Pictures from Outer Space

Objective

Students will simulate the interrelated processes by which spacecraft computers encode pictures of a planet, and computers on Earth later decode digitized data and transform it back into an image of the planet.

Engage

Ask students to think about the last time they or one of their family members took pictures with their still camera. Ask them how they think the image of the real world got from inside their camera into their hands as finished prints. (The answer is, of course, a physical thing called film which, after being exposed to light, is removed from the camera, chemically processed at the photo shop and returned as prints or slides). Ask them how they think we get pictures from the HST and other spacecraft? Early satellites did indeed parachute film packs back to Earth, but that's not the way it's done today. And astronauts aren't always popping up to change the film, so how does it work?

Figures for this section.
Instructions on how to make/use the diagrams.

TO Make this chart:

Use a ruler and a pen or pencil the chart is a rectangle
1" wide and 7" long. It is divided into 28 by 4 1/4" squares

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  L
______
!_!_!_!
!_!_!_!  The Table is filled out |
!_!_!_!              this way.  V
! ! ! !

  (etc.)
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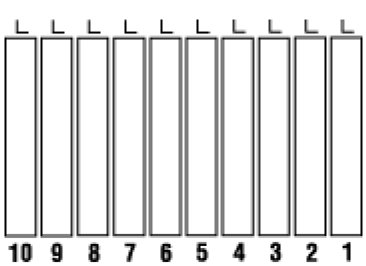
Each of these strips is assembled together
to make the entire "picture."

Diagram of data strip placement.



Materials (for each team)

photocopy of the grid
set of 4 paper sheets of differing shades of black to white (black, dark gray, light gray, white)
glue, scissors, four paper cups (to hold sets of paper squares)

Explore/Explain

Have the students examine a TV or computer screen with a magnifying glass. Ask them to describe what they see. They'll note the picture is actually made up of little dots (called pixels, or picture elements.) Explain that the HST and other spacecraft actually send images to Earth by radio as a long string of numbers which tell the location and brightness of each pixel in the image. Then computers put all the pixels together like a great cosmic jigsaw puzzle. Explain that in this Activity, they are going to take the place of NASA computers and convert a string of coded data from a spacecraft back into the image of an actual object in space.

Procedure

Begin by dividing the class up into ten Data Analysis Teams (and since this is a space-related project, you can call them DAT's. All space agencies love acronyms.) Give each DAT a copy of one of the coded lists of numbers (their "data stream") from your Master Code List. Also provide a copy of the grid.

Tell them:

1. their grid provides the framework for one portion, strip or slice of the picture to be deciphered from space
2. the numbers in their data stream represent information on the brightness of the 1120 image pixels that they will be responsible for putting in place
3. the order of the pixels in their data stream is a clue to the order in which their pixels are to be arranged in their portion of the final image

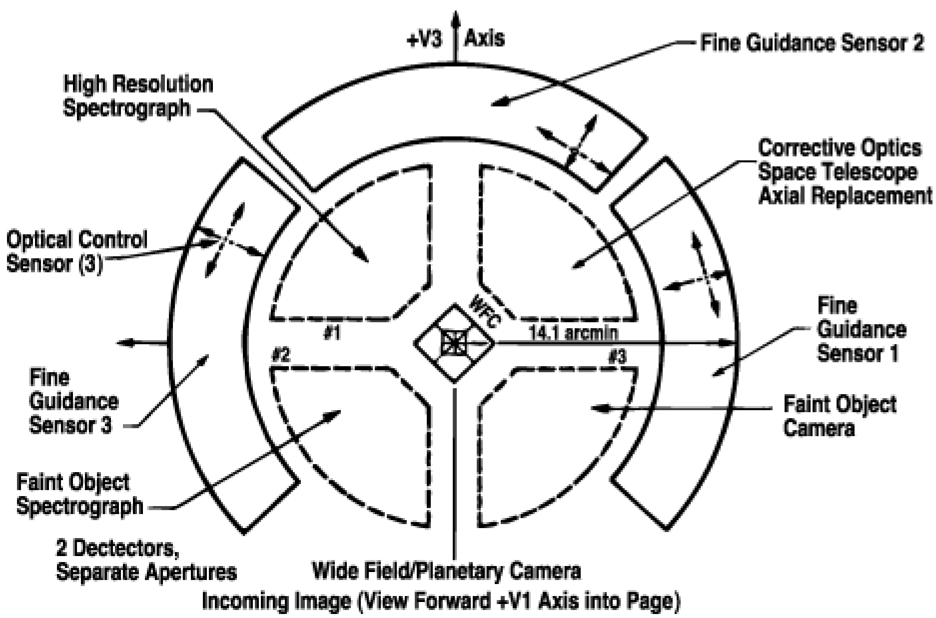
Instruct them to place the grid horizontally on their desk tops (with the "L" mark on the left) and begin to encode the image by placing the first number in their data stream in the uppermost left box in their image grid. (Here they are doing, in a greatly simplified way, what the CCD detectors on board a spacecraft do when they observe a target.) Then place the second number in the data stream in the box on the same line immediately to the right, the third number in the next box, etc. When the first line is complete, tell them to begin filling in the second line of the grid, again from left to right, and continuing until their entire grid is filled in. Then one member of the team should re-read the numbers as the others check for accuracy.

