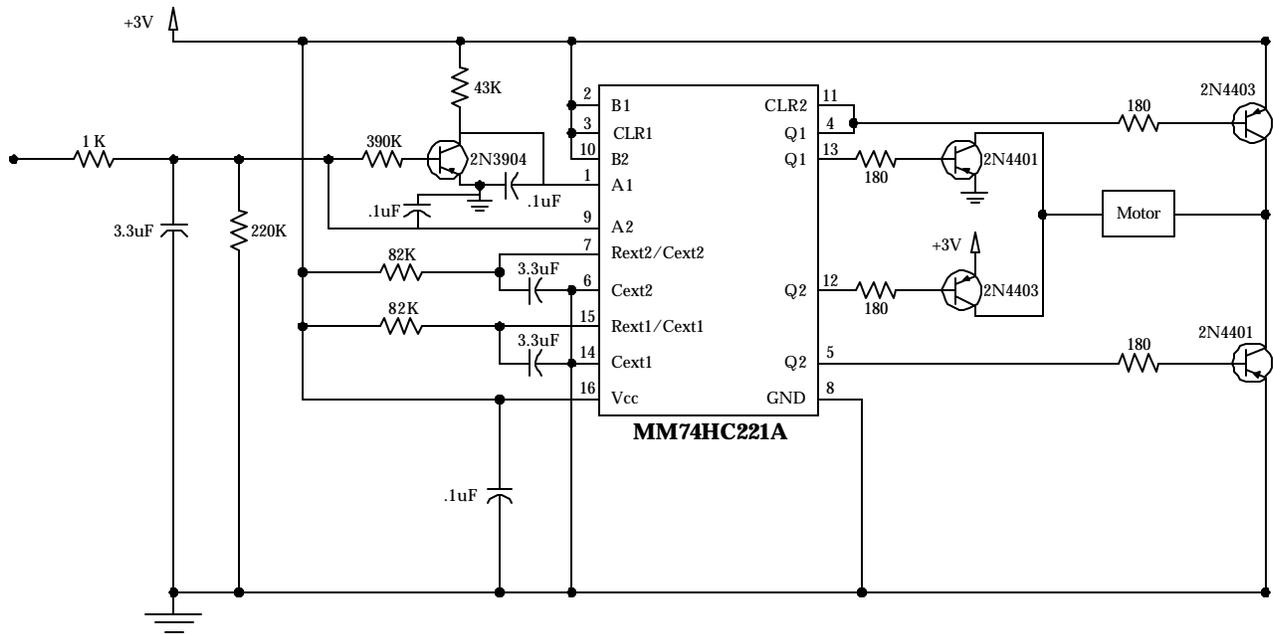


Figure 6.3. Circuit Diagram for Control of Smell Isolation Unit.

