

# CHAPTER 20

## WAYNE STATE UNIVERSITY

Electrical and Computer Engineering  
College of Engineering  
5050 Anthony Wayne Drive  
Detroit, Michigan 48202

**Principal Investigator:**

*Robert F. Erlandson*

*[rerlands@ece.eng.wayne.edu](mailto:rerlands@ece.eng.wayne.edu)*

# ART FOR A CAUSE: PROJECT 1: RIBBON CUTTER PROJECT 2: CREFORM PAINTING WORKSTATION & INVENTORY CART

## PROJECT 1: RIBBON CUTTER

*Phase 1: Preliminary Design*

*Designers: Mandip Kaur, Vaibhav Kamboj*

*Phase 2: Final Design and Implementation*

*Designers: Pavan Kumar Jakka, Umer Khalid*

## PROJECT 2: CREFORM PAINTING WORKSTATION & INVENTORY CART

*Designers: Sonja Daniels, Nicole Bianchi, Golnaz Ahadi*

*Client Coordinator: Lisa Knoppe-Reed, President, Art For A Cause, 2294 Cole Street  
Birmingham, Michigan 48009*

*Supervising Professor: Dr. Robert Erlandson*

*Electrical and Computer Engineering Department*

*Wayne State University*

*Detroit, Michigan 98202*

### PROJECT 1:

#### INTRODUCTION

Art For A Cause produces Cute Tools!®, a line of hand-painted, decorative kitchen, household and garden tools. Art For A Cause employs workers with disabilities. Figure 20.1 shows a package of Cute Tools!®, each with the signature ribbon, characteristic of Cute Tools!®. Cutting the ribbons has become a daunting task as business volume has dramatically and rapidly increased. Prior to this design project, workers without disabilities cut the ribbons. Scissors and a variety of jigs and fixtures had been tried, but none were satisfactory. A switch-operated ribbon cutter was designed to be operated by workers with disabilities.

#### SUMMARY OF IMPACT

The Switch-Operated Ribbon Cutter is a major improvement over prior methods of cutting ribbon. A supervisor is required to configure the system for a new task, such as determining length of ribbon. After that, workers with disabilities may change the ribbon spool and start the device. The new ribbon cutting process eliminates the use of scissors and the associated repetitive motion and muscle strain that goes with large-scale cutting. Also, the new process enables better quality control with respect to consistent length and quality of the cut ribbon edge. The new ribbon cutter will enable Art For A Cause



Fig. 20.1. Packaging with Ribbon, a Signature Characteristic of Cute Tools!®.

to increase productivity as required by their expanding business.

#### TECHNICAL DESCRIPTION

A ribbon spool is placed onto a shaft and is secured by side disks and held using a wing nut. The ribbon is fed into the rollers. The rollers start moving when a sensor detects the ribbon. The ribbon is fed through the device until the desired length is dispensed. At that point a switch is pushed to cut the ribbon. This configuration programs the process controller to remember the desired length. Once the training mode is done a cover is placed over the cutting head and rollers and another



Fig. 20.2. Ribbon Cutter Mounted on Custom Mobile Cart (Note Yellow Emergency Stop Button (Red Cap) Behind Ribbon Cutter).

switch push starts the cutting process. The ribbon is cut into the required lengths and dispensed into a container below the cutting surface. Sensors detect when the ribbon has been depleted and stop the cutting process.

There are numerous safety features. The cover must be securely in place before the cutting process begins. Sensors detect ribbon jams, slips and cutting head jams. The ribbon cutter is affixed to a mobile Creform workstation, which has storage for the required inventory of ribbon spools as well as spare parts for the ribbon cutter, i.e., spare cutting disk blades.

The ribbon cutter is a custom designed device. It uses a rotary blade with a compression cutting technique. A 12VDC linear actuator (Duff-Norton TMD01-1906-4) with a range of 4 inches moves the blade over the ribbon on the cutting surface. A pair of rollers driven by 12V DC gear motors connected in parallel move the ribbon to the cutting surface. Reflective infrared sensors are used to determine the presence of the ribbon. A simple shaft with collars holds the spool of ribbon.

