

Transparent Anatomical Mannequin Upgrade

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Introduction

The Ruth Lily Health Education Center has had TAM¹ (Transparent Anatomical Mannequin) since the mid-1980's. She is a life size model of an adult female with clear plastic "skin" and organs that light up. She is used to teach pre-school, elementary and middle school children about health and fitness. For instance, each year hundreds of fifth graders come to the Health Education Center to see and hear TAM explain the human reproduction system.

In the original configuration, one proprietary "box" controlled not only TAM's lights and rotation, but also the audio and video tapes. The "box" could only play one program, and it hadn't been changed since the system had been installed over 15 years ago. The health education staff wanted to update the content of the audio-video, but this required more than just a new video tape – it required new hardware. Sonar Studios agreed to work with the teachers at the center to develop a new script, and turn this script into digital video. But a new interface between the computer sourcing the digital video and TAM was also needed. Part of the new interface was given as a class project in an upper level course.

System Overview

The piece of the system that the visitors are most aware of is TAM herself. (See Figure 1) She is focal point of the theater with audio and video screens on either side. TAM is a life size model of an adult female that you can see inside of. All the major organs are shown: brain, lungs, heart, bones, arteries, stomach, etc – including the female reproductive organs. Each of the 19 organs is lit by a 24 volt dc bulb. These lights are controlled by individual data lines. A common +24V is supplied to all the bulbs, and specific bulbs are lit by grounding the individual data line. There are also 120V ac spot lights above and below TAM. Finally, TAM can rotate almost 360° by means of a dc motor mounted in her pedestal.

A Mac computer running MAC-OS 9 controls the system. Digital video and audio clips are stored and played back by the computer. With the use of a video card that can control up to three monitors, two screens of video are displayed overhead to the audience, and a touch screen monitor is used by instructors to select content. The MAC program Director coordinates the entire script, including video, audio, lights and

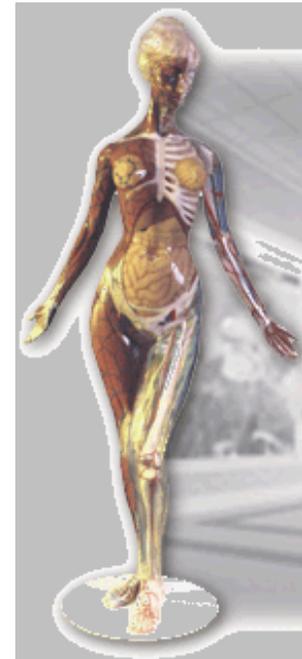


Figure 1:TAM

motion. For example, if the instructor wishes to show a segment on digestion, she selects “Digestion” on the touch panel display. The Director program accepts this selection, begins the audio and video clips, and queues the hardware interface program to light the esophagus, stomach, intestines, etc. as they are described in the audio and video. When the kidney is discussed, the Director program queues the interface program to turn TAM to the full right position and light the kidney. At the end of the segment audio/video segment, Director tells the interface to turn off all the lights and turn TAM back to the center position.

Computer Interface

What makes the TAM theater unique is that the organs in TAM can be illuminated to correspond with the videos. For instance, the computer synchronizes the illumination of the brain and spinal cord with discussion of the central nervous system. Pictures of food are displayed while the stomach is lit. This coordination is possible because of the interface software and hardware that allows the Director software to control the lights and rotation of TAM.

A National Instruments PCI-DIO-96 Digital I/O card² is installed in the MAC. (This card can be used in either a MAC or a PC.) Up to 96 bits of I/O can be monitored or controlled. A cable from the I/O board connects to a cable adaptor board. (See Figure 2.) Two 16 bit relay boxes are then attached to the adaptor board. Each relay controls one light. Using this relay configuration, both the dc and the 120V ac lights can be controlled. The digital I/O card, cable adaptor board, relay boxes, and cables are all purchased from National Instruments. At this time, only outputs from the computer are used: there is no feedback back into the computer.

