COMPARING COSMIC CAMERAS

Developed for Stardust-NExT mission

STUDENT GUIDE

Objectives:

You will

- describe how focal length affects the field of view of an image
- describe the relationship between focal length and distance
- describe the combined impact of focal length and resolution on image quality
- predict/verify ways in which the image quality will be different between the pictures taken by different cameras

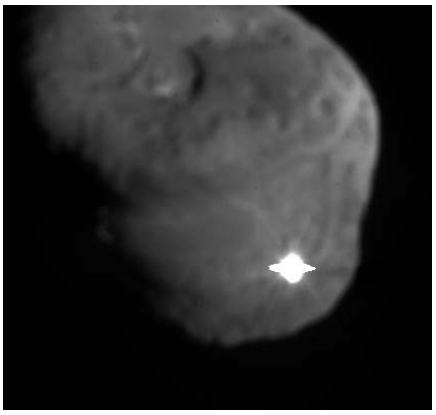


Figure 1

The image depicts the first moments after Deep Impact's probe interfaced with comet Tempel 1.

This image was taken by Deep Impact's high-resolution camera which has a final image resolution of 88m/pixel.

Image credit: NASA/JPL-Caltech/UMD
This image can be found at:
http://www.nasa.gov/mission_pages/deepimpact/multimedia/pia02141.html

Deep Impact

On the evening of July 3, 2005, Deep Impact, a NASA Discovery Mission, performed an incredibly complex experiment in space to probe beneath the surface of a comet and reveal the secrets of its interior. As a larger "flyby" spacecraft released a smaller "impactor" spacecraft into the path of Comet Tempel 1, the experiment became one of a cometary bullet chasing down a spacecraft bullet while a third spacecraft bullet sped along to watch.

With a total of three different the Deep Impact spacecraft was able to capture spectacular images of the comet and it's impact. The flyby spacecraft was equip with two cameras, one was a high-resolution imager (HRI), which produced images at closest approach that had a final resolution of about 2 meters/pixel and another medium-resolution imager (MRI) which produced images at closest approach that had a final resolution of 10 meters/pixel. The impactor probe also equipped with an imager similar to the MRI on-board the flyby spacecraft. The uniqueness of this camera was that it would capture the final and closest approach images at a resolution of 0.5 m/pixel as the comet slammed into the impactor probe.

Though scientists were unable to see the crater created by the impactor probe due to the amount of debris thrown off the comet at the time of impact images taken from Deep Impact revealed interesting facts that, when interpreted through the eyes and methods of science, lead to exciting and sometimes startling conclusions. For example, the nucleus of Tempel 1 is estimated to have a density of around 0.7 g/mL or g/cm ^{3}– it would float in water!

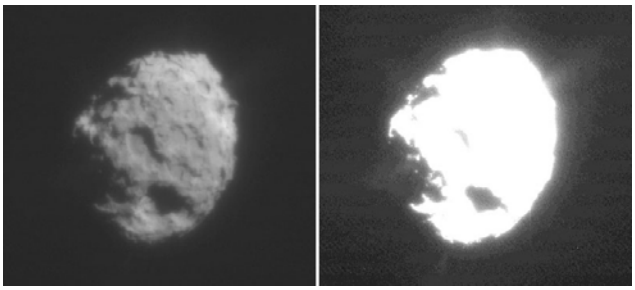


Figure 2

Comet Wild 2 is shown in this image taken by the Stardust navigation camera during the spacecraft's closest approach to the comet on January 2, 2004. The image was taken within a distance of 500 kilometers (about 311 miles) of the comet's nucleus.

Image credit: NASA/JPL-Caltech

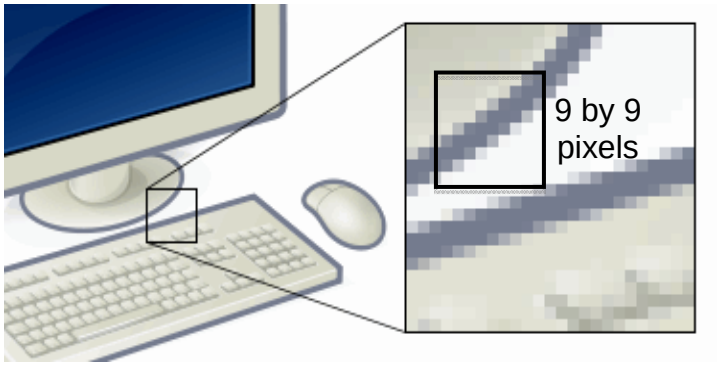
This image can be found at:
http://stardust.jpl.nasa.gov/news/status/040102.html

What next? Stardust-NExT

In July 2007, NASA commissioned the Stardust spacecraft (launched in February of 1999) - which successfully collected cometary and interstellar dust particles from Comet Wild 2 (pronounced "Vilt") and returned a treasure trove of particles back to Earth in 2006 - to revisit Comet Tempel 1 and gather new images.