An Omron Zen 10C1AR-A-V1 PLC is used to control the system's operation. The device was programmed in ladder logic using Zen software provided by Omron. The device has a configuration



Fig. 20.3. A Close-Up View of the Ribbon Cutter mechanism. Cut Ribbon Falls into the Tray on the Middle Shelf.

mode and an operational mode. There is an easily reached emergency stop pushbutton. The ribbon cutter device is affixed to a mobile Creform workstation cart, custom designed for this application. The workstation cart has storage areas for ribbon inventory and consumables such as cutting blades. Figure 20.2 shows the ribbon cutter on its mobile workstation. Figure 20.3 shows a close-up of the ribbon cutter device.

## PROJECT 2: INTRODUCTION

The Cute Tools!® all have wooden handles and require several applications of paint. First the wooden handles must be primed, then the decorative pattern applied, and, finally, a protective polyurethane coating is applied.

## SUMMARY OF IMPACT

The new design is being used at Art For A Cause and appears to be working well. The workstation is wheelchair-accessible, and its mobility and size are

satisfactory. The vertical slatboard allows for hanging a variety of tool types and sizes. The storage drawers and flat workspace on top of the drawers is also satisfactory. One problem arose with a left-handed painter. A few workstations need to be designed for left-handed workers.

### **TECHNICAL DESCRIPTION**

There were four important design constraints. The workstation was to be mobile, wheelchair-accessible, as small as possible, and allow for working with a variety of tools (from hammers and corkscrews to canes and plungers).

A painting task analysis determined that the process of getting unpainted tools to the painters was problematic and entailed a great deal of non-value-added activity. A custom inventory delivery cart was created to address the inventory delivery problem. It is a simple cart designed for the

dimensions of the tool's shipping boxes. In this way a painter is supplied with the entire unpainted tool inventory needed for a typical work session. Figure 20.4 shows the new Creform Painting Workstation and Fig. 20.5 shows the delivery cart.

The workstation is built from Creform. Creform is a complete system of pipes, joints and hardware accessories that allows one to design and build custom devices. Creform is widely used throughout industry for designing and assembling material handling, positioning, and storage systems. Creform exemplifies the industrial engineering concept of an agile system, i.e., a system that can easily change to meet new work requirements. Creform devices can be assembled with only an Allan wrench, ruler and saw. The joints use a standard nut and bolt, as do all accessory items. CATIA was used to layout the basic design and determine pipe lengths and joints.



Fig. 20.4. New Creform Painting Workstation with Storage Drawers and Small Work Surface [Note Vertical Surface is Slatboard and Allows for a Variety of Tools to be Hung for Drying].



Fig. 20.5. Custom-Designed Delivery Cart for Raw, Unpainted Tools.

# BATS 2: BLIND AUDIO-TACTILE SYSTEM

*Designers: Junaid Ahmed, Rina Brambhatt, Vinita Aggarwal, Qi He, and Pooja Swami*

*Supervising Professor: Dr. Robert Erlandson*

*Electrical and Computer Engineering Department*

*Wayne State University*

*Detroit, Michigan 48202*

## INTRODUCTION

The goal of this project was to design and implement a multi-modal system that enables students who are blind or have visual impairments to participate in GIS-related activities. This is the second version of the Blind Audio-Tactile Mapping System (BATS 2). The first was designed and implemented by students at the Computer Science Department, University of North Carolina, Chapel Hill, under the supervision of Dr. Gary Bishop [1].

GIS digital mapping systems are used to study ecological issues related to the Lake Erie watershed system. Blind and visually impaired students cannot use the digital maps and related databases. BATS augments the visual display with tactical and auditory feedback. The original version of BATS used a Logitech Wingman force feedback mouse and text to voice, including recorded sounds (running water, wind through trees, waves, etc.), to provide information about digital map items. BATS2 entails enhanced multi-modal capabilities for enhanced GIS activities involving digital maps and projects.

The original BATS ran under Microsoft Windows 2000 with an outdated version of Python. Python is an object-oriented language used by ESRI in its Arc View product line. ESRI's Arc View is the dominant GIS digital mapping software and the software being used by the client. The original BATS also used the Logitech force feedback mouse, which is no longer made or supported by Logitech.