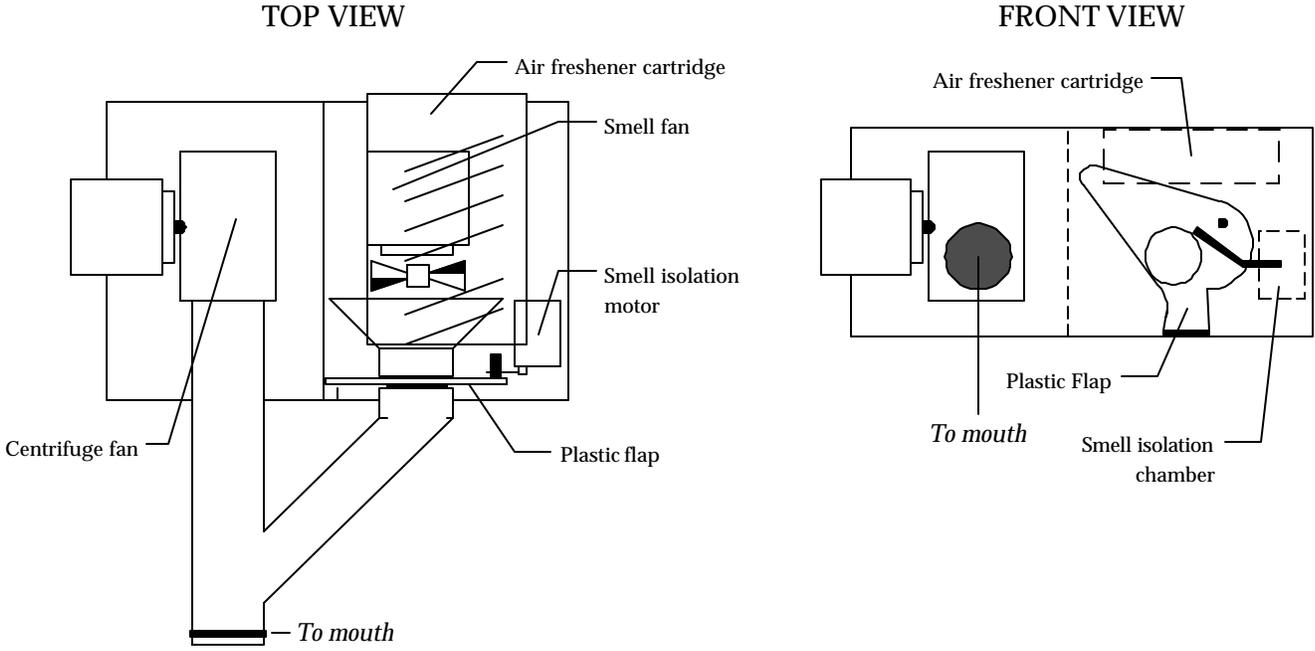


Figure 6.4. Diagram of Air Blowing and Smell Activities.

CHILD-FRIENDLY ACTIVITY TIMER

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INTRODUCTION

The electronic Child-Friendly Activity Timer (CFAT) was constructed for use in pediatric therapy sessions. The CFAT features a small rabbit moving across a hill toward its burrow, and a digital display that shows the time remaining. When time expires, a beeper sounds and the rabbit returns to its starting location.

SUMMARY OF IMPACT

Generally, for timed sessions, a therapist sets an electronic kitchen timer that beeps when time is finished. However, most young children do not have a clear concept of time and cannot understand how much longer their practice sessions should continue. The CFAT was created to provide children with a visual and qualitative measure of time during therapy sessions.

The client is a two-year-old with a feeding disorder. Part of his prescribed therapy includes timed feeding sessions, where he is required to practice activities, such as holding his spoon and drinking from a cup for specific periods of time.

TECHNICAL DESCRIPTION

The CFAT is a microprocessor-controlled device that contains both a numerical and physical display of the progression of time. The user programs the CFAT using six pushbuttons. Three buttons set the time in increments of 30 seconds, one minute, and 10 minutes. The other three buttons start, stop, and clear the timing process. The microprocessor reads from these six pushbuttons and controls the time displayed on a 4 ½ digit LCD 7 segment display as well as the movement of a toy rabbit, attached to an arm on the shaft of a servomotor.

The CFAT consists of three sections: 1) input acquisition; 2) time and display processing; and 3) numerical

and physical display (see Figure 6.6). The input ac-



Figure 6.5. The Child-Friendly Activity Timer.

quisition section contains the pushbutton hardware and the software required to process user input. The pushbuttons connect to the data lines on a Z-180 microprocessor (Z2 Prototyping board, ZWorld, Inc, Davis, California) through a tri-state latch (74HCT373). The six-bit binary number representing the state of the pushbuttons is translated into an instruction by the microprocessor. The program contains de-bouncing routines that prevent the microprocessor from reading unintentional input. Additionally, the input software prevents the user from making logistical errors, such as accidentally clearing the time remaining during operation without first stopping the timer.

The time and display section controls a countdown timer and the servomotor. The countdown timer uses the real-time clock on the Z2 board to calculate the time remaining. The servomotor is controlled using an 8-bit binary number that increases at a constant rate determined by the input time. This binary number is converted into an analog current using a digital to analog converter (DAC0832), and then converted to a voltage using a single-sided operational amplifier

circuit (LM358). This varying voltage is translated into a square wave with linearly varying pulse width using a voltage-controlled oscillator (CD4046). The square wave is connected to the control line of the servomotor. The servomotor moves through 30 steps over an angle of 120°.

The output section comprises a numeric display, a physical display and an audible buzzer. The time is displayed on a Varitronix 4½ digit LCD display. This display is controlled using 32 serial bits from a MM5452 controller chip. The serial clock and count data are generated by the microprocessor. The physical display is a toy rabbit attached to the shaft of the servomotor. To conserve power, a transistor switching circuit turns off the servomotor whenever it is not being moved. This feature dramatically reduces

power consumption since the servomotor only operates for 30 seconds, regardless of the input time. Finally, a small buzzer sounds when the time is finished.

