An **optical**[**computer mouse**](https://en.wikipedia.org/wiki/Mouse_(computing)) uses a light source, typically an [LED](https://en.wikipedia.org/wiki/LED), and a light detector, such as an array of [photodiodes](https://en.wikipedia.org/wiki/Photodiode), to detect movement relative to a surface. It is an alternative to the [mechanical mouse](https://en.wikipedia.org/wiki/Mechanical_mouse), which uses moving parts to sense motion.

The earliest optical mice detected movement on pre-printed mouse pad surfaces. Whereas modern optical mice work on most opaque [diffusely reflective](https://en.wikipedia.org/wiki/Diffuse_reflection) surfaces like paper, they usually aren't able to detect movement on [specularly reflective](https://en.wikipedia.org/wiki/Specular_reflection" \o "Specular reflection) surfaces like polished stone; laser mice can function even on such glossy surfaces, but perform poorly on transparent surfaces; [dark field illumination](https://en.wikipedia.org/wiki/Dark_field_microscopy) allows mice to function reliably even on glass. Laser diodes are also used for better resolution and precision.

Mechanical mice

Though not commonly referred to as optical mice, nearly all mechanical mice tracked movement using LEDs and [photodiodes](https://en.wikipedia.org/wiki/Photodiode) to detect when beams of infrared light did and didn't pass through holes in an [incremental rotary encoder wheel](https://en.wikipedia.org/wiki/Rotary_encoder#Incremental_rotary_encoder). Thus the primary distinction of “optical mice” is not their use of optics, but their complete lack of moving parts to track mouse movement, in lieu of an entirely solid-state system.

Early optical mice

An early Xerox optical mouse chip, before the development of the inverted packaging design of Williams and Cherry

Early optical mice, first demonstrated by two independent inventors in 1980, came in two different varieties: Some, such as those invented by [Steve Kirsch](https://en.wikipedia.org/wiki/Steve_Kirsch) of [MIT](https://en.wikipedia.org/wiki/MIT) and [Mouse Systems Corporation](https://en.wikipedia.org/wiki/Mouse_Systems_Corporation), used an infrared LED and a four-quadrant infrared sensor to detect grid lines printed with infrared absorbing ink on a special metallic surface. Predictive [algorithms](https://en.wikipedia.org/wiki/Algorithm) in the [CPU](https://en.wikipedia.org/wiki/CPU) of the mouse calculated the speed and direction over the grid.

Others, invented by [Richard F. Lyon](https://en.wikipedia.org/wiki/Richard_Francis_Lyon) of Xerox, used a 16-pixel visible-light image sensor with integrated motion detection on the same chip and tracked the motion of light dots in a dark field of a printed paper or similar mouse pad. The optical mouse ultimately sold with the Xerox STAR office computer used an inverted sensor chip packaging approach patented by Lisa M. Williams and Robert S. Cherry of the Xerox Microelectronics Center.

The Kirsch and Lyon mouse types had very different behaviors, as the Kirsch mouse used an x-y coordinate system embedded in the pad, and would not work correctly when the pad was rotated, while the Lyon mouse used the x-y coordinate system of the mouse body, as mechanical mice do.

Modern optical mice

The first modern optical computer mice were the [Microsoft IntelliMouse](https://en.wikipedia.org/wiki/Microsoft_IntelliMouse) with IntelliEye and IntelliMouse Explorer, introduced in 1999 using technology developed by Hewlett-Packard. It worked on almost any surface, and presented a welcome improvement over mechanical mice. Other manufacturers soon followed Microsoft’s lead using components manufactured by the HP spin-off [Agilent Technologies](https://en.wikipedia.org/wiki/Agilent_Technologies), and over the next several years mechanical mice became obsolete.

The technology underlying the modern optical computer mouse is known as [digital image correlation](https://en.wikipedia.org/wiki/Digital_image_correlation), a technology pioneered by the defense industry for tracking military targets. A simple binary-image version of digital image correlation was used in the 1980 Lyon optical mouse. Optical mice use image sensors to image naturally occurring texture in materials such as wood, cloth and mouse pads.. Images of these surfaces are captured in continuous succession and compared with each other to determine how far the mouse has moved.

To understand how optical mice work, imagine two photographs of the same object except slightly offset from each other. Place both photographs on a [light table](https://en.wikipedia.org/wiki/Light_table) to make them transparent, and slide one across the other until their images line up. The amount that the edges of one photograph overhang the other represents the offset between the images, and in the case of an optical computer mouse the distance it has moved.

Optical mice capture one thousand successive images or more per second. Depending on how fast the mouse is moving, each image will be offset from the previous one by a fraction of a pixel or as many as several pixels. Optical mice mathematically process these images using cross correlation to calculate how much each successive image is offset from the previous one.

An optical mouse might use an image sensor having an 18 × 18 pixel array of monochromatic pixels. Its sensor would normally share the same [ASIC](https://en.wikipedia.org/wiki/Application-specific_integrated_circuit) as that used for storing and processing the images. One refinement would be accelerating the correlation process by using information from previous motions, and another refinement would be preventing deadbands when moving slowly by adding interpolation or frame-skipping.

The development of the modern optical mouse at HP was supported by a succession of related projects during the 1990s at its central research laboratory. In 1992 William Holland was awarded US Patent 5,089,712 and John Ertel, William Holland, Kent Vincent, Rueiming Jamp, and Richard Baldwin were awarded US Patent 5,149,980 for measuring paper advance in a printer by correlating images of paper fibers. In 1998 Travis N. Blalock, Richard A. Baumgartner, Thomas Hornak, Mark T. Smith, and Barclay J. Tullis were awarded US Patent 5,729,008 for tracking motion in a hand-held scanner by correlating images of paper fibers and document features, a technology commercialized in 1998 with the HP 920 Capshare handheld scanner. In 2002 Geoffrey Lee was awarded US Patent 6,392,632 titled "Optical mouse having an integrated camera." In 2002, Gary Gordon, Derek Knee, Rajeev Badyal and Jason Hartlove were awarded US Patent 6,433,780 for an optical computer mouse using image correlation.

LED mice

The blue-LED-based V-Mouse VM-101

Optical mice often used [light-emitting diodes](https://en.wikipedia.org/wiki/Light-emitting_diode) (LEDs) for illumination when first popularized. The color of the optical mouse's LEDs can vary, but red is most common, as red diodes are inexpensive and silicon photodetectors are very sensitive to red light. Other colors are sometimes used, such as the blue LED of the V-Mouse VM-101.

Laser mice

Although invisible to the naked eye, the light produced by this laser mouse is captured as the color purple because CCDs are sensitive to a broader light wavelength range than the human eye.

The laser mouse uses an [infrared](https://en.wikipedia.org/wiki/Infrared) [laser diode](https://en.wikipedia.org/wiki/Laser_diode) instead of an LED to illuminate the surface beneath their sensor. As early as 1998, [Sun Microsystems](https://en.wikipedia.org/wiki/Sun