## SUMMARY OF IMPACT

The Python code was upgraded. Software interfaces to support the use of the SensAble Technologies PHANTOM® Omni haptic device, and a variety of sonification software systems, text-to-voice operations, and voice recognition for program control and map navigation and database queries were developed. The system's capabilities were tested on digital maps.

The current system can detect the basic GIS features of points, lines and polygons. Multi-modal output can be provided depending on the information and data contained in the digital maps' attribute table and associated data tables. The system uses auditory icons to provide audible information to the user. Text-to-voice allows the auditory presentation of information contained in the attribute table.

Sonification processes may be associated with data in the attribute tables. "Sonification is the use of sound, mainly non-speech audio signals, for presenting or displaying data. Similar to scientific visualization, sonification aims at enabling human listeners to make use of their highly-developed perceptual skills (in this case the listening skills) for making sense of the data. More specifically, sonification refers to the technique used to create a sound signal that involves the data as essential ingredient for its construction" [2]. The current system uses simple sonification techniques, e.g., rising or lowering frequency for increasing data values, simple virtual spatial positioning (using a stereo-headset) depending on the geographic position of the data source on the digital map. Auditory sound files complement the sonification techniques, i.e., files for running water, waves, wind, etc. There is only rudimentary voice recognition and it is targeted at map navigation.

## TECHNICAL DESCRIPTION

The Omni device requires drivers to interface the commands from the application to the device that is connected via the Firewire port. Sonification was achieved using DirectSound - a derivative of DirectX (version 9.0). Microsoft's Speech API (SAPI 5.3) was used to render the text to voice and voice recognition features. Some of these features require the use of C++ drivers, hence, from a technical perspective, the ability to use programs written in C++ or other languages from within Python was the central problem. A visit to online Python support groups showed difficulty of this seemingly simple task. The phantom device requires a multithreaded

environment for various schedulers that work with it. The device drivers were not directly compatible with the Python code required for BATS. Also, converting the C++ code to Python using programs such as SWIG was not feasible. The best way to solve this problem with the given device drivers was by running compiled functions written in C++, or other languages, in BATS through a multithreaded DLL. DLLs were written for the Omni device, sonification software, and voice recognition functions. The original code contained the TTS module that enabled text-to-speech.

In accordance with the original BATS system, all the different sound features assigned to each map element were defined in map files by layer attributes. Following this scheme, a new layer attribute named "Haptic Movement" was added to the BATS system. Using this attribute, the user can assign and change the movement to a certain area, which the haptic device will perform when the

mouse cursor is moved into that area. For example, if user assigns the "Vibrate Movement" to "Lake", then when the mouse cursor is moved into any lake, the haptic device will start to vibrate. The intensity direction of the force may be automatically derived from the information from the "Haptic Movement" layer. Likewise a "Sonification" attribute layer can be used to assign specific sonification techniques to map data.

#### REFERENCES

- [1] P. Parente, Bishop, G., BATS: The Blind Audio Tactile Mapping System. <http://www.cs.unc.edu/Research/assist/bats/papers/BATS.pdf>: Computer Science Department, University of North Carolina, Chapel Hill, 2003.
- [2] T. Hermann, <http://www.sonification.de/>, vol. Neuroinformatics Group Faculty of Technology Bielefeld University.

# WIRELESS TASK SEQUENCING SYSTEM

*Phase 1: Smart Sensor and Wireless System Evaluation and Selection*

*Phase 2: Preliminary Design of the Wireless Smart Sensor*

*Phase 3: Final Design of the TSS*

*Phase 1 Designers: Amir Sadri and Christopher Wallis*

*Phase 2 Designers: Simon Rayes, Adnan Haider and Ning Fu*

*Phase 3 Designers:*

*Hardware Team: Matthew Chudy, Arun Sridaran and Charles Patillo*

*Smart Sensor Team: Jason Mantey, Eduardo Carvalho Neto and Dave Conger*

*The PC Controller Team: Jablan Djordjevic and Sasha Mojic*

*Client Coordinator: Dennis McElhone, Special Education Teacher, Visions Unlimited*

*Supervising Professor: Dr. Robert Erlandson*

*Electrical and Computer Engineering Department*

*Wayne State University*

*Detroit, Michigan 48202*

## INTRODUCTION

The Task Sequencing System (TSS) was designed to provide cognitive support for tasks requiring a sequence of specific tasks. A version of the TSS already existed and had been operational in vocational training facilities [1]. The earlier version uses a serial communications protocol with a daisy-chain cable interconnection. The new design is based on feedback from current TSS users. The most common complaint of the current TSS is "all the cables." The new design uses a Zigbee wireless communication protocol, thereby addressing the foremost user complaint. The new version also uses a new infrared smart sensor for human hand detection. The smart sensor and Zigbee transceiver unit are packaged as a Wireless Smart Sensor (WSS). The basic system configuration is shown in Fig. 20.6.