The CFAT uses four C batteries in series to provide a 6V DC supply, which powers the servomotor and the buzzer directly. The 6V DC is regulated to 5.2 volts to power the microprocessor and the other IC's.

The final cost of the Child Friendly Activity Timer was approximately \$380.

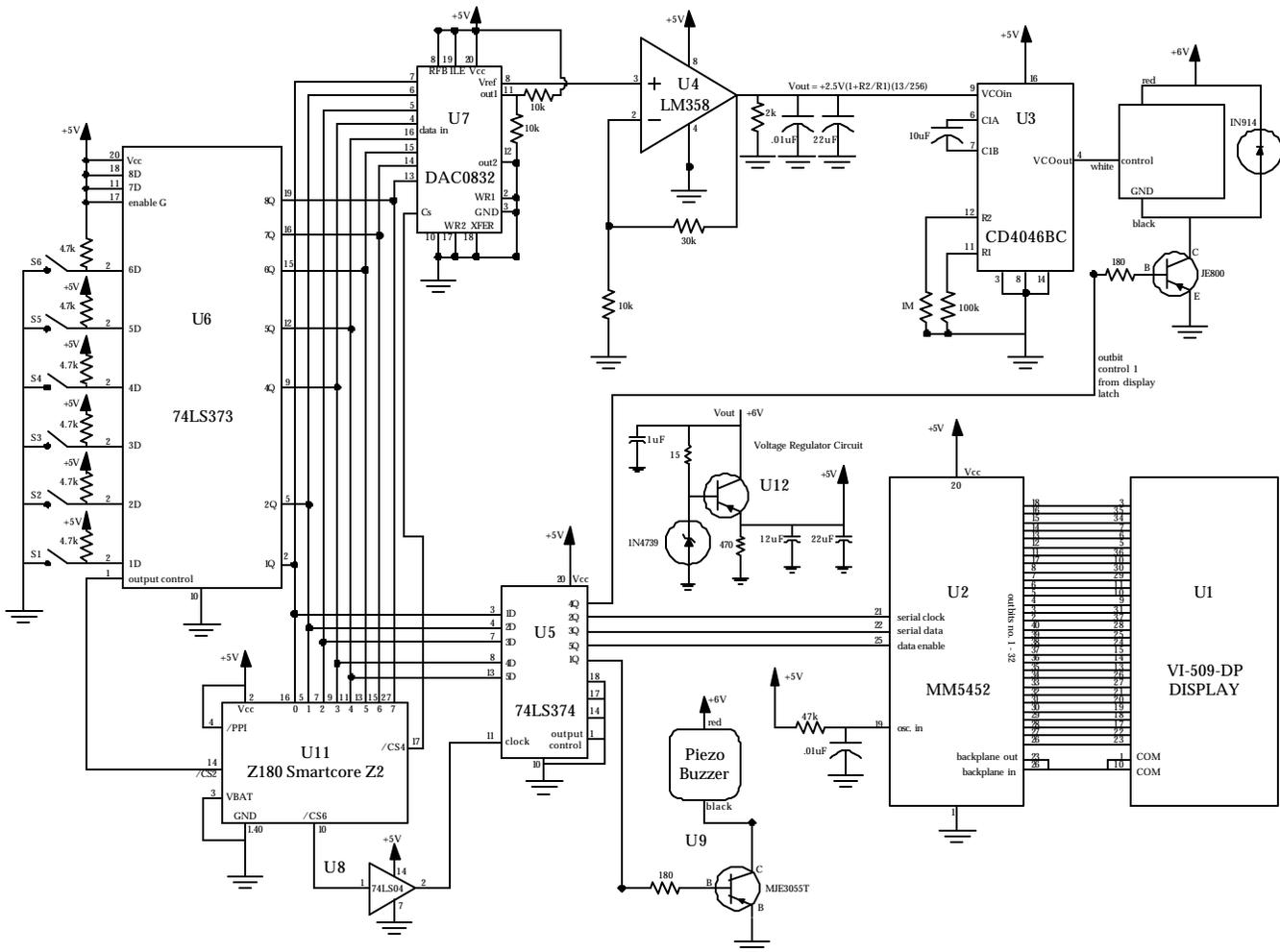


Figure 6.6. Timer Schematic.

