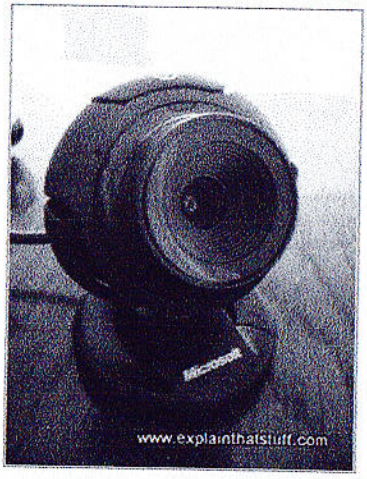
Annexure-1



Webcams

by Chris Woodford. *Last updated: January 14, 2022.*

Ever wanted to run your own TV station? A **webcam** lets you do just that. With one of these tiny, bug-eyed cameras hooked up to your computer, you can broadcast pictures of yourself or your home to the entire world! A webcam is a bit like a digital camera and works much the same way. But unlike a digital camera, it's designed to make relatively compact digital photos that are easy to upload onto Web pages or send across the Internet. It all sounds simple enough, but how do webcams actually work? Let's take a closer look!

Photo: This Microsoft LifeCam VX-1000 webcam can stand on a table or clip to the screen of a laptop. It has a built-in microphone and a long USB cable carries both picture and sound to your computer. Some laptops and netbooks have built-in webcams. That sounds like a good idea in theory but, again, it limits you to showing pictures of what is directly in front of the computer. Other popular cams are made by Logitech, Creative, Hue, and TeckNet.

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How does a webcam work?

A webcam is a compact digital camera you can hook up to your computer to broadcast video images in real time (as they happen). Just like a digital camera, it captures light through a small lens at the front using a tiny grid of microscopic light-detectors built into an image-sensing microchip (either a **charge-coupled device (CCD)** or, more likely these days, a **CMOS image sensor**). As we'll see in a moment, the image sensor and its circuitry converts the picture in front of the camera into digital format—a string of zeros and ones that a computer knows how to handle.

Photo: Unlike the webcam above, which you can focus by twisting its lens, this Microsoft LifeCam VX-800 has a preset focus. If you look closely, you can just see the power indicator light (top left, not currently lit up) and the microphone (top right). The stand can simply rest on a table or open up to clip on top of your laptop.

Unlike a digital camera, a webcam has no built-in memory chip or flash memory card: it doesn't need to "remember"

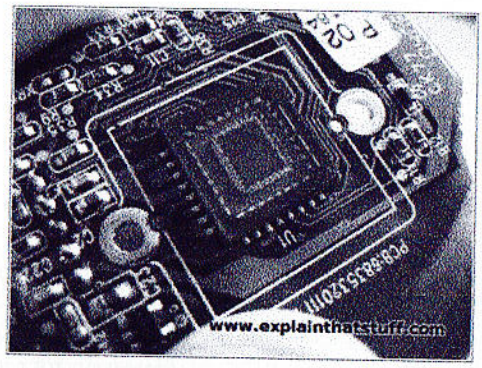
pictures because it's designed to capture and transmit them immediately to a computer. That's why webcams have USB cables coming out of the back. The USB cable supplies power to the webcam from the computer and takes the digital information captured by the webcam's image sensor back to the computer—from where it travels on to the Internet. Some cams work wirelessly and don't need to be connected to a computer: typically they use Wi-Fi to transmit their pictures to your Internet router, which can then make them available to other machines on your home network or, using the Internet, to anyone, anywhere in the world.

How does an image sensor chip work?

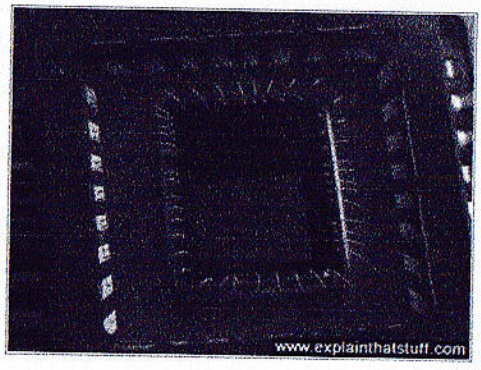
All webcams work in broadly the same way: they use an image sensor chip to catch moving images and convert them into streams of digits that are uploaded over the Internet. The image sensor chip is the heart of a webcam—so how does that bit work? Let's take a webcam apart and find out.

