Pictures from Numbers

Instructional Objectives

After viewing the program and participating in accompanying activities, the student will be able to:

1. state that the Hubble Space Telescope communicates to earth through encoded radio waves, and
2. explain how the digital information received from the Hubble Space Telescope is converted back into an image and is available for use by scientists.

Synopsis

Program 2 opens with a view from the Hubble Space Telescope. Dr. Eric Chaisson shares this view with us, as well as his own insights as to the significance of the image we see.

The program also describes the flow of data from the stars to earth, emphasizing the transferring of an image by the camera onto a computer screen here on earth. The role of the Hubble instrument, the Tracking and Data Relay System, and the computers is detailed to provide students with a sense of the process. The picture element or pixel is explained in detail and related to the computers the students use in school. This explanation builds to an explanation of the gray scale.

A contrast of the process used for black and white images is made with the process used for color images. The result is that students perceive the similarities and differences between the two processes.

Vocabulary

Byte - An eight-bit character, two groups of four-bits each, used in a code. A unit of eight binary digits, used as a measure of the capacity of a computer memory.

CCD - Charge-Coupled Device — The CCD detects, stores, and reads out an electrical charge that becomes a video signal. The CCD detects by absorbing the light focused on it into a photoconductive layer.

Facsimile - An electronic method of transmitting images or printed matter.

Filter - A device for permitting only waves of particular frequencies to pass; a device for absorbing or reflecting light of particular wavelengths.

Pixel - A picture element that produces a single dot of color from a combination of red, green, and blue illuminated bands.

Telemetry - Three separate functions are involved: (1) generation of a signal; (2) transmission of the information to the remote location; and (3) conversion of the data into a form appropriate for display, recording, or further data processing.

Previewing

Discuss the graphics the students have seen on computer screens. What makes them particularly effective or close to real?

Examine a color photograph from a magazine with a hand lens or dissecting microscope. Ask students to describe or draw what they see.

Magnify a picture of George Washington from a dollar bill. Ask the students to describe the result.

Go over the vocabulary terms.

Postviewing

Ask the students to describe what information they were shown from the Hubble Space Telescope.

Ask the students to sketch the path of the data from the Hubble Space Telescope instruments to the computers at the Science Institute. Discuss the importance of telemetry.

Discuss other possible methods of collecting data from the Hubble Space Telescope. What alternatives can the students generate? Discuss possible glitches in the current method of transmission, and what scientists and engineers could do to work around the difficulty.

Ask students to explain the importance of the Science Computing and Research Support Division to astronomers who have observing time on the HST.

Active Involvement

Have students convert a small black and white photograph into digital information. Students should then exchange their encoded picture and tone keys. Ask them to convert the digital information back into an image.

Were there any glitches in transmission? Why?

Students can write to NASA to obtain publications on this technology. To get started, ask for:

NASA Facts
NF-151/7-87
"How We Get Pictures from Space"
by Robert Haynes
From: Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402

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Bitter, Gary G. *Exploring with Computers.* New York: Julian Messner, 1981.

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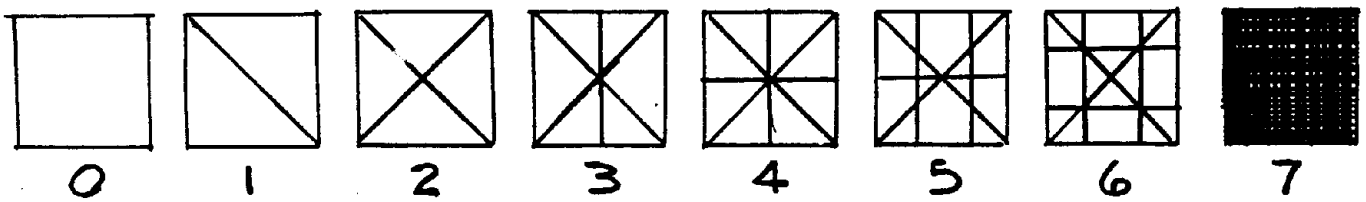
See For Yourself: Experiments/Projects

STARFINDER
PROGRAM 2

Monopectral Scanner

▶MATERIALS:

- Eight value scale
- Image values from a space experiment (data chart)
- Graph paper
- Pencil



▶DIRECTIONS:

This activity uses an eight value scale (see diagram above). In this particular image, 0 is white and 7 is black. One through six are increasing shades of gray.

There are several acceptable methods for determining how to achieve a consistent gray scale. For this activity you are asked to follow the data chart provided at right, so that your segment of the image can be put together with your classmates' segments to form a mosaic.

For the rows and columns assigned to you by your instructor, complete the coding to an image on the graph paper. Be sure to label which rows and columns you were assigned on the back of the graph paper so that all of the work can be assembled into a single mosaic.