COMPUTER GAMES FOR LEARNING JOYSTICK CONTROL

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INTRODUCTION

Two joystick-controlled computer games, "Catch the Butterfly" and "Bump & Go", have been developed to train children to use powered wheelchairs. Compared to other wheelchair trainers currently available, these games are more fun to play. They also provide feedback concerning the child's progress to the therapist. The software can be shared to enable the child to practice at the hospital with the therapist, or at home under a parent's supervision.

SUMMARY OF IMPACT

Since most powered wheelchairs use joystick control, it is helpful if children learn to operate a joystick prior to trying a powered wheelchair. "Catch the Butterfly" and "Bump & Go" help improve joystick skills because they are fun to play and motivate the child to improve performance. In addition, statistical data may be used to evaluate whether a child has difficulty stopping or moving in a certain direction.

TECHNICAL DESCRIPTION

The computer games are written in Visual Basic 5.0 for IBM compatible computers. These games require a Windows 95 operating system, 4 MB free hard drive space, and a sound card with a joystick port

"Catch the Butterfly" helps beginners and younger children become adjusted to using a joystick. In this game, the child manipulates, on the screen, an image of a boy holding a net. The object is to catch a butterfly. To encourage the child, a reward screen using visual and audio stimuli is shown each time a butterfly is caught. The game contains three levels of difficulty. In the first level, the butterfly remains station-

ary to allow the child to learn how to handle the joy-

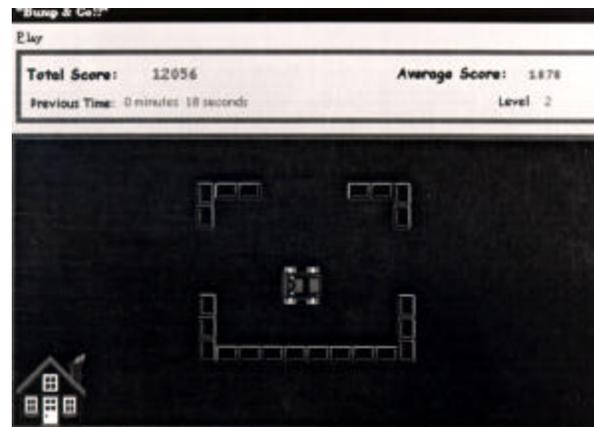


Figure 6.7. Screen for the Bump & Go Game.

stick. In the second level the butterfly flies around the screen. This allows the child to practice following an object and moving the joystick in different directions. The third level features a bee (see Figure 6.7) that the child must avoid while attempting to catch the butterfly. If the boy is "stung" he is moved further away from the butterfly.

"Bump & Go" is a more challenging game that acquires statistical feedback on the progress of the child. There are four levels of increasing difficulty. Each level consists of a car that the player must move with the joystick to reach his or her "destination," an image that appears in random positions on the screen. The player drives the car from the starting point in middle of the screen to the destination. Walls act as barriers between the car and the destination, except in the first level. With increasing levels, the number of walls increases and the size of the openings between them decreases. Though the images appear randomly, they are placed in specific areas of the screen. This al-

lows the therapist to determine if the child is having trouble moving the joystick in a particular direction.

“Bump & Go” contains a stop sign function that records the amount of time it takes for the child to stop moving. A timer also records how long it takes for the car to reach each destination. This information is saved in a file to allow the therapist to evaluate whether the child is having difficulty moving in a particular direction.

A scoring system is implemented in “Bump and Go” in order to motivate the child. The final score is determined according to the amount of time the child requires to reach the destination image and the number of objects the child hits during the game.

Each object in these games is represented by a bit-map image. Its position in the game field is given by the object’s x and y coordinates with respect to the upper-left corner of the field (0,0). Visual Basic 5.0 automatically calculates many properties of the object in the program including the height, width, and coordinates of the top, bottom, right, and left edges of the image.

To make the game more entertaining for the child, colorful animated images were used (e.g. the boy in “Catch the Butterfly” runs around the screen). This requires a series of images, each slightly different, which create the effect of movement when rapidly alternated (i.e. like a flipbook.) Joystick control is given to the characters using the program *joystick.exe* from Mabry Software (Stanwood, WA), which returns the x and y coordinates of the joystick. These values are used to position the image on the screen. When the joystick moves a certain distance in one direction the function *Joystick1_Move* is activated and moves the object (the car or the boy with the net) in the direction the joystick is pushed. The distance the image moves can be increased or decreased by changing the number of pixels the image shifts when the function is read. The program also ensures that the image does not move off the screen.

