

## Slide 1 – Title Slide

Hello and welcome to Week 10, part 7 of EGM310: Using digital imagery. In this lesson, we'll cover the basics of digital imagery, including how they're formed by the sensor and how they're represented within a GIS software. This is the final lesson in week 10. After this, you can get started on the second practical – you'll find all of the materials in the Practicals section on blackboard.

## Slide 2 – In the before times...

I've put this slide up because apparently, there are people who are unfamiliar with the old ways of film photography, which can cause confusion when watching TV shows set in different eras. I'm hoping that at the very least, you'll learn from this lesson that digital images are still a relatively new development, and that in the past, cameras recorded images on film, rather than in a digital format.

## Slide 3 – In the before times...

Before there were digital cameras, there were film cameras. Or, as we used to call them back then, "cameras." The basic way that a camera works is that light reflecting off of an object enters the camera's lens, which captures the light and focuses it. The image of the object is recorded on a light-sensitive medium, such as photographic film, when that medium is briefly exposed to light by the opening of a shutter. Photographic film is a plastic or paper that is normally coated with a mixture containing silver halide crystals. When exposed to light, these crystals change color. The short amount of time that the film is exposed – while the shutter is opened – causes a slight reaction in the film. When the film is developed – the confusing process referenced in the previous slide – we have what is called a "negative" image, shown in the image marked D here. That is, the dark areas of the negative image actually correspond to the brightest parts of the image (marked C), and vice-versa. The next step in creating a photograph is to project the negative onto a light-sensitive paper, reversing the process. Bright areas in the photograph then correspond to where there is more light or energy reaching the sensor, while dark areas correspond to where there is less light or energy reaching the sensor. In other words, the brightness of the image is determined by how much light reflects off the object being photographed.

## Slide 4 – Digital detectors

Modern digital detectors work off of the same idea as photographic film. They still measure the intensity of electromagnetic radiation, using something called a charge-coupled device, or CCD; or, a complementary metal-oxide semiconductor, or CMOS. When exposed to electromagnetic radiation, these sensors create an electric charge that is converted to a voltage that is then recorded by the camera. The amount of voltage is proportional to the intensity of the energy, again similar to how photographic film works. These sensors are monochromatic, meaning they only record in a single band or wavelength range of EMR. Thus, if we want to record in multiple bands, we need to somehow filter or split the incoming radiation into its component wavelengths.

## Slide 5 – Digital images

On a computer, digital images are typically stored as arrays, made up of rows (or lines) in the y-direction, and columns (sometimes called pixels) in the x-direction. If we zoom in, we can start to see the individual cells, or pixels, that make up the image. Each of these cells contains a digital number, or DN – this represents the brightness value recorded by the sensor – lower values are represented as darker colors, while higher values are represented as lighter colors. The ground sample distance, sometimes called the pixel resolution, is the amount of ground distance that is covered by each pixel. This is measured in both the column (y) and row (x) direction; for many images, these are the same size (i.e., the pixels are square), but it is not always the case.

## Slide 6 – Colour depth

We've talked a bit about the radiometric resolution of sensors – that is, how many possible values the sensor has to represent a range of brightnesses. This also translates into how values are stored in digital images. For images, we typically used what are called “unsigned integer” values – that is, non-negative integers such as 0, 1, 2, and so on. Similar to radiometric resolution, we refer to an image's color or bit depth – in other words, how many different values we can use in the image. These values are expressed as a power of 2 – so a 1 bit image has 2 to the 1, or 2, possible values. A 2-bit image has 2 to the 2, or 4 possible values, and on down the line. As we have discussed in the first practical, a computer screen will usually have 3 different 8-bit channels, making a 24-bit image, allowing for over 16 million possible color values. In general, the more possible values in an image, the better the radiometric resolution of the sensor. As we go up in bit depth, we also typically have larger file sizes and a correspondingly increased need for storage space.

## Slide 7 – Comparing colour depths

This slide shows the same image, but represented using 8 different bit depths. You may notice that in the bottom row, the images look nearly identical. This has more to do with the way the image is represented on the computer screen than the image itself – if we were to look at the gradient of the image, for example, we would see significantly more variation in the 12 or 16-bit image than in the 8-bit image.

## Slide 8 – Spatial information

In order to use digital images in a GIS software, we need to have some spatial referencing information that is stored with the image. This typically includes the size of the pixels, or ground sample distance; the location of the image, or at least the coordinates of one of the corners of the image, normally the upper left corner; we also need to know the way in which the image is being projected – that is, its spatial reference system. Pixel coordinates can be referenced to either the pixel center or one of the corners; again, this is usually the upper left corner. These different locations are not normally a problem for displaying an image in a GIS, but it can cause problems when you start doing different image manipulations, if the software is not properly accounting for the different locations. Many, but not all,

of the images that you will work with are referenced using a universal transverse Mercator projection, as this preserves angles and shapes over small regions, such as within the bounds of most satellite images.

## **Slide 9 – Summary**

In this lesson, we've learned how the images required by a sensor, whether using the comparatively ancient technology of photographic film or a digital detector, represent the amount of energy that is "seen" by the sensor.

The properties of the image – its dimensions, its bit depth – are determined by the sensor and how the image is stored.

Most of the images we will use are arrays of unsigned, or non-negative, integers.

If we want to use satellite images in a GIS, they need to also be stored with spatial information to help locate and project the image.

## **Slide 10 – Additional Resources**

Once again, you can read more about the concepts we've covered in this lesson in the textbooks, Chapter 7 of Lillesand, Kiefer & Chipman and Chapter 4 of Campbell & Wynne. I've also linked to a few different videos that discuss how cameras work, and that go over the basics of digital images and how they're stored and represented on a computer. That's all for this lesson – I hope you found it interesting, and you have any questions, please don't hesitate to e-mail me or post in the discussion forum on blackboard. Bye!