Take the outer case off a webcam and you'll find it's little more than a plastic lens mounted directly onto a tiny electronic circuit board underneath. The lens screws in and out to increase its focal length, controlling the focus of your cam:

Now take the lens off and you can see the image sensor (CCD or CMOS chip): it's the square thing in the middle of this circuit. Only the tiny, green-colored central part is light-sensitive: the rest of the chip is concerned with connecting the light detector to the bigger circuit that surrounds it:



Here's a closeup:



Webcams versus digital cameras

So the image sensor is the "electronic eye" of a webcam or a digital camera. It's a semiconductor chip made of millions of tiny, light-sensitive squares arranged in a grid pattern. These squares are called **pixels**. Basic webcams use relatively small sensors with just a few hundred thousand pixels (typically a grid of 640 × 480. Good digital cameras use sensors with many more pixels; that's why cameras are compared by how many **megapixels** (millions of pixels) they have. A basic webcam has about 0.3 megapixels (300,000, in other words), while a digital camera with 6 megapixels has over 20 times more—probably arranged in a rectangle with three thousand across and two thousand down (3000 x 2000 = 6 million). A better camera rated at 12 megapixels would have a 4000 x 3000 pixel sensor. Take a photo the same size with those two cameras and the 12 megapixel one is going to give you 1000 more dots horizontally and 1000 more vertically—smaller dots giving more detail and **higher resolution**. A single pixel in a really good sensor is something like 10 micrometers (10µm) in diameter (5–10 times smaller than the diameter of a typical human hair)!

How does an image sensor convert a picture into digital form?

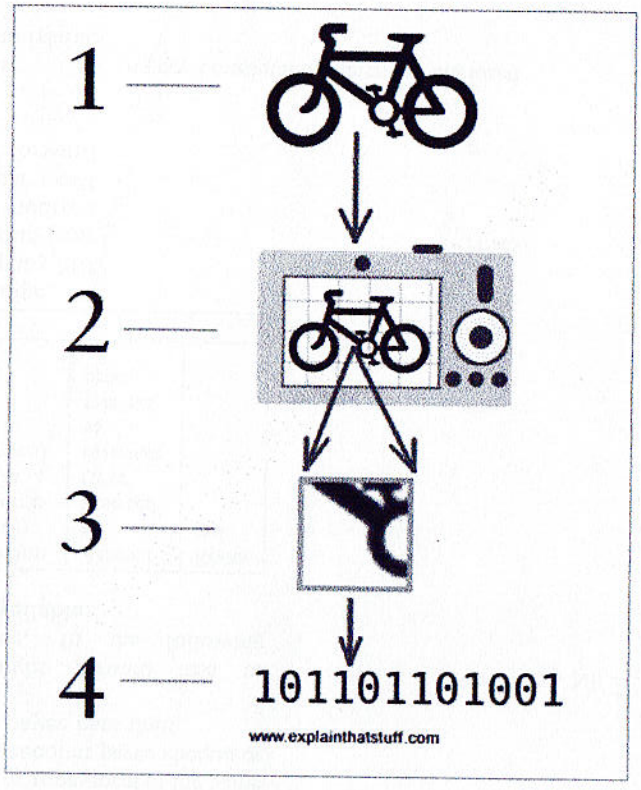
When you take a digital photo or stare into your webcam, light zooms into the lens. This incoming "picture" hits the image sensor, which breaks it up into individual pixels that are converted into numeric form.

CCDs and CMOS chips, the two kinds of image sensor, do this job in slightly different ways. Both initially convert incoming light rays into electricity, much like photoelectric cells (used in things like "magic eye" intruder alarms or restroom washbasins that switch on automatically when you put your hands under the faucet). But a CCD is essentially an *analog* optical chip that converts light into varying

electrical signals, which are then passed on to one or more other chips where they're digitized (turned into numbers). By contrast, a CMOS chip does everything in one place: it captures light rays and turns them into digital signals all on the one chip. So it's essentially a *digital* device where a CCD is an analog one. CMOS chips work faster and are cheaper to make in high volume than CCDs, so they're now used in most low-cost cellphone cameras and webcams. But CCDs are still widely used in some applications, such as low-light astronomy.

Whether images are being generated by a CMOS sensor or a CCD and other circuitry, the basic process is the same: an incoming image is converted into an outgoing pattern of digital pixels. Let's just refer to "the image sensor" from now on (and forget about whether it's a CCD and other chips or a CMOS sensor). First, the image sensor measures how much light is arriving at each pixel. This information is turned into a number that can be stored on a memory chip inside the camera. Thus, taking a digital photograph converts the picture you see into a very long string of numbers. Each number describes one pixel in the image—how bright or dark and what color it is.

Step by step



1. Light from the object (in this case, a bicycle) enters the camera lens.
2. The image sensor inside the camera splits the image up into millions of pixels (squares). An LCD display on the back of the camera shows you the image that the sensor is capturing—not an image of the object seen through a series of lenses (as with a conventional camera), but a redrawn, computerized version of the original object displayed on a screen.
3. The sensor measures the color and brightness of each pixel.
4. The color and brightness are stored as binary numbers (patterns of zeros and ones) in the camera's memory card. When you connect your camera to a computer, these numbers are transmitted instantly down the wire.