GIS - Geographic Information Systems, Aerial Photography,

Digitized Multimedia Formats, Medical Records, and Scanned Miscellaneous Documents

Aerial Photography, Digital Orthophotography, and Remote Sensing Pixel Sizes

Aerial photography uses photographs taken from the air, recording the visible electromagnetic spectrum (light), as maps of geographic areas. Remote sensing includes photographs taken from the air and from beyond the atmosphere of areas on the earth and other celestial bodies, using many segments of the electromagnetic spectrum including visible light, ultraviolet, infrared, and radar illumination. Digital orthophotography digitally rectifies the pixels of digitized aerial photographs into a continuous map, usually registered to a layer of a GIS (Geographic Information System).

For cities, 2 inch to 6 inch pixels are popular for digital orthophotography. A digital orthophotograph of a 500 square mile city using 6 inch pixels would have 4 pixels per square foot, 100 million pixels per square mile (There are approximately 25 million square feet per square mile.), for a total of 50 GigaPels (50 billion pixels). Using 8 bit uncompressed grayscale or using 24 bit color with an estimated lossless three-to-one compression, this digital orthophographic image would require 50 GigaBytes to store. If 2 inch pixels were used, a 500 square mile city would have 9 times as many pixels or 450 GigaPels requiring 450 GigaBytes to store using the same assumptions. Using 2 inch pixels a 50 square mile city would have 45 GigaPels requiring 45 GigaBytes to store using the same compression assumptions. The metric equivalents are 50 millimeter (mm) and 100 mm pixels, which are respectively 400 and 100 to the square meter. For a 1 thousand square kilometer city this would be 100 GigaPels using 100 mm pixels and would require 100 GigaBytes to store. Using 50 mm pixels for a 1 thousand square kilometer city, this would require 400 GigaPels requiring 400 GigaBytes to store. A 100 square Kilometer city, using 50 mm pixels would be imaged in 40 GigaPels, which would require 40 GigaBytes to store.

In digital orthophotography, in addition to color, each pixel has an associated z axis value, the height of the pixel above sea level. When added to the x and y Cartesian coordinates of the pixel, the z values construct a digital terrain model over which the image can be mapped as a surface. This is similar to the way that images are created in virtual reality. By adding a t value, a 4 fourth dimension that represents a specific point in time, animations can be done telling a geologic story or the developmental history of a city.

In remote sensing (satellite imagery such as weather photographs or images for crop quality assessment or storm damage / flooding), a 24 bit color image of an area 1 thousand kilometers by 1 thousand kilometers, using 100 meter pixels (pixels that are 100 meters by 100 meters), would contain 100 million pixels. Estimating a lossless three-to-one compression this would require 100 MegaBytes to store. The pixels used can be of any size. In astronomy, a single pixel can include an entire earth type planet (10 thousand kilometer pixels = 10 Mm, 10 MegaMeter pixel), a sun type star (1 million Kilometer pixels = 1 Gm, 1 Gigameter pixel), or a galaxy (100 thousand light year pixels =~ 1 Zm, 1 Zettameter pixel). The largest practical pixel is a 400 Ym, 400 Yottameter pixel, the diameter of the observable universe.

See also ACSM (American Congress on Surveying and Mapping) [http://www.SurvMap.org] ASPRS (American Society for Photogrammetry and Remote Sensing) [http://www.ASPRS.org] IAU (International Astronomical Union) [http://www.IAU.org]

GIS (Geographic Information System) Data Storage Requirements

GIS data, average, in city, without images: 1 square mile = 50 MegaBytes; 20 sq. miles = 1 GigaByte, 1 square Kilometer = 20 MegaBytes, 50 sq. Kilometers = 1 GigaByte

Digital Orthophoto data, 6 inch pixels, uncompressed monochrome (or losslessly compressed color), 1 square mile = 100 MegaBytes; 10 square miles = 1 GigaByte; Using 100 mm pixels: 1 square meter = 100 Bytes, 1 square Kilometer = 100 MegaBytes, 10 square Kilometers = 1 GigaByte

Digital Orthophoto data, 2 inch pixels, uncompressed monochrome (or losslessly compressed color): 1 square mile = 1 GigaByte; Using 50 mm pixels: 1 square meter = 400 Bytes, 1 square Kilometer = 400 MegaBytes, 2.5 square Kilometers = 1 GigaByte

See also URISA (Urban and Regional Information Systems Association) [http://www.URISA.org]