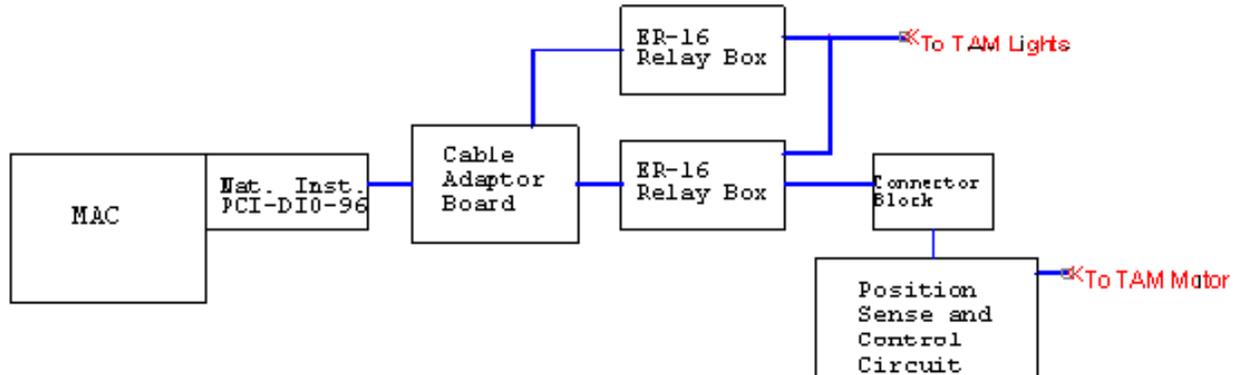


Figure 2: TAM System Hardware

The I/O card is controlled by a LabVIEW³ program. LabVIEW is also from National Instruments, but a unique application, or VI, was written for this project. Since the Director video software doesn't support DLL (not unusual for MAC-OS 9 applications), a more basic approach to communicate between applications is used. The Director application writes a 32 bit number to an ASCII file. Each bit corresponds to a particular light to illuminate or TAM's desired position. By writing the correct number to the file, Director can queue the scripted TAM lights and position. Once every second the LabVIEW VI reads the file and sets the corresponding bits on the digital I/O card, which, in turn, sets the relay to turn on the required light or position bit.

Position Control

To move TAM is not complex. A pre-existing (from the 1980 installation) motor and motor controller turns her pedestal. In essence, this controller is really a dc power supply. The speed is controlled manually with a knob on the controller. It is not changed during operation. When the computer tells her to move, power is applied to the motor controller. Direction is changed by switching the polarity of the dc voltage.

The complex part is making TAM stop where she should. The most involved hardware in this project is the circuit to monitor and control TAM's position. (See Figure 3.)

