THE ELECTRONIC PLANETARIUM
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INTRODUCTION

The demonstrations by Evans and Sutherland of the computer-generated star fields projected on the dome of a number of planetariums forecast the ultimate replacement of electromechanical planetarium projectors.

It's easy to forecast now that the computer/TV system will also appear in the small planetariums because the cost will drop below electromechanical planetarium projectors. The Computer/TV system is more versatile. It depends only on programming for those flights to elsewhere, reachable only in the mind or in the Planetarium.

Digital projectors will have more precise planet motions and positions. Precision of one minute of arc will be the norm. The gears and cams and levers that were never more accurate than 3-4 degrees, in small machines, may be laid safely to rest, barely beyond a primitive adolescence. And the new electronic marvels will prove more reliable. The growth potential staggers the mind because the electronic planetarium instrument can become its own special effects projector replacing all those delightful contraptions of light bulbs, levers, switches, rubber bands, lenses, bits and pieces of plastic and string that have intrigued our generation of Planetarians.

The Herkimer BOCES Planetarium uses a Minolta MS 8 but IV has been an increasing part of our school programs and public programs for the last five (5) years. Table 1 summarizes some of the functions performed during this period. We also have 15 PETI computers. These machines form the core of our privileged student programs in grades 4 through 12 for children 10 through 18 years of age. In the paper session titled "The Multidiscipline Planetarium: Computers in Astronomy Education" presented at the Mid-Atlantic Planetarium Society Conference in April 1980 at Boston, other schools, science centers, and college planetariums discussed a wide range of applications to astronomy. We believe the next step in the development of the electronic planetarium is the application of the optical video disc to the system under computer control.

THE OPTICAL VIDEO DISC

In 1970 Phillips of the Netherlands announced a successful video disc system in which a TV signal was contained in tracks on a rigid disc that could be detected by a photosensitive semiconductor for playback on a conventional TV set. Actually the first successful video disc had been developed when TV was very young. That video disc was a modified audio record player and operated when TV resolution was 30 lines. Current U.S. TV resolution is based on a 525 line system that actually produces a picture with half that line resolution. Since 1970, four major approaches have appeared for video disc systems. These are:

1. LASERDISC: A system in which a laser-illuminated, rigid plastic disc is encoded with video information that can be played on a special player.

2. CED SYSTEM: The widely-advertised method of RCA that uses a needle in a groove. This needle, a capacitance pickup, is subject to wear.

3. VHD SYSTEM OF MATSUSHITA (JVC) and GE: This uses a needle that is subject to wear but needs no groove. The disc so far has not been available.

4. THOMPSON—CSF/FRANCE: Their optical "floppy" disc uses a thin medium. The laser can be refocused from top to bottom side of the disc so that both sides can be played without flipping the disc.

The attractive system for the school or planetarium use is the LASERDISC. None of the discs are interchangeable among the four systems. The LASERDISCS are interchangeable between the players of several manufacturers; however. The discs of RCA, Pioneer, Sony, Philips, and Goldstar are all playable on the machines of RCA-Discvision Associates, Pioneer, Sony, Magnavox, and Philips. Not all the players are identical in functions and there may be differences in operation. The LASERDISC is the unit of choice for the following reasons:

1. There is no disc wear. The Pioneer, VP1000 can be set on a single frame for hour after hour on any of the 54,000 frames of a half-hour disc. The laser illumination simply does not wear the disc.

2. The Pioneer contains microprocessor chips that allow a flexible set of control functions; for example:
   a. A single frame number may be entered on a remote control and the machine automatically searches out the specific frame and displays it.
   b. The machine can run forward or back, a single frame at a time, or in high, low, or adjustable speeds.
   c. There are six audio channels with frequency response from 40Hz to 20kHz, selectable by the control.

3. The Pioneer is easily controlled by a computer program through an adapter circuit.

4. In specially prepared discs, the computer programs can be contained in the video or audio channels interspersed with regular audio.

5. The same video material can be used at many grade levels simply by altering the computer program.

6. The laser disc players are relatively inexpensive, often less than the cost of a quality 16mm sound projector.

7. Disc production costs are low in small quantities.

Commercial discs are in short supply. Disc manufacturers have underestimated the demand by a factor of four times. Those who purchase the laser disc players take 6-8 discs at the time of purchase and return within two weeks for 4-6 more discs. The major disc manufacturer is RCA-Discvision, a partnership among RCA which owns the movie factory, Universal Studios and IBM, a company noted for its interests in computers. Other production companies like 3M are coming into production and the delivery problem is expected to be solved by mid-1982.