The games must be able to identify collisions between two images on the screen. The functions *Collided*, *HitUpDown*, *HitLeftRight*, and *LtRtShort* detect the collision of two objects. *Collided* obtains the coordinates of the right, bottom corner of two bitmaps, which are then passed to the Windows API function called *In-*

tersectRect. This function will return 0 if the two images do not overlap. If they do overlap, *IntersectRect* returns a 1. This invokes the reward screen that is controlled by the function *Timer2*. *Collided* is used in “Catch the Butterfly.”

To detect collisions between the car and walls or destinations in “Bump & Go,” the functions *HitUpDown*, *HitLeftRight*, and *LtRtShort* are used. In these functions, the coordinates of the car are compared to each object on the screen by a series of *if-then* statements to see if they are touching each other. If the car touches a block, the position of the car changes so it “bounces” back from the wall. If the car touches a destination point, *Timer2* is invoked and the reward screen appears.

A function was written to record the time it takes for the child to move the car from the starting point to the final destination. When the car appears on the screen, the command *Timer*, which captures the time of day in seconds, is called and is saved as *Start*. *Timer* is then called when the child reaches the destination image and the time is saved as *Finish*. The difference between *Finish* and *Start* is used to determine the average time required to reach each destination on the screen. This information is then written to a file specified by the therapist if he/she chooses to record the data.

Though the games are in good working condition and satisfy the original objectives, there are several components that could improve the project. Improvements could be made on the feedback information for the therapist and time analysis. One way that this could be done would be to consider the speed of the car. If the car is set to a higher speed, the car will reach the destination more quickly, and the average time might not be a good indicator of performance. It may be useful to implement a performance gauge function that averages speed and time. This could be coupled with an evaluation screen that would give suggestions to the therapist on what the child should work on and if he or she is ready to play at a more difficult level.

The total cost of this project was \$195, including the cost of the joystick and sound card for the PC.

AUTOMATIC FEEDER MODIFICATIONS AND WHEELCHAIR-TO-BED TRANSFER APPARATUS

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INTRODUCTION

An electric feeder was modified and a wheelchair-to-bed transfer apparatus was developed for a young man with cerebral palsy in order to increase his independence in everyday activities. A ceiling mounted transfer bar was created to allow the client to transport himself between his bed and wheelchair.

SUMMARY OF IMPACT

The client is a 20-year-old man with cerebral palsy who uses a wheelchair. Because of his muscle control limitations, he previously had to be fed by his parents. The modifications made to the Winsford feeder now allow the client to feed himself.

His disability, along with injuries he suffered in a recent car accident, make it impossible for him to get into and out of his wheelchair from his bed without assistance. At the client's suggestion, the transfer apparatus was built, allowing him to move himself between his bed and wheelchair.

These items have reduced the client's dependence on others in his daily life. He comments, "I enjoy the independence (the feeder) gives me to be able to feed myself. Sometimes I get a little messy but that's ok. I'm sure my mom enjoys getting a break from feeding me everything that I eat. I continue to enjoy the transfer bar in my bedroom. It is a big help when I get in and out of bed. These projects that you developed for me have been very beneficial."

TECHNICAL DESCRIPTION

A damaged Winsford feeder (Klemco Engineering, Plumsteadville, PA) was donated and repaired to make it operable. A new clamp was designed and

constructed from aluminum block to allow the Buddy Bar to attach to the client's new wheelchair, which was purchased after his automobile accident. The Buddy Bar allows table-mounted devices, such as a computer, to attach to the wheelchair.

To accommodate the feeder, a Plexiglas plate was designed to fit tightly into the feeder's base. A key mechanism was designed from aluminum to slide and lock into place on the Buddy Bar lock plate. In order to increase stability, a Velcro strap wraps around the arms of the wheelchair and connect at both ends to the base of the feeder.

The client and his father noted other possible improvements that might be made to the feeder. The mechanical arm lifted the food in an arc that extended past the plate. Hence, any spilled food fell onto the client's lap. To fix this shortcoming, the feeder was modified as follows. To control the topmost point in the feeder's arc, the pentagonal cam of the feeder was positioned so that the slanted side was flush to the feeder when the arm was in its apex. To keep the arm angle suitable for picking up food, an adjustable stop was constructed out of aluminum and attached to the feeder's surface below the arm. The cams were also altered so the lifter stopped at the angle the client desired.