Case study: the City of Los Angeles GIS database includes a digital orthophoto image, which is a 50 gigapixel 8 bit image with an optical resolution of 316 thousand by 474 thousand pixels, with an irregular border (City boundary plus a buffer). This image uses 6 inch pixels, covers 468 square miles, with 2 foot contour lines, and has a virtual reality pan and zoom (continuous roaming and zooming over a dialup Internet connection, from 1 pixel to 50 billion pixels, and more)) based on progressive Internet transmission of raster and vector image resolution (and map layer and image area) using [http://www.ERMapper.com] The digital orthophoto is an 8 bit image and the maps and drawings are 1 bit images with 8 bit images, the maps and drawings are available on request. Beyond 8-bit images, the ER Mapper software supports 24 and 36 bit per pixel color resolution as well as multispectral imaging. The MapGuide [http://www.AutoDesk.com] display software combines the image with over 250 layers of spatial GIS indices (for over 900 thousand parcels). The GIS uses [http://www.ESRI.com] (Earth Sciences and Resources Institute 'esz-ree') software to use the 250 layers and the digital orthophoto as an index for 850 thousand scanned map and engineering drawing images (these are 75 megapixel images, with an optical resolution of 10 thousand by 7,500 pixels) over the Internet. Examples of layers of GIS information include: Graffiti Zones, Geologic Faults (Earthquake Faults), Hillside Grading (Landslide and Mudslide areas), High Potential Methane, High Wind Areas, Liquifaction / Subsidence, Potential Methane, Fire Brush Clearance, Street Resurfacing, Flood Plains, Storm Pipes (Drains), Storm Drain Inlets, and Truck Routes (High and Heavy Loads). The GIS system and images are on the Internet at [http://NavigateLA.LACity.org/samples/start]. Interactive permitting is at [http://Eng.LACity.org/demos]. Real time interactive disaster mapping and reporting from the field is planned.

Digitized Multimedia Formats

1 hour of compressed color video = 2 GigaBytes (DVD, MPEG 2) (image quality dependent) (On a DVD, 4 GigaBytes ~= One 2 hour feature length movie.)

1 hour of audio = 10 MegaBytes (dictation, answering machine quality) to 500 Mbytes (CD quality audio) (A CD holds 74 minutes of music.)

1 color picture = 10 KiloBytes (thumbnail quality) to 5 MBytes (for each of 100 photos on a 500 MByte PhotoCD, PhotoCD Quality)

The size of a compressed image file depends on the resolution (dpi: dots per inch) and the detail (information) in the photograph. The detail in a photograph is dependent on the size of the negative and the quality of the film and the camera and lens (It is not related to the print size unless the print is smaller than the negative). The resolution of the scan should be chosen to match the detail of the photograph, not the size of the print. For most cameras, films, and formats 35mm and smaller, the 5 MByte Photo CD format (2048 by 3072 pixels) captures all of the information in the image. Note that this is in dots per image rather than dots per inch. Displays are also given in dots per image (Horizontal x Vertical: e.g. 1280 x 1024), with the horizontal dimensional always being given first.

Medical Records

1 Chest X-ray (14 x 17 inches) = 1 MegaByte: 150 dpi (dots per inch), 12 bits (compressed) (Wavelet compression, lossless mode, has FDA 510(k) approval.) (12 bits per pixel provide 4,096 shades of gray.) 150 dpi, 12 bit images are recommended by the American College of Radiology for primary reads. See also ACR (American College of Radiology) [http://www.acr.org] RSNA (Radiological Society of North America) [http://www.RSNA.org] FDA (United States Food and Drug Administration) [http://www.FDA.gov] HIMSS (Health Information Management Systems Society) [http://www.HIMSS.org]

A lossy compression, 14 x 17 Chest X-ray = 200 KiloBytes (For secondary reads: wavelet compression, lossy mode, has FDA 510(k) approval.)

X-rays that are originally recorded digitally rather than on film provide a resolution (image depth) of 16 bits per pixel which records 65,536 shades of gray per pixel. More shades of gray allow doctors to see very fine variations in the health of tissues, increasing the early detection of disease.

Scanned Miscellaneous Documents

1 check (2 sided) (remittance) = 50 KiloBytes per item, 25 KiloBytes (1 sided), less if no patterns are present.

1 credit card receipt (long: 3 1/4 x 7 7/16 inches, 2 sided) (remittance) = 35 KiloBytes, short (3 1/4 x 5 in., 2 sided) = 25 KBytes The long size credit card receipt is the same as an 80 column punch card, which was based on the older 90 column, round hole, punched card, which in 1890 was based on the size of the old US dollar bill (before 1929). US dollar bills are now 6.14 x 2.61 inches (~156 x ~66 mm), before 1929, US dollar bills were 7.4218 x 3.125 inches (~189 x ~79 mm). [~ emphasizes an approximation, rather than a precise measure.]

1 library book (average, scanned in black and white) = 10 MegaBytes; 50 books = 500 MBytes = 1 CD; 100 books = 1 GByte, 400 books = 1 DVD