OPTICAL VIDEO DISC APPLICATIONS

A publishing company executive called the optical video disc a round book with 108,000 pages, a plaintive expression of bafflement about what to do with the technology since no book of 108,000 pages all in color has ever been published.
Sears, Roebuck has published and distributed 1200 copies of a laser disc that was equal to the contents of their 275 page 1981 Summer Catalog. They called it the Teledisc. IBM reportedly has made close to 100 different video discs to train their servicemen. They ship a disc with each new type of equipment to insure correct repair and maintenance procedures.

NASA's subcontractor, JPL plans a series of video discs of the 750,000 planet images gathered since the survey photo missions to the Moon. Ben Cassados of JPL also announced that the Center for Aerospace Education at Drew University will produce a series of three video discs with availability by December 15, 1981.

The National Education Association's (NEA) organization, the National Foundation for the Improvement of Education (NIFIE) have cosponsored a test disc: "The SchoolDisc" produced by the ABC Television Enterprises. It was intended to be used by teachers as a current events classroom resource much like a video cassette. ABC's plan is to produce a bi-weekly video disc, multidiscipline in nature, including a short section for teacher interests in classroom management.

At this time a number of major institutions are engaged in laser disc projects. These include the Encyclopedia, National Geographic, the Metropolitan Opera, SVE, IBM, Ford Motor, GM, and the NEA.

Out planetarium staff has developed a control system for the Pioneer VP 1000 laserdisc player which, together with the PET or VIC 20 computer and color monitor, form an intelligent interactive video disc learning system. We plan to use it for individualized learning.

The objectives of our work in Astronomy education with the intelligent video disc learning system are:

1. To continue development of a low cost student interactive system.
2. To establish criteria for optimum learning modules.
3. To explore alternative instructional modes that could transform schools and drop the cost of education to approximately 17% of present-day costs.
4. To individualize the instruction to the student and, by research, explore what students learn using the system.

The present status of our work in this educational enterprise is:

1. A complete intelligent video disc system has been operating since October 1980.
2. The intelligent video disc has been implemented for all of the PET computers and the Commodore VIC 20.
3. Our research so far shows that:
   a. Third graders can use the system with reasonably complex topics such as weather, biology, and astronomy.
   b. Learning modules can be made from almost any video disc including some of those made solely for entertainment.
   c. BASIC or even TINY-BASIC can be used as a suitable programming language.
   d. Programming methods can be taught far short of a full understanding of a BASIC language course.

VIDEO DISC SYSTEMS FOR THE PLANETARIUM

We believe there are many uses for a computer-controlled laser disc system in the Planetarium. The microcomputers today are quite powerful machines equal in power to some PDP 11's that are used in a few major Planetariums. These new machines, properly programmed and implemented, have memory capacities of up to 256 Kilobytes. There are 8-inch floppy disc memories with storage capacities of more than 8 million bytes of memory that sell for less than $2,000. Some highly automated Planetariums now in existence operate on less than 32 Kilobytes of RAM memory.

Infra-red (IR) light emitting diodes can perform as digital links between transmitters at the center of the planetarium dome, eliminating control wiring between the computer and photosensitive controllers around the dome. It is therefore possible to overlay existing systems at low cost. The combination of IR, multibit digital encoding and signal isolation from the ordinary electrical systems can provide a high level of immunity from spurious operations. A single microcomputer can handle between 256 and 4,096 functions such as slide changes, stepper motor operation, fades, mirror movers, and other special effects in precise time sequence, to a microsecond if necessary. The care of such a system is within the capability of an average, well-motivated technician.

It is also possible for a laser disc player and large screen TV to stand as planetarium production equipment. We have used a test disc of the Jet Propulsion Laboratory containing Voyager 1 pictures displayed on the three TV's for Planetarium shows and with gifted child programs.

One exercise is to lay a piece of Saran wrap on the TV monitor and with a marker pen (the type used with overhead projectors) trace the limb of, say, the Moon Io. Also trace the caldera and the eruption plume of the volcano found on the limb. From the measured Io diameter and its true diameter, the caldera diameter and the size of the plume can be estimated.