Now the Stardust-NExT (New Exploration of Tempel 1) Mission will return to provide images of the surface for scientists to compare and study. Because of differences in camera focal length and distance, the navigation camera in Stardust-NExT will send back less detailed images (lower final image resolution) than those previously seen from Deep Impact.

Since the size and depth of the impact crater on the nucleus of Comet Tempel 1 is unknown, it is hard to predict the quality of the image(s) and the kind of information that may be collected by Stardust-NExT. At its closest approach (~ 200 km) the best resolution the Stardust-NExT navigation camera is capable of is 12 m/pixel. This means that if the real crater is 100 meters in diameter, the image will show this in 8 or 9 pixels!



THIS TABLE CONTAINS KEY INFORMATION ABOUT THE CAMERAS IN THIS LESSON:

	Stardust-NExT Navigation Camera	Deep Impact Medium-resolution Imager	Deep Impact High-resolution Imager
Focal Length	0.200 m	2.1 m	10.5 m
Field of View	3.5 degrees	0.587 degrees	0.118 degrees
Distance at closest approach	200 km	700 km	700 km
Final Image Resolution at closest approach	12 m/pixel	10 m/pixel	2 m/pixel*

Introduction

1) Compare the images you are given.

Activity

1) Setup a photography space by:
   a) Selecting an object to image.
   b) Setting the object against a wall or other suitably drab backdrop.

2) Investigating the effect of focal length.
   a) Record what values on the camera's lens are the designated focal lengths below.

Focal Length	Camera Setting
Short	
Medium	
Long	

   b) Take three images of your object. Each should use a different focal length - short, medium, and long. You'll need to know what order these are taken in!
   c) Connect your camera to the computer and:
      i) Download the images to a new folder – called focal length.
      ii) Use the images to fill in the comparison chart below.
      Data:

Focal Length	
Short	
Medium	
Long	

      iii) Compare the effects of focal length on the images you produced.

Comparison	
Ways the images are similar:	
Ways the images are different:	

      iv) Write one sentence that talks about the general effects of focal length on an image.

      v) Write the name of the camera next to the focal length it models.

Investigating the effect of distance.

a) Using masking tape, mark a short, medium, and long distance from your object.
b) Take three images of your object at each distance using a short, medium, and long focal length.
c) Connect your camera to the computer and:
   i) Download the images to a new folder – called Focal Length and Distance.
   ii) Use the images to fill in the comparison chart below.
   iii) Compare the effects of focal length and distance on the images.

	Distance		
Focal Length	Far	Medium	Close
Short			
Medium			
Long			
Comparison			
Ways the images are similar:			
Ways the images are different:			
Conclusion			

iv) Identify any combinations of focal length and distance that produce similar images.

v) Identify which combinations of focal length and distance models which camera.

2) Investigating the effect of final image resolution.
   a) Record what values of the camera's resolution below.

Resolution	Low	Medium	High
Camera Setting			

   b) Pick one distance to take the next set of images at.
   c) Take nine images of your object: one at each resolution (low, medium, high) and with a short, medium, and long focal length.
   d) Connect your camera to the computer and:
      i) Download the images to a new folder – called Focal length and resolution.
      ii) Use the images to fill in the comparison chart below.
      iii) Compare the effects of focal length and resolution on the images you produced.

	Final Image Resolution		
Focal Length	Low	Medium	High
Short			
Medium			
Long			
Comparison			
Ways the images are similar:			
Ways the images are different:			
Conclusion			

      iv) Identify which combinations of focal length and final image resolution models which camera.

3) Investigating the properties of final image resolution.
   a) Copy the images from the above data table and paste them into this one.
   b) Crop each image so it shows only the object.
   c) Enlarge the cropped images to the same size.
   d) Compare the effects of enlarging images of differing resolution.

	Resolution		
Focal Length	Low	Medium	High
Short			
Medium			
Long			
Comparison			
Ways the images are similar:			
Ways the images are different:			
Conclusion			

4) Pair and answer the following questions:
   i) Do any images give a good model of the differences in the images of Tempel 1 by Deep Impact and Stardust-NExT?

      Why or why not?

   ii) What would you predict are some ways in which the final image quality will be different between the pictures taken by two different cameras, for example the pictures of Tempel 1 by Deep Impact's medium resolution camera and Stardust-NExT's navigation camera?