Aerial Imagery

An aerial image is a type of digital photography obtained from a camera located above the Earth using an airplane, air balloon, space satellite, etc. Such an image can be used to better understand relative locations and different local characteristics of geographic object on the surface.

Explorer's Guide

Before You Start

In small groups take two photographs of a wall painting using a digital camera. The first photograph shall be done from a distance of just a few steps and the second shot should be made from 2-3 times further behind using the same zoom setting. Compare the two images. What happens to the area in the photograph? What can you observe when zooming on the downloaded image very close?

Learning by Doing

1. Assume that you want to obtain an aerial photograph of an 80 ft long backyard (*L* = 80 ft) with a camera having 62˚ field of view (*FOV*). What is the minimum height needed to capture the entire backyard using this camera? Hint: use the following mathematical equation:

$$Height = \frac{L/2}{\tan\left(FOV/2\right)} = \frac{\_\_\_/2}{\tan\left(\_\_\_/2\right)} = \frac{\_\_\_\_\_\_}{\_\_\_\_\_\_} = \_\_\_\_\_\_ \ ft$$

For example, for L = 100 ft and FOV = 50˚:

$$Height = \frac{100/2}{\tan\left(50/2\right)} = \frac{50}{0.466} = 107.3 \ ft$$

2. What will happen to the length of the viewing area if you raise camera 50% (half) of the original height? Hint: use the following proportion:

$$\frac{Height_1}{L_1} = \frac{Height_2}{L_2}$$

Lowering camera 50% the original height will result in $\frac{Height_2}{Height_1} = \_\_\_\_\_\_$

From the equation above:

$$L_2 = \frac{Height_2}{Height_1} L_1 = \_\_\_\_\_\_ \cdot \_\_\_\_\_\_ = \_\_\_\_\_\_ \ ft$$

3. Assume that 80 ft and 40 ft wide image is constructed using a matrix of 1000 by 500 pixels. What is the sixe of one pixel? Hint: use the following formula:

$$L_{pixel} = \frac{L_{image}}{N_{pixels}} = \frac{\_\_\_\_\_\_\_}{\_\_\_\_\_\_\_} = \_\_\_\_\_\_\_ \; ft = \_\_\_\_\_\_\_ \; in$$

How Does It Work

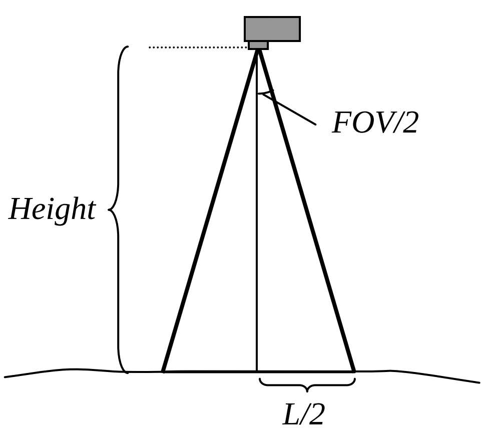
Aerial imagery is similar to regular photography except that the camera is located at an elevated point and directed downward. For example, the camera or another image sensor can be mounted on a space satellite, airplane, helicopter, air balloon, rocket, kite, tall tower, and many more. These platforms can move or be stationary, be operated by a pilot or controlled remotely, collect images continuously or at a specific time.

Most typical aerial photography is done using airplanes. A small hole cut in the floor of the aircraft belly serves as the camera port. As the plane flies back and forth across an area the camera snaps images with a given frequency. Than these images can be “glued” together using some sophisticated software. This software also has to account for image distortions caused by the airplane orientation in space, Earth terrain, and other distortions.

Aerial photos can be taken with a film or digital cameras. Digital cameras are becoming more and more popular because of a relatively easy image processing technique. Since digital images are already in digital format, they can be imported into GIS software without many preliminary steps.

Some space satellites have been used to capture Earth images all the time (e.g., IKONOS, MODIS, or LANDSAT). Images obtained using these satellites and some airplane platforms can not only be black and white (panchromatic) or color (blue + green + red), but also color-infrared. In this case, blue color is used to display actual green, green color shows red, and red color illustrates light reflectance in the near-infrared part of the visual spectrum. Such images are very useful for studying vegetation as any healthy crop provides much higher infrared light reflectance than green.

Size of the image depends on the field of view (FOV) for the camera used (see figure below). FOV for a given camera remains unchanged unless optical zoom is used or lenses are replaced. However, moving camera higher above surface makes surface area captured with one shot larger. In a right triangle, tangent of one of the sharp angles equals to the ratio of the opposite side to the adjacent side of the triangle. Therefore, the relationship between the height (distance to the target) and size of the image (ground length) is as follows.



$$\tan\left(\frac{FOV}{2}\right) = \frac{L/2}{Height}$$

Image resolution is a measure of the fineness of details in an image. The smallest particle of a digital image is called pixel. A two-dimensional rectangular grid of sensing elements define camera resolution (see below). Each such “sensor” can only detect the amount of reflected light, but many sensors together can create a picture. The more pixels are available the better quality of an image. Image resolution defines density of the pixels. Since the number of pixels does not change with the viewing area, the size of a pixel is increased when camera is moved up. Satellite images have 1 pixel equal to several meters when some lower altitude alternatives have only a few centimeters size of a pixel.

Additional Challenge

Help your instructor to collect actual aerial images using an air balloon or a remotely controlled aircraft. Download images to a computer and check their size and resolution using ground references (objects of known size placed on the ground). Use the follow-up activity (21) to georeference these images.

Vocabulary

Field of View (FOV) *is an angle between two opposite edges of the camera’s viewing space.*
Pixel *is the smallest (usually square) element of a digital photograph that has a single light reflectance value.*
Resolution *is the linear size of a square pixel.*

Interesting to Know

Aerial photography was first practiced by the French photographer and balloonist Nadar over Paris, France.

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