A minicomputer system for audio-animatronics show data generation

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INTRODUCTION

Audio-Animatronics® shows have been produced by Disney since the introduction of several attractions at the 1964 New York World's Fair.* Since then a variety of shows have been permanently installed at both Disneyland and Walt Disney World. They typically consist of a stage, or some enclosed show area, and a variety of special lighting effects, mechanized characters and other movable stage equipment. Some of the shows include: “Great Moments with Mr. Lincoln,” “The Country Bear Jamboree,” and “Pirates of the Caribbean.”

The technology used to produce these shows has been constantly evolving and improving toward a more complex and versatile medium for the animator's use. A significant advance in this technology was the move to all digital show data that occurred in 1968-1969. Since then a minicomputer has been an integral part of the show development system. It allows the animator to easily generate, review and edit this digital database to produce the animated show. The name given to this system was DACS (Digital Animation Control System).

In 1971, the minicomputer used for DACS was a Honeywell 516. It has served this purpose at both Disneyland and Walt Disney World for every Audio-Animatronics show that has been produced since then. In 1979, however, with the upcoming expansion at Walt Disney World and the Tokyo Disneyland project, it became necessary to upgrade DACS to a more modern computer system. This second generation DACS is the subject of this paper.

THE DIGITAL AUDIO-ANIMATRONICS SHOW

All components of the digital Audio-Animatronics shows are controlled by a single, unified channel-addressing scheme. This design allows a single show to include up to 1000 separate channels. Each channel can be an eight-bit analog value or eight separate digital subchannels. Analog channels are used for the bulk of the show to provide signals for most of the figure movements, the light dimming functions, and other smooth linear motions. The digital subchannels are used for on/off functions such as eye blinks, platform lifts, and other special effects.

Figure 1 shows the show data transmission system. All of the show data are demultiplexed from a cabinet called an RTU (Remote Terminal Unit). From this point, signals are routed through servo control cabinets (in the case of the air- and oil-actuated figure movements) or directly to other control points. The RTU cabinet is located immediately adjacent to the show area and receives data over twisted pair conductors from a remote central control area. All data are transmitted by serial synchronous communication over these cables. The show data reside on a fixed head disk and are played back by a hardwired controller. This combination is called a Show Control Unit.

The Show Control Unit in turn is synchronized using a telemetry encoding scheme to a multi-track audio tape machine which provides all of the show's audio. In this way the show actions, including mouth movements, are always in complete sync with the audio soundtrack, regardless of tape speed variations. The data update rate is the same as the movie industry's 24 frames per second. Data that are not changing are updated less frequently to save disk space.

Future Show Control Units will likely incorporate another medium for show data storage such as bubble memory. The show data generation process, however, will continue to be identical regardless of the playback medium used.

Show data generation

During show data generation, a minicomputer is substituted for the Show Control Unit to provide data transmission to the show being animated. In addition, a special purpose control panel called an Animator's Console is connected to the minicomputer to provide the input device for the animator to use to generate show data. Figure 2 illustrates this connection, and shows the Animator's Console located in front of the stage area to provide a clear view of the show for the animator.

By manipulating knobs and switches on the Animator's

Console, a show database is gradually built up, a few channels at a time. The DACS minicomputer provides immediate visual feedback via the RTU and includes various editing and playback features. During animation sessions, data are stored on the minicomputer's disk drives. After animation is complete, show data are transferred to the Show Control Unit disks.

The computer system

A Data General Eclipse S250 forms the basis of the second generation DACS. The show data transmission and channel addressing design was left identical to the original DACS so that the new system could be used to reanimate existing shows. A redesigned Animator's Console and single custom interface board for the S250 were mated to standard Data General components. The Eclipse system includes three 50 megabyte disk drives. One is used for system support and the remaining two provide redundant database storage during show data generation.

The Animator's Console was redesigned to incorporate more functions in a much smaller package. It includes a large number of switches, knobs and displays to provide a variety of data manipulation functions for the animator. The microprocessor located in the Animator's Console scans the switches and knobs and drives the console indicators. Message blocks are sent continuously at 30 hertz to the Eclipse incorporating the current analog pot positions as well as the switch scanning information. The microprocessor receives message blocks from the Eclipse with indicator and display information. Error checking is incorporated at both ends of the communication link. The Eclipse is responsible for interpreting all of the console requests and sending back the proper console response along with show data to the RTU. With the console the animator may position himself anywhere within the entire show and restrict his area of operation by use of scene limits. He may further restrict the working space to a subset of all the channels used for the show to focus his attention on a single figure or group of actions. With the console he may play back the existing show data forward or reverse at rates between one and 24 frames per second. He may, in addition, repeat the current scene continuously for critical viewing. New data may be deposited on the disk and viewed immediately by using any or all of the 32 pots and 16 switches on the console. The pots may be dynamically assigned to any of the analog show channels and the switches likewise may be assigned to any of the digital subchannels. Following this assignment new data may be entered or old data changed one frame at a time or continuously at rates between one and 24 frames per second.

The second generation DACS system incorporates many features not available at the time the first generation system was designed. An extremely straightforward hardware and software interface to the custom components of this system has been chosen. Standard RDOS operating system features were used wherever possible, and 95 percent of the code for this system has been generated in the FORTRAN V language. The Honeywell 516 DACS was coded entirely in assembly language without benefit of a true operating system.
The communication link to the Animator's Console was accomplished with a standard Asynchronous Line Multiplexor operating at 19.2K baud. This full duplex line uses two twisted pairs with outboard line drivers and receivers to operate at distances up to one mile. Character interrupts are buffered at the Eclipse by a DCU 200 programmable I/O processor. The DCU 200 incorporates message checking and shields the S250 processor from the character interrupt processing overhead. Data are transferred via DMA channel directly from main processor memory to DCU 200 processor memory and vice versa. A single custom I/O board is inserted in the S250 chassis. It includes a DMA interface for show data transmission, a 24 hertz clock for show timing, and a Time Code Translator interface for audio sync. This board is the only non-standard connection needed to the S250 for this application.

The software design relies heavily on the RDOS multitasking operating system features. Separate tasks are used to partition necessary functions into multiple asynchronous processes, leaving a minimum of interrupt driven code. This partitioning results in an extremely flexible and easy system to maintain and enhance. The FORTRAN V language was found to be fast enough to perform all real-time data manipulation and computations required to keep up with the 24 frames per second rate. Disk data access is accomplished using standard direct block I/O and contiguous files. Real-time data response is insured by multiple block read and write buffers. The buffer size was chosen to overcome worst case disk rotational latency and still provide up to 24 frames per second throughput. All console button and indicator lamp assignments are implemented in software, making changes in console function and button sequences easy.

The DACS minicomputer also provides all of the data manipulation and housekeeping functions performed off-line before and after animation sessions. One of the most important of these functions is data compression. In this operation up to four 33 megabyte files are compressed from tape to a single 2 megabyte disk file. This compressed file is then transferred to the Show Control Unit for repetitive playback. Compression is achieved by eliminating redundant data entries for successive frames, providing only occasional updates to correct any possible noise errors.

**CONCLUSION**

A second generation system for Audio-Animatronics show data generation has been developed taking advantage of standard hardware and software products available today. This new system enhances the capability of the animator to produce more complex shows with higher quality in a shorter time frame.