

## Document: Introduction to Images

### Images in History

An image is a *visual* representation of something that is either real or imagined. **Visual** means it is perceived by the light that enters the eyes. Computer science is largely about information, and an image conveys information. While images are typically two-dimensional, certain technologies, such as holograms and stereoscopic images, can create the perception of three-dimensionality.

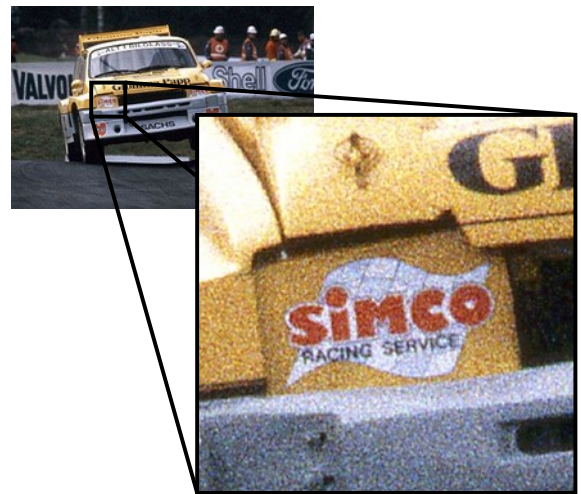


Images have a long history in human society. Some known cave paintings are estimated to be tens of thousands of years old. This image of a pig was found on a cave wall in Leang Tedongnge, Sulawesi, Indonesia, and is estimated to be at least 45,500 years old.

### Analog Film Images

In traditional analog film photography, the clarity of an image was determined by the chemical composition of the film. The size and distribution of silver halide crystals within the emulsion dictated the film's sensitivity to light (ISO rating) and the prominence of "grain" in the final image. Films with higher ISO ratings are more sensitive to light, contain larger silver crystals, and typically exhibit more noticeable grain.

The image to the right is from a film photograph. The limitations in image quality, resulting from the graininess of the silver halide crystals, are evident in the zoomed-in section of the image.



### Picture Elements

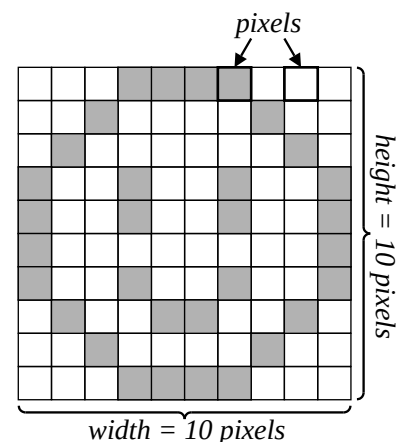
Digital images are composed of a grid of tiny units called **pixels**. It is not important for you to remember this, but "pictures" is sometimes shortened to "pics" or "pix", and "pixel" is short for "picture element".

Just as the size and density of grains in an analog image limits the clarity of an analog image, the size and density of pixels limits the clarity of a digital image.

### Resolution

The **resolution** of a digital image is the total number of pixels. The resolution is usually expressed as  $width \times height$  rather than just the total number.

The image to the right has a width of 10 pixels and a height of 10 pixels. We would typically say the resolution of this image is 10x10 pixels.



**Document: Introduction to Images****Aspect Ratio**

The **aspect ratio** of an image is a proportional relationship between the width and the height, and is usually expressed as two numbers separated by a colon. The aspect ratio of older analog televisions and early computer monitors was 4:3, while movie theaters were commonly 1.85:1, or sometimes the very wide 2.39:1. Modern flat panel HDTV televisions are 16:9 – just slightly narrower than the aspect ratio of typical movie theatres. The diagram below provides a comparison of these aspect ratios, maintaining a constant height between them and varying the width.



For discussion, consider how one might display a movie filmed for a widescreen movie theatre on a screen with a ratio of 4:3. Below the picture on the left has a ratio of 16:9 and shows where a cut to 4:3 might be, and the picture on the right has a ratio of 4:3 and shows where a 16:9 cut might be made.



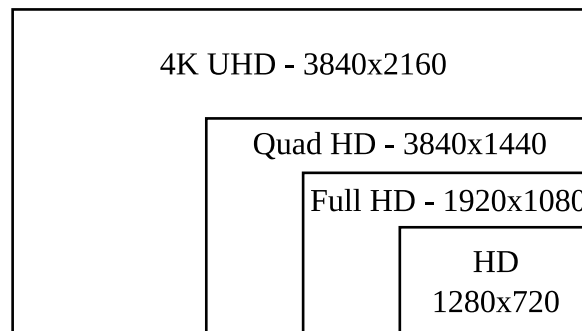
For further research, you may look up the *pan-and-scan* and *letterbox* techniques.

**Document: Introduction to Images****Resolution of Displays**

The NTSC (National Television System Committee) standard for analog television was established in 1941, and color was added to the standard about ten years later. There was little change to television in North America for the following fifty years! In the years 2001-2007, High Definition Television (HDTV) broadcasts and flat panel displays rapidly replaced the older system.

Although the NTSC format was not digital, the image quality was approximately equivalent to a digital image with a resolution of approximately 640x480 pixels. The first HDTVs standards included a resolution of 1280x720 for the 720p format, and a resolution of 1920x1080 for the 1080i and 1080p formats. The most recent television standards, 4K UHD has a resolution of 3840x2160 and 8K UHD has a resolution of 7680x4320. You can verify for yourself that each of the HDTV standards have an aspect ratio of 16:9.

The diagram below shows the relative screen sizes if pixel size is held constant. Quad HD has four times the number of pixels that 720p has, while 4K UHD has four times the number of pixels that Full HD has. 8K UHD again has four times the number of pixels that 4K UHD has. Four times the number of pixels means four times the amount of data for each image. Transmitting an 8K UHD image requires a significant amount of bandwidth, so requires good hardware and high quality cables.



Recall that movie theaters displays have a slightly different aspect ratio, so their standard resolutions are slightly different. As well computer displays and smart phones sometimes have different aspect ratios, so there again there are a number of different resolutions. Ultra-wide computer monitors have an aspect ratio of 21:9 (resolutions include 3440x1440), and super ultra-wide have an aspect ratio of 32:9 – the same pixel width as two HDTV resolution screens.