The basic operation of the TSS is as follows. For an assembly, sorting or packaging job, inventory is presented to a worker in bins. Each WSS module is attached to a bin. To start, the controller signals bin 1's WSS and turns on an indicator light. A voice prompt instructs the worker to take a part out of the bin with a light on. If the worker's hand is sensed in bin 1 by the WSS it signals the controller which turns off the indicator light on bin 1 and turns on a light on bin 2 and provides additional prompting as provided by the supervisor to the PC. If the worker enters a bin without a light, a warning prompt is given. This process continues until the inventory is depleted.

## SUMMARY OF IMPACT

Overall, the new TSS addresses user complaints and recommendations from user's of the old TSS and incorporates a number of new features. It is currently being tested and evaluated.

The new TSS is a wireless system, so addresses the major user complaint of the older system. The new TSS automatically configures itself upon startup and runs through a comprehensive diagnostic procedure to identify any malfunctions or defective components. The new WSS modules can easily be attached to a variety of containers using Velcro. The human proximity sensing works as expected. There is a much simpler system configuration process and the system includes data collection facilities and report generation features necessary for monitoring student performance in line with IEP requirements.

## TECHNICAL DESCRIPTION

This project had three phases. Phase 1 involved the testing and selection of a wireless protocol and sensor for human hand detection. Phase 2 involved the design and implementation of one WSS prototype module. Phase 3 involved the design and implementation of a working prototype TSS, as shown in Fig. 20.6.

### PHASE 1

The requirements for TSS operation led naturally to the Zigbee wireless protocol. The application requires relatively small bandwidth and transmission speeds but, most significantly, it must be power efficient for long-term battery operation.

The next task was to select a specific Zigbee chipset. The TSS must be able to detect a human hand as it enters the bin to take a component. After a review of the available devices, a smart sensor configuration developed by Ann Arbor Sensor Systems was selected. It is a low-power device with an embedded microprocessor that signals the presence of a hand in its proximity. Proximity can be specified as a set-up parameter.

A series of experiments was designed and conducted to test the sensing capabilities of the smart sensor and its communications capabilities with an external control microprocessor. Another series of experiments was designed and conducted to test the efficacy of the Zigbee chipset. Of concern was the bandwidth requirements and speed of communications. A third series of experiments established the viability of the entire WSS concept in terms of sensing a human hand within the desired proximity and communicating this information to a control PC via the Zigbee wireless link. The results of Phase 1 were the selection of the smart sensor, a Zigbee chipset, and specific technical requirements for the integration of these components into a wireless smart sensor module.

### **PHASE 2**

Based on the results of Phase 1 a preliminary WSS was designed, implemented, and tested. It was necessary to design, build and test one WSS module to verify the design concept and communication protocols. Concurrent with the circuit design and PCB layout and assembly, was the operational software for the WSS embedded process controller. The design of this code included discussions with the client coordinator as to TSS operational requirements. An operational WSS module resulted from Phase 2 activities. The module did not perform exactly as planned and a list of changes and modifications were prepared for the next phase of the project.

### **PHASE 3**

Based on Phase 2 results, a complete TSS design was developed and implemented. The required changes resulted in a significant modification of the circuit design. Also of special concern for this phase were the power supply and power management strategy. Together these circuit design changes led to a new PCB layout.

The basic functional circuit elements, microprocessor, Zigbee chipset, and IR smart sensor remained unchanged allowing WSS software and communication protocol design to run in parallel with the new PCB layout efforts. The WSS software team used the Phase 2 WSS prototype for software development and implementation. When the new WSS was designed and built, the newly developed WSS software was downloaded to the new WSS.

