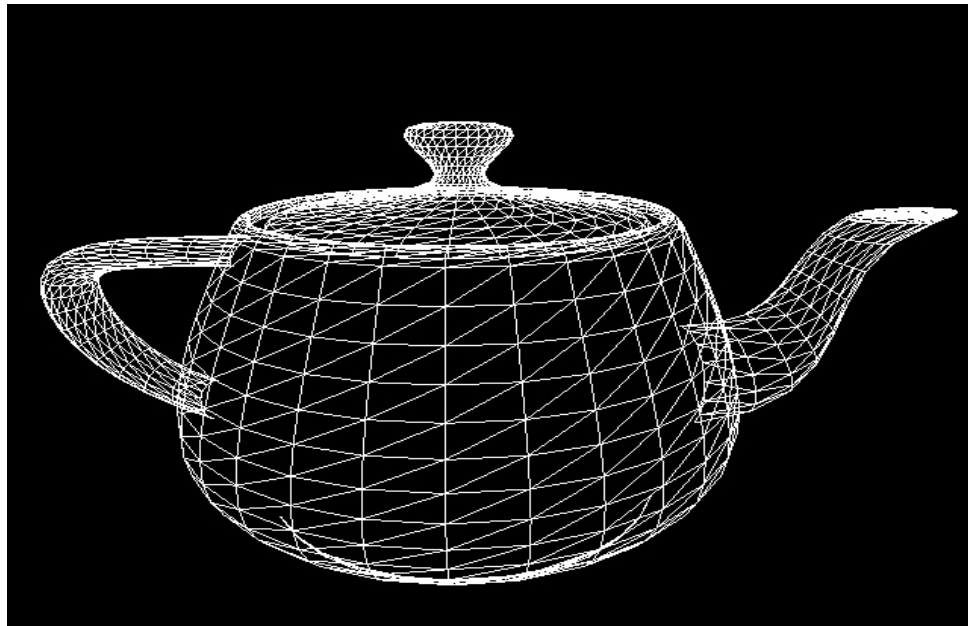


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## Introduction to Computer Graphics

Computer graphics uses hardware and software to create realistic images and animations, and ways for users to interact with them. This involves methods that users employ to create and enter 2D or 3D representations of objects to be imaged and, possibly, animated.



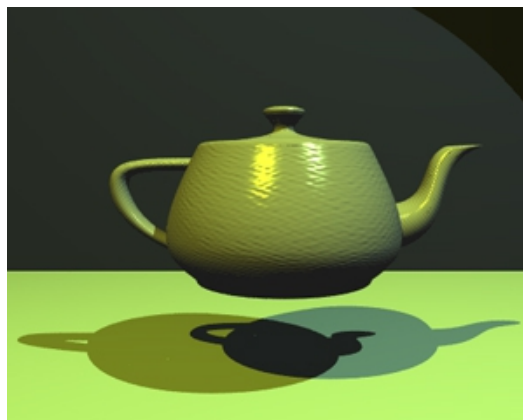
*Illustration 1: A wire-mesh model of a once famous teapot*



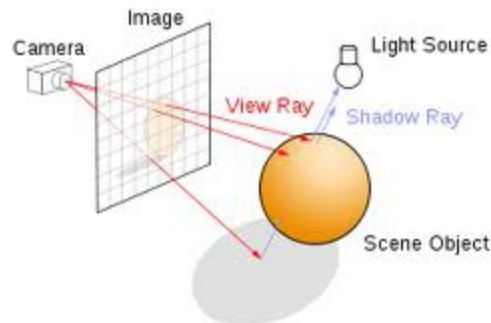
*Illustration 2: A mirror-like rendering of the teapot*

## Representing Objects

Illustration 1 shows a triangulation of 3D points that create a teapot. Various methods exist to define such objects in ways that can be entered in a computer and then realistically rendered on a display. For instance, real objects can be scanned with range finders to obtain surface points in 3D that can be later attached to form a sets of small planar triangles. Alternatively, mathematical methods may be used to define objects amenable to this type of modeling. Once an object is in a suitable representation, algorithms can be used to provide a vantage point for the user, a set of transformations (such as a rotation, a translation, a scaling, and a shearing), a rendering technique, and possibly an animation sequence for the object.



*Illustration 3: A rendering of the teapot with two light sources*



*Illustration 4: The principles behind ray tracing techniques*

Computer graphics techniques allow users to create computer animations (movies) and virtual reality environments, to visualize scientific data, to create graphical user interfaces, and so on. To create realistic renderings, we need to learn the physics of light reflection and refraction, including color theory and shading. In addition, projective transformations must be mastered in order to render 3D scenes and objects onto a 2D computer display.