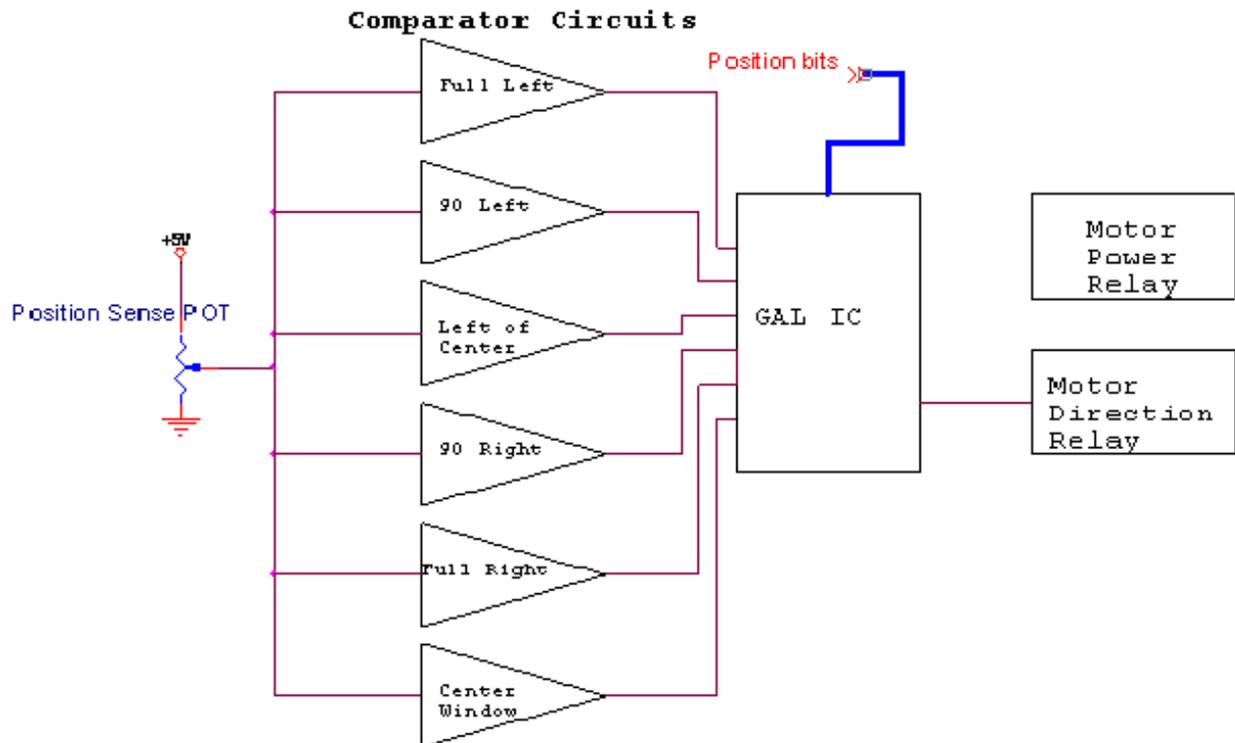


Figure 3: Position Sense and Control Circuit

A potentiometer is mounted to the axis. (See Figure 4.) With five volts applied to the outer terminals, the wiper potential (an analog signal) indicates the position. Only five positions are required by the script: center (TAM facing front), right 90°, left 90°, back full right (TAM turns to the right to show her back), and back full left.

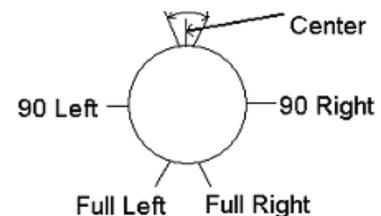


Figure 4: Potentiometer drawing with position indications

A circuit utilizing five high/low comparator sub-circuits transforms the analog signal into digital bits. A window comparator sub-circuit is used to accurately sense the center position. These six bits are feed into a GAL (Generic Array Logic) IC programmed for this application. The outputs from the GAL control the two relays: one that switches the motor on and off; and a second that switches the polarity of the dc voltage applied to the motor, to set direction.

Student Project

The GAL chip described above was programmed by students as a class project in EET 417 Analog and Digital Systems. Professor Cooney posed as a “customer”, the students posed as team members in a contract design firm, with the course instructor as their manager. The students had the opportunity to visit the Health Education Center and view the TAM presentation, then met once in a mock “project planning meeting” where the operation of TAM and the project requirements were explained. In the meeting, the customer specifications were given, and the “designers” could ask questions. Specifications included:

- Inputs: 6 bits from the comparator circuit giving TAM's current position and 5 position bits representing TAM's desired position from the I/O card (through the connector block)
- Two outputs: Motor On and Left/not Right
- +5V Logic
- Documentation that would explain the IC's operation after 15 years, even after the technology was obsolete.

This project was presented in a different manner than students were accustomed to - typical weekly laboratory assignments. The students were told that, from a classroom perspective, this design project was to be a competition between each lab group for best design, best presentation, and best documentation. From a "real-life project" viewpoint, the students were told that the "manager" selected their group for this project. The “manager” (instructor) also explained how vital the success of this project was to the company. Students were encouraged to find all necessary information at the initial meeting (typical of situations they may face after graduation) since “designers” could only contact the “customer” with their “manager’s” agreement after the meeting. To make the scenario more interesting, the students only had nine days to complete the project, and the “manager” was available only via email for five of those days.

Students were given one laboratory session to work on their designs, but as a few groups discovered, they needed time outside of class to fully implement the design, including designing, programming, and testing the design. Some design teams, especially groups who did not have a member with experience in industry, thought that their circuit would certainly work once it was programmed into the chip. They had the experience of demonstrating a circuit that did not work to their customer. This gave the opportunity to discuss differences between a typical laboratory project (if it doesn't work, continue with assistance) and an industrial project (with a firm deadline).

After the allotted time, the design teams met again to demonstrate their programmed GAL chips to the customer. The best design was selected and used in the TAM position control circuit. The team members were recognized in the permanent documentation of the project.

Conclusion

Hundreds of preschoolers, first and fifth graders have now seen the new TAM presentation. The teachers and students are impressed with the coordination of the video and model. The old

hardware has been replaced with modern, more modular technology. The new hardware is working reliably. Elementary and middle school students can see state of the industry computer controls in an unusual setting. Junior and senior EET students not only have had experience working on a group project in an industry-like setting, but have had an opportunity to give back to the community.

References

1. Ruth Lilly Health Education Center <http://www.healtheducationcenter.org/standard.htm>
2. National Instruments Digital I/O card <http://sine.ni.com/apps/we/nioc.vp?cid=10843&lang=US>
3. National Instruments LabVIEW program <http://sine.ni.com/apps/we/nioc.vp?cid=1381&lang=US>

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