Concurrent with WSS development was the PC user interface and TSS control software. This element represents the user's view of the TSS; its design is critical to overall TSS functioning. The PC controller team had extensive discussions with the Client Coordinator, which included user walk-throughs of the TSS process using simulated WSS operations. The PC control software was completed and ready for use as the WSS modules came online.

The WSS uses a Maxstream XBee Zigbee Transceiver module. The smart sensor is from Ann Arbor systems (A2NCT02). It is a non-contact temperature sensor and works on a 1-Wire interface. The WSS uses a PIC 16F767 running on an internal 8MHz clock as the WSS microcontroller. The firmware for the microcontroller was written in C using the CCS cross-compiler. The entire system being battery operated is designed to optimally use batteries and has a battery life expectancy of a few months. This was achieved by using both hardware and software techniques. The sensor modules are designed for AA lithium batteries but will also run on Alkaline, NiMH and NiCd batteries. Carefully chosen surface mount components were used in conjunction to a double sided printed circuit board to achieve a major reduction in size of the sensor module. The boards are housed in an ABS plastic casing that contains a battery compartment, thus making it easy to attach it to a box or a bin and change batteries.

The PC control system was written in VB.Net 2005 and runs on a Windows XP operating system.

### REFERENCES

- [1] ETL, "Task Sequencing System," 2000.

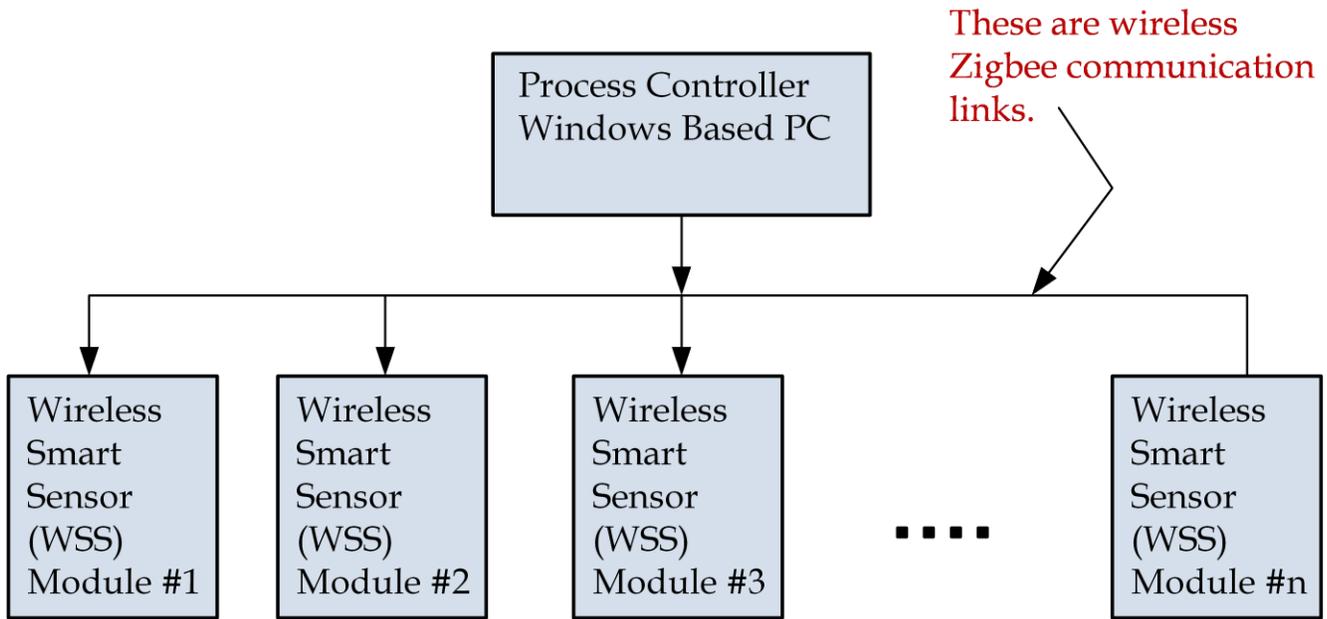


Fig. 20.6. Block Diagram of the TSS System.