## Rendering Images

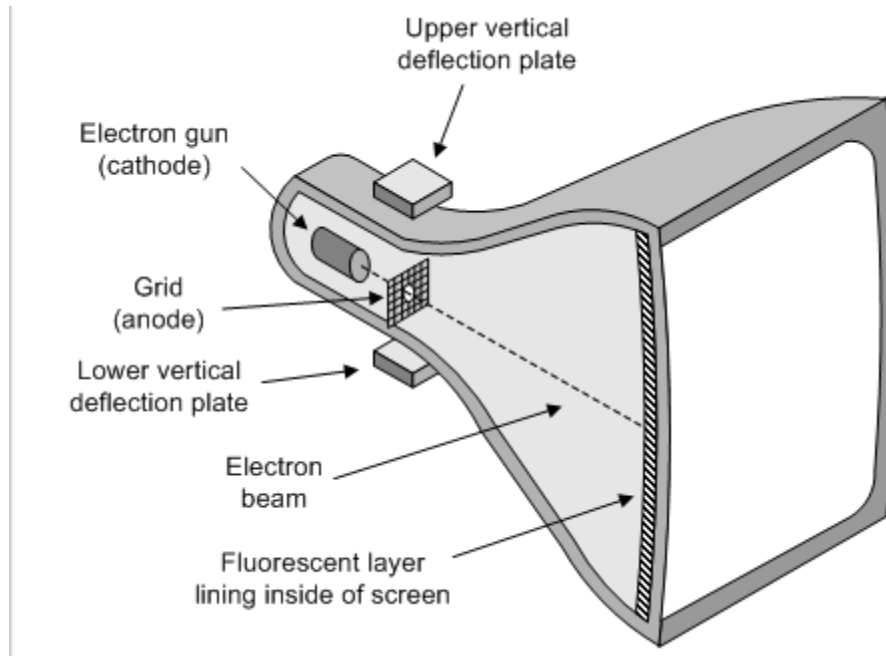
Objects can be represented as collections of planar polygons (the teapot in Illustration 1 uses triangles) and rendering techniques (such as ray tracing) can be used to make objects appear smooth (as in Illustrations 2 and 3). Ray tracing encompasses a set of very powerful algorithms for rendering images in a very realistic manner. Illustration 4 shows the basic principles while Illustration 5 shows a beautifully realistic rendering of a scene.

There exists a version of the Turing test for computer graphics: Can a human tell the difference between a computer generated image and a real one? As you can probably conclude, for a lot of scenes, we are not there yet. However, immense progress has been made and it is logical to think that in the near future we will not be able to tell which is which.