The spring mounted in the utensil holder was replaced with a rigid, stainless steel tube to improve the client's ability to eat without spilling food. In order to increase the amount of food that the lifter would carry during each cycle, a modified utensil was made. The initial utensil was a spoon; however, it did not lay flush against the plate when the lifter arm was in the down position. The spoon was replaced with a spork (a spoon with prongs on its end). The spork was

used because it has a much flatter tip than any available spoon. The spork was flattened and its prongs were rounded. The modified utensil consistently picks up almost twice the amount of food per cycle as the original spoon. The transfer apparatus (Figure 6.8) uses an arm consisting of a rod within a tube, both constructed of stainless steel. The inner rod has tapped holes at 2" intervals, allowing the height of the handle to be adjusted by aligning it with screws placed through holes in the outer tube. The handle is constructed from 1" diameter stainless-steel rod to provide an adequate grip diameter for Ray. The top of the pipe is connected to a universal joint from McMaster-Carr Supply Company (Atlanta, GA). The

original joint only provided a 25° angle of vertical motion and very limited rotation. The vertical angle was increased to approximately 80° by grinding the joint's surface. 360° rotation was enabled by using a thrust bearing from Dixie Bearing Co. (Durham, NC). The transfer apparatus was mounted to the ceiling of the client's bedroom using a custom plate constructed of 1 x 4 x 20" aluminum block, which distributes the load across two ceiling studs above the bed. Holes in the plate allow the transfer apparatus to be mounted in three locations relative to two ceiling studs. The estimated cost of the feeder modifications was \$185. The complete transfer apparatus cost approximately \$170.



Figure 6.8. Bed-to-Wheelchair Transfer Apparatus.

POOL CHAIR

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INTRODUCTION

A wheelchair was designed and constructed to enable therapists to transport patients into and out of a pool.

SUMMARY OF IMPACT

Previously, therapists had difficulty moving elderly patients into and out of a pool for therapy sessions. The wheelchair previously in use had small wheels that made movement on the rubber matting surrounding the pool difficult or impossible, requiring two therapists to lift patients seated in the chair.

The new chair, with its larger wheels, can be maneuvered easily by one person and is safer than the previous chair. Lifting is not required. The braking mechanism allows the chair to be fixed in position once in the water, and is easily operated from the back of the chair by the therapist. Finally, the wheelchair is equipped with a dark green webbed seat in order to improve its visibility in the pool water.

This chair makes transport into and out of the pool safer and more enjoyable for both patient and therapist. A physical therapist who has used the pool chair with patients says, "I feel safe with residents when I use the chair. It maneuvers easily over various surfaces and I can push it up the ramp by myself. Residents like the seat belt feature and the chair stays put at the bottom of the ramp... all positive changes over any off the shelf chair we could find."

TECHNICAL DESCRIPTION

The pool chair (see Figure 6.9) was designed to assist a person weighing up to 250 pounds into and out of a pool. It was constructed for easy mobility and control around a pool and also provides a simple and effective safety latch.



Figure 6.9. The Pool Chair.

The frame of the chair is made of 1 ¼ inch diameter, schedule 40 PVC pipe (see Figure 6.10). 3/8-inch holes are drilled in the bottom pipes to allow water to enter the chair once in the pool and drain the chair when exiting the pool. This prevents the chair from floating and allows the patients to easily get back into it after therapy. 1/4-inch holes are drilled in the top pipes to allow air within the chair to escape as it fills with water. Front safety bars with ring connectors are attached to one side of the chair. The bars pivot hori-

zontally from this side and attach with spring pins to the other side of the chair. The front wheels are four-inch diameter plastic casters. The rear wheels are 1/8-inch diameter plastic wheels with mold-on rubber tires and Delrin bearings. They are attached to the chair by a 3/4-inch nylon axle that is reinforced by four nylon sheaths over the section of the axle between the wheels. The wheels are held onto the axle by small outer caps bolted to the axle. The seat and backrest are made of vinyl coated polyester fabric. The seat is cushioned and has a seatbelt. A curved PVC bar supports the seat.