An update on this exercise is the addition of a light pen. This allows measurements without the need for the plastic wrap and pen. A computer program actually can handle the distortion problem without the experimenter noticing the corrections or it can be interactive with the student participating in the corrections.

Claire Carr and students explore the universe with one form of the "electronic planetarium." The Commodore computer is used for simulation, calculation, and computer-aided instruction (CAI). It is a particularly valuable instructional aid when it is used to comment and quiz on the video disc material, and displayed under its control on the large TV screens.
This JPL disc can also be used with the computer and a tape deck for an automatic slide show. The interesting part is that if every frame were numbered and contained a different picture, the system would be a random access projector with 54,000 pictures. The average access time is 7.5 seconds.

We can also foresee a planetarium system of four or more large screen projection TVs with wide angle lenses covering a planetarium dome. These projectors operating from digital data stored on an optical video disc could contain the star field. The computer program causes the star field to move across the dome in any prescribed pattern. In latitude, diurnal, annual, or precession modes as selected by the operator or the show’s computer program. In a color system, where three color cathode ray tubes (CRT) are used, the images can be at least twice as bright as with a single monochrome CRT. Equally important, the up-coming 1125 line standard for the high definition TV (HDTV) has better image quality than a 16mm movie frame. The aspect ratio will be at least 5:3 and perhaps 2:1 (width to height). Several film makers, including George Lucas of Star Wars fame have said their movies will be made by HDTV recording rather than on film in the future. Lower cost is one reason, but better and faster special effects are expected.

The Evans and Sutherland projection TV Planetarium installation for the Science Museum of Virginia at Richmond, Virginia is in a 76-foot dome using a very bright CRT. The star positions are limited only by the resolution of the graphics systems with a field of 4096 x 4096 screen locations that can be addressed by the computer. The computations by the computer are accurate to ±1 minute of arc but the practical realization on the dome probably will fall between ±10 minutes to ±30 minutes. Planet positions will therefore be better than most present equipment.

The computer for the starfield positions has 124 Kilobytes of 16 bit RAM memory. The graphics, however, use 256 Kilobytes. FORTRAN is the computer language and graphics can be entered from a tablet.

Lest there be any concern about memory, 16 Kilobyte memory chips cost less than 1 Kilobyte chips did five years ago and that includes inflation. The first 256 Kilobyte chips have already been made and are expected in quantity by 1984 and will cost less than $10 by 1987.

The recently announced Sony magnetic recording still camera, which takes 50 to 80 pictures on a 1/4-inch floppy disc that costs $2.65 may not provide extremely high resolution pictures, but its playback is through a TV system. This well matches a move to the future electronic planetarium.

It was perhaps a collective sense about these kinds of futures and alternatives that led the International Planetarium Society Board meeting in Mexico City in August 1981 to accept the proposal we made for producing a laser disc on Astronomy. Since that time a number of other organizations have expressed interest.

Dr. Derek McNally, Editor of the International Astronomical Union’s Astronomy Education Newsletter will publish the details of this project in the fall Newsletter of the IAU’s Commission 46 on Astronomy Education. The authors may be contacted for a prospectus and order form for the IPS disc.

NOTES:

TABLE 1
TV Applications in the Planetarium 1976–1981

1. SPECIAL EFFECTS
   Display Computer Readouts
   Communications
   Pictorial and Graphics
   Vocabulary
   Simulations
     “Crash on the Moon”
     “Men to Mars”
     “The Exploration of Mars”

2. PROGRAM PRODUCTION—Video Tapes
   Off The Air
   First Apollo 17 (Launch, Rover, etc.)
   First Apollo/Soyuz Rendezvous
   Program Chips
   Dr. Roger Rockefeller, Utica College
     “The Size of the Universe”
   Dr. Charles Holbrow, Colgate University
     “Cities in Space”
   Animation in Real Time
   Titles (Dissolves, Wipes, Superpositions)
   Scale Models (Macro, Zooms)
   Simultaneous Front and Rear Projection
   Blue Key: Real Size, Macro and Micro
   Backgrounds

3. ELECTRONIC SLATE
   Interactive Programs
   Questions and Answers to the Celestial Computer
     Star Positions
     Planet Positions
     Sunrises/Sunsets
     Moonris/Moonset
     Moon Phases

4. HANDICAPPED PROGRAMS
   Video Display Synchronized with Planetarium
   Internal Planetarium Broadcast System
   Loudcast Earphone System
   Simultaneous Three Language Program