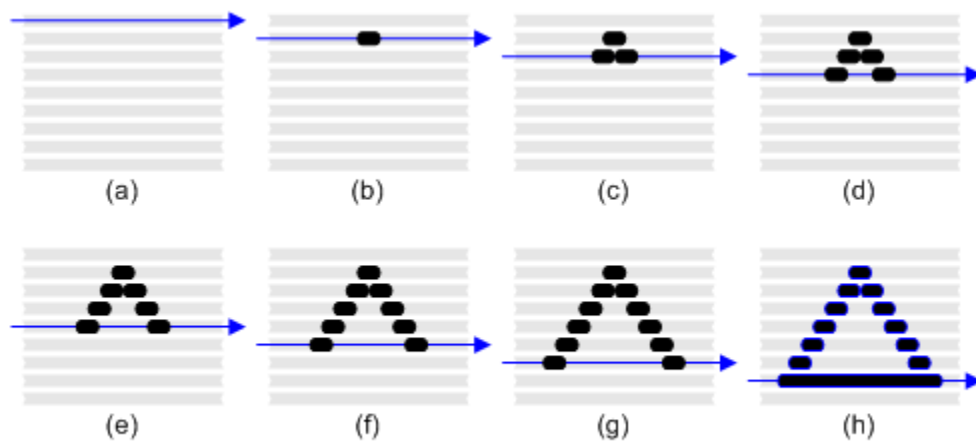


*Illustration 5: An example of realistic ray-tracing*

## CRT Raster Displays

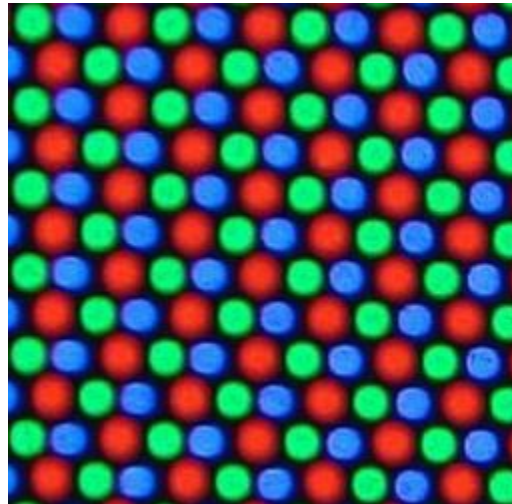
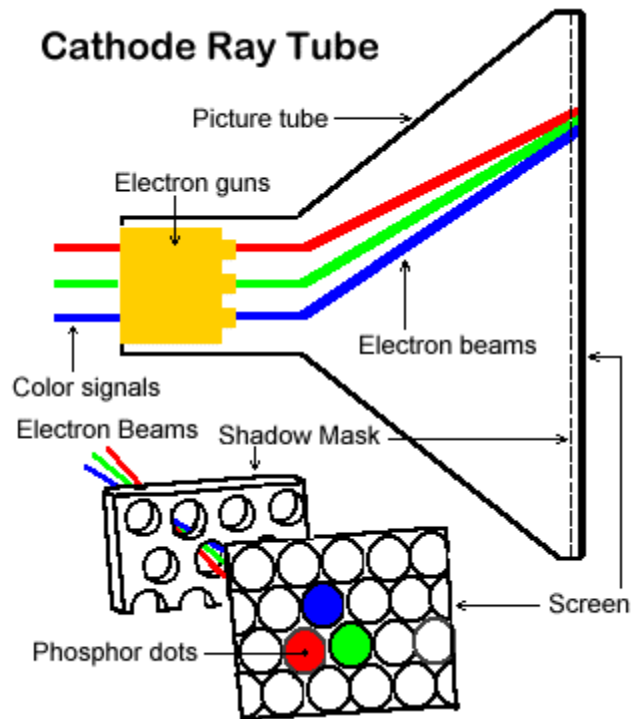


Raster means rake in Latin. The term was coined quite a while ago. Nowadays, the technology is quite different and does not use an electron gun.



**Constructing an image of a triangle on a cathode ray tube**

Still, pixels need to be addressed in a way that a user (or program) can set color and intensity. Color is achieved by interleaving red, green, and blue phosphors.



## LCD Raster Displays

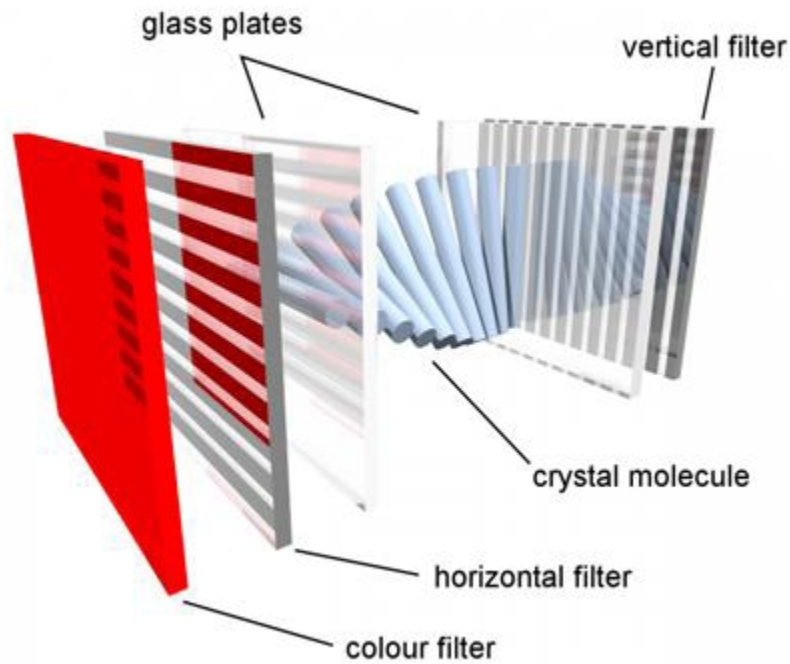
For LCD displays, the same fundamental technique is used, except from the way in which

pixels emit light (no need for an electron beam anymore).

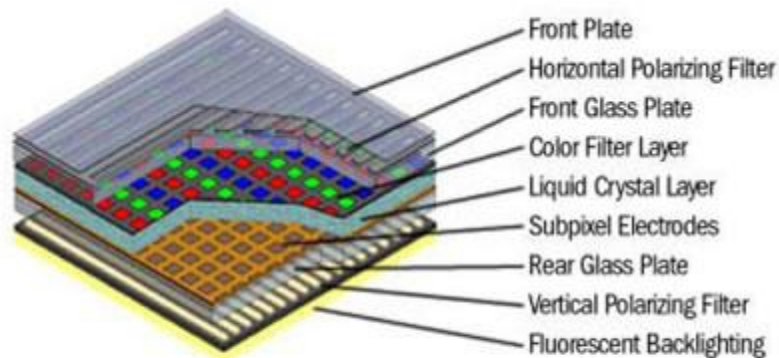


*Illustration 6: Flat screens are possible because there is LCD technology*

Crystal rapidly aligns with polarized light to match filter:



*Illustration 7: LCD filters and crystal molecules*

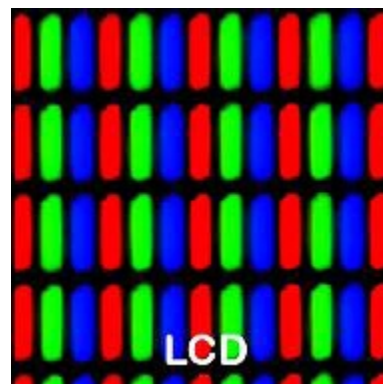
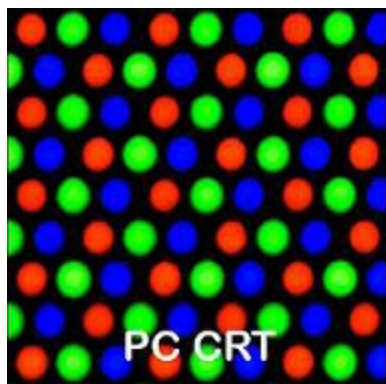


**The multi-layered structure of an active-matrix LCD panel.**

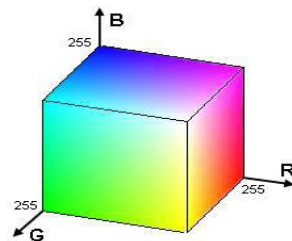
Because they use red, green and blue color filters in place of phosphor dots, LCD panels are completely immune to image burn-in.

## Raster Images Inside Computers

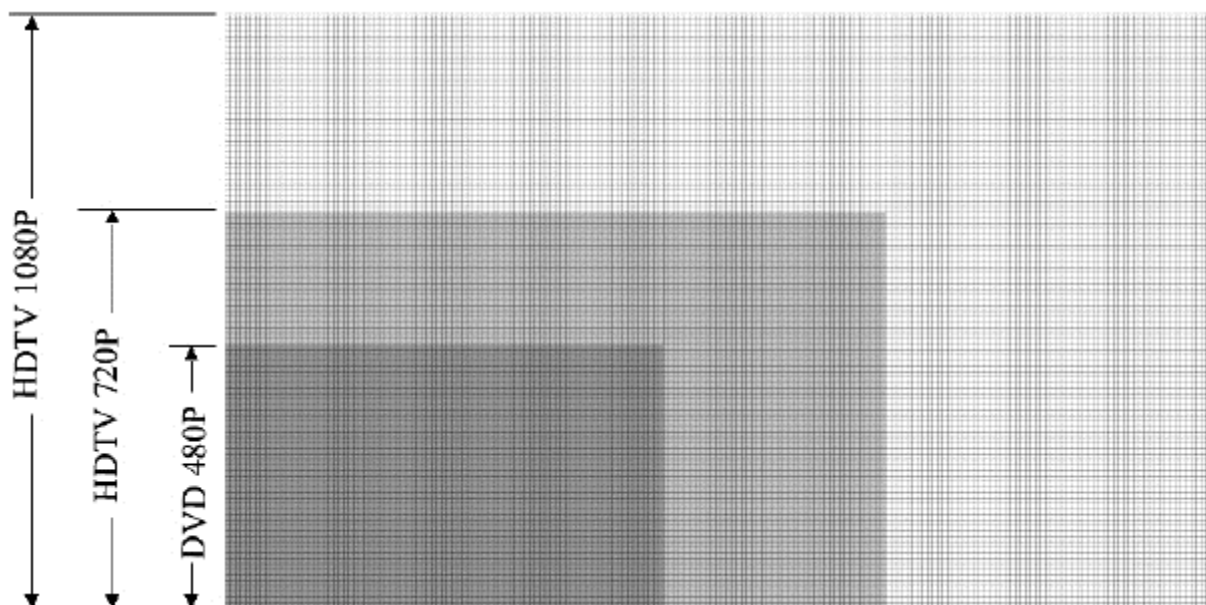
There are 3 channels per pixel (R,G,B), in order to represent color. A pixel is a picture element that, as a whole, displays a perceivable color.



A pixel can be defined as an intensity triplet (R,G,B) where each value is between 0 and 1. In order to save memory space, the intensity values are mapped to 0..255 (where each can reside in a byte, rather than a float).



The memory bandwidth required for raster displays can be easily computed:



1920 (width in pixels) times 1080 (height in pixels) times 24 (bits per pixel) times 60 Hz. This is about 2.8 Gbit per second.