

# Digital microscope

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A **digital microscope** is a variation of a traditional optical microscope that uses optics and a charge-coupled device (CCD) camera to output a digital image to a monitor. A digital microscope differs from an optical microscope in that there is no provision to observe the sample directly through an eyepiece. Since the optical image is projected directly on the CCD camera, the entire system is designed for the monitor image. The optics for the human eye are omitted.

## History

An early digital microscope was made by a lens company in Tokyo, Japan in 1986, which is now known as Hirox Co Ltd. It included a control box and a lens connected to a computer. Other versions of digital microscope were later developed by Keyence Corp and Leica Microsystems. Invention of the USB port resulted in a multitude of usb digital microscopes ranging in quality and magnification. They continue to fall in price, especially compared with conventional optical microscopes.



miniature digital microscope

## Optical and digital microscopes

A primary difference between an optical microscope and a digital microscope is the magnification. With an optical microscope the magnification is found by multiplying the lens magnification by the eyepiece magnification. Since the digital microscope does not have an eyepiece, the magnification cannot be found using this method. Instead the magnification for a digital microscope is found by how many times larger the sample is reproduced on the monitor. Therefore the magnification will depend on the size of the monitor. The average digital microscope system has a 15" monitor, would result in a average difference in magnification between an optical microscope and a digital microscope of about 60%. Thus the magnification number of an optical microscope is usually 60% larger than the magnification number of an digital microscope.

Since the digital microscope has the image projected directly on to the CCD camera, it is possible to have higher quality recorded images than with an optical microscope. With the optical microscope, the lenses are made for the optics of the eye. Attaching a CCD camera to an optical microscope will result in a image that has compromises made for the eyepiece. Although the monitor image and recorded image may be of higher quality compared with the digital microscope, the application for the microscope may dictate which microscope is preferred.

## Resolution

With a typical 2 megapixel CCD, a 1600×1200 pixels image is generated. The resolution of the image depends on the field of view of the lens used with the camera. The approximate pixel resolution can be determined by dividing the horizontal field of view (FOV) by 1600.

Increased resolution can be accomplished by creating a sub-pixel image. The Pixel Shift Method uses an actuator to physically move the CCD in order to take multiple overlapping images. By combining the images within the microscope, sub-pixel resolution can be generated. This method provides sub-pixel information, simply averaging a standard image is also a proven method to provide sub-pixel information.

## 2D Measurement

Most of the high end digital microscope systems have the ability to measure samples in 2D. The measurements are done onscreen by measuring the distance from pixel to pixel. This allows for length, width, diagonal, and circle measurements as well as much more. Some systems are even capable of counting particles.

## 3D Measurement

3D measurement is achieved with a digital microscope by image stacking. Using a step motor, the system takes images from the lowest focal plane in the field of view to the highest focal plane. Then it reconstructs these images into a 3D model based on contrast to give a 3D color image of the sample. From these 3D model measurements can be made, but their accuracy is based on the step motor and depth of field of the lens.

## Limitations

Few USB models are supplied with stands capable of supporting the camera in a stable way, so it can be racked up and down, for example, but this is only true with USB microscopes. The higher end digital microscopes, that do not connect by USB, do not suffer this limitation.

## See also

- Microscope
- High dynamic range
- Optical microscope

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