1. Were there any noticeable anomalies or glitches in the final image? What are possible explanations for them?
2. Suggest what techniques in encoding could occur to go from a gray scale to a three color image.

```
                  1111111111222222
        12345678901234567890123456
A       44444444444444144443434 34
B       44444444344444444343444444
C       44414444444444443434444444
D       44114444434444434442442444
E       44444444444444344434424444
F       44344444444434442544444444
G       44443444443444444444434444
H       44444444344444443444444444
I       44444444444444444444444442
J       44444443444444434443444424
K       44344444444444444444443424
L       44444444466644444344444434
M       44444344411443444434444444
N       44444444444444444444444444
O       44444466664444444444554444
P       44444461114444444445522444
Q       44444414444444555552226623
R       44444555555555222222661177
S       44545422222226666666117777
T       44454542666662211111177777
U       34444462111227777777777777
V       33121217777777777777777777
W       77777777777777777777777777
X       77777777777777777777777777
Y       77777777777777777777777777
Z       77777777777777777777777777
```

Discovery I

▶ **MATERIALS:**

- Graph paper (2 sheets)
- Pencil

▶ **DIRECTIONS:**

Below is a list of the values of the picture elements on a celestial body sent back by Discovery I.

002	015	070	010	030	035	035	035	003	005	003
003	011	048	060	070	100	118	160	100	004	003
002	004	016	070	118	110	078	085	140	040	003
000	001	030	100	110	100	081	090	110	065	007
001	002	061	120	110	125	130	155	135	065	005
002	000	015	125	090	110	129	148	125	030	000
003	002	008	040	129	090	110	125	060	030	000
004	005	008	009	020	060	058	030	040	100	011

This activity has you design your own gray scale. Set up eight intervals covering the range of values from 0 to 255. Design a symbol or shading system with eight values, one corresponding to each of the intervals. Remember that 0 represents black and 255 represents white. Some sample values in between would be 9 = dark gray, 62 = gray, and 183 = pale gray. Draw your scale below.

Interval	I	II	III	IV	V	VI	VII	VIII
Digital Value	0	—	—	—	—	—	—	255

Using your designed scale, translate the values of the Discovery I image back into a picture on a separate piece of graph paper. Each number will represent a single block on the graph paper.

1. Was the scale you designed effective in showing the image?
2. Compare your picture with that of your classmates. Describe the kinds of gray scales that worked best for converting the image.
3. What characteristics improve or enhance the effectiveness of the gray scale?

   Design another gray scale using 16 intervals. Draw the scale and list the intervals on a separate piece of paper. Convert the digital values to your scale on the second piece of graph paper.
4. What is the difference between your first image and your second?
5. How could your second gray scale be improved?

Science Career Profile

STARFINDER
PROGRAM 2

DAVID SODERBLOM,
Chief, Research Support Branch
Space Telescope Science Institute
Education: A.B. Astronomy
Ph.D. Astronomy

Chief Responsibilities

Dr. David Soderblom's chief responsibilities at the Space Telescope Science Institute include managing the personnel in the Research Support Branch. This branch provides service to the astronomers after the observations by the Hubble Space Telescope are complete. Research Support helps the astronomers retrieve data from computers, work out problems, and get maximum usage of the data. Eventually astronomers will be able to work at remote sites, but at the present time they come to the Science Institute to work with the data.

David also participates in the review and planning exercises at the Science Institute. As part of his overall support of the Institute's mission, David provides scientific oversight of the workshops and science publications. In addition to these responsibilities, he also manages the graphics arts section.

A Typical Day

David's days are made up of meetings with Science Institute personnel, collaborating with researchers, and preparing publications. His job gives him the role of coordinating the many activities of the Research Support Branch, including reduction and analysis of HST data, graphics arts production for support of the Science Institute's publications, and the science projects in the small shops at the Science Institute.

David is also involved in discussions of computer purchases and in communicating to the Research Support Branch the needs and focus of the Science Institute as a whole.

Career Viewpoint

David feels that the essence of science is curiosity. If you are curious enough about the world around you to delve deeply into it, then you have the beginnings of a career in science.

David explains that peers can subtly discourage an individual from being different or excelling academically. A student must realize that it is all right to do well and for peers to be the way they are. It is important to take the chance to experiment and think for yourself.

David's own research interests are in comparing our sun to other stars and in observational studies of the evolution of low-mass stars. His position at the Science Institute allows him to continue to pursue his research interests.

Content Consultants for STARFINDER-Program 2

Eric Chaisson
Space Telescope Science Institute
Operated by AURA for NASA

Greg Helms
Arundel High School
Gambrills, MD

Teacher's Guide

Writers
Pat Murphy
Barbara Bourne

Editor
Kate Harrison

Illustrator
Dave Weaver

Graphic Design
Bob Lindler
The Design Co-op

Typesetting
Blue Heron Typesetters