The brakes of the chair have two handles, one for each wheel. Each handle is made of a length of PVC

tubing. The handles are attached to nylon hollow tubing by a pivot. The entire brake system is attached to the chair by a ring of PVC glued to the frame and held in place by two screws. When the handles are turned, the pivot drives the nylon tube into the wheel well. The wheel is held stationary when the nylon rod comes into contact with the spokes of the wheel. This contact prevents any further motion of the wheel. The end of the hollow nylon tube is sectioned so that it will fit inside the wheel well.

The total cost of the pool chair was approximately \$280.

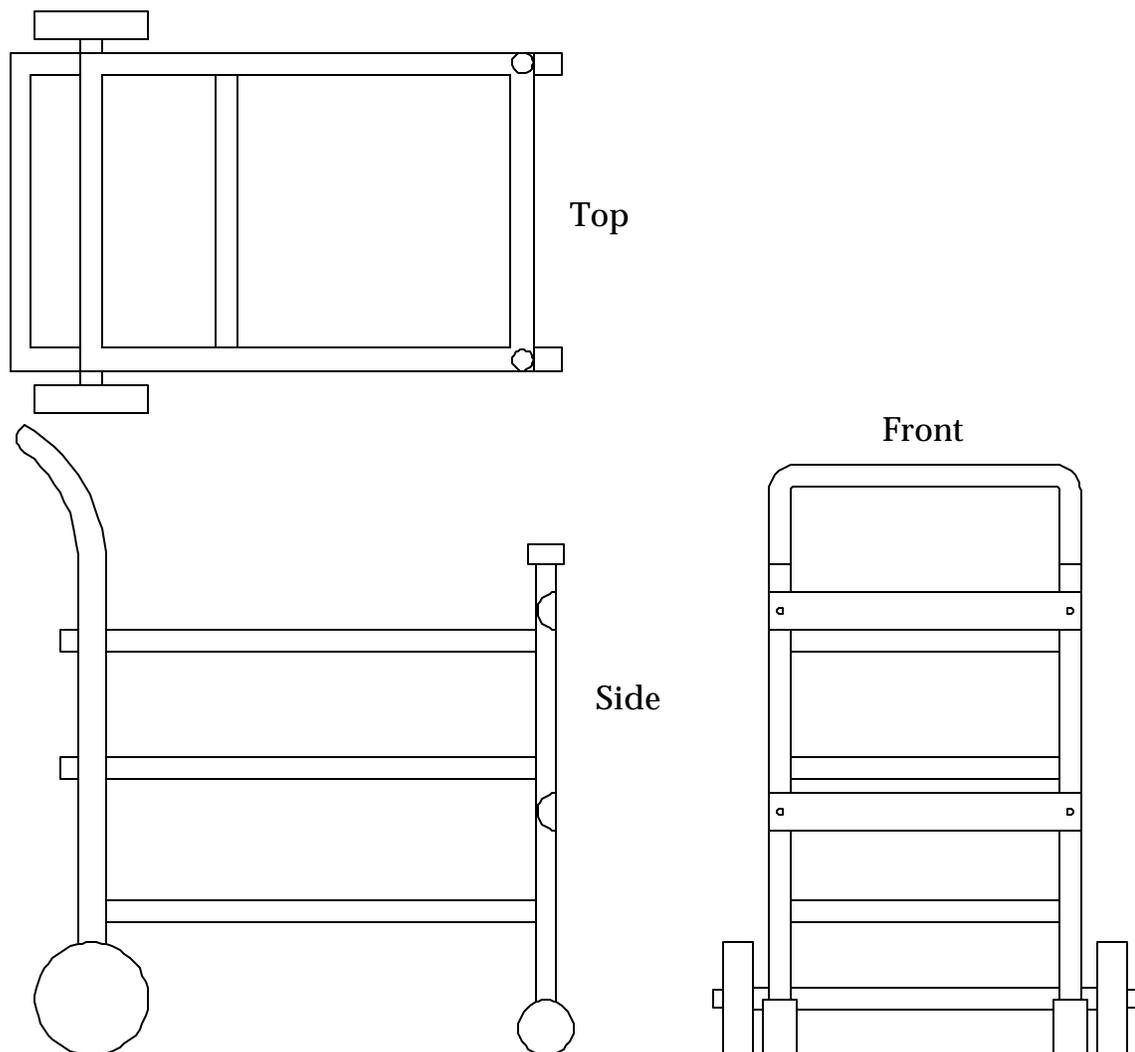


Figure 6.10. PVC Frame of the Pool Chair.