When all teams have completed this task, pass out a set of paper sheets to each team. Explain that the shades of brightness and darkness correspond to the numbers sent down by the spacecraft with 0 representing pure white, 1 light gray, 2 dark gray and 3 representing black. Tell them to carefully cut the pieces of paper into small squares each the size of one of the grid boxes and to group each different color into a different pile. (An alternative is to use a paper-cutter, carefully, to mass produce squares in advance, then distribute them in paper cups) Have students glue an appropriately shaded square over each correspondingly-numbered grid box. Be sure to have one member of the DAT time how long the process takes to code their grids. When all the DATs are finished, assemble all the pieces of the image to create the full image (as shown below left) on a larger piece of paper or card. As the image comes together, challenge them to identify it, giving clues as you go. When completed, tell them the significance of Jupiter's Great Red Spot, and show them the actual image from Voyager 2 for comparison (to be seen in Program 1, "The Great Planet Debate" and on the HST lithographs co-packaged with the Guide).

Engage

Relate the coarsely-detailed (or "low resolution") image the students assembled to an actual image from the HST, as on the enclosed lithographs. These images clearly have more detail because they contain many more pixels in the same space and incorporate many more shades of gray between white and black. In short, it contains much more (picture and computer) information.

(See Activity 3A page 30 for how black and white data becomes a color image.) Have the students compare the number of pixels and shades of gray in their image and one from the HST, using the information given in their Worksheets. Finally, ask them to calculate how much longer it would have taken them to assemble the real image at the rate they worked.



From pixels to pictures

The Hubble Space Telescope and other spacecraft, including weather satellites, take pictures using video technology and devices known as charge coupled devices, or CCDs for short. Like a picture on a TV set or computer screen, each image is made up of thousands of tiny dots or picture elements ("pixels"). The pictures are not sent down to the ground as hard copy. Instead, the photons of light reflected off an object are collected by the sensitive CCDs, and recorded and analyzed pixel by pixel. Then, the information on the location of each pixel within the picture and the brightness of that particular pixel is radioed down to Earth. Computers convert this information back into light and dark spots and place these pixels in their correct positions, so that a complete picture is re-constituted by computer. Prints and slides can then be made. This is the process you and your students will see happening for images of Jupiter, Neptune and Pluto during the videos, and you'll be able to follow the Planet Advocates' image processing work on-line, during the hectic weeks between the live broadcasts.

Another key thing to appreciate is that the HST and other spacecraft take their images in black and white. Yet we see beautiful spacecraft images in full color, such as the M-16/Eagle Nebula picture co-packaged with this Guide. How is this possible? To make a color image of an object, the spacecraft takes several black and white images, each through a different colored filter. By carefully examining how bright different parts of the object look through the different filters, scientists using computers can figure out the true appearance of the object, and so re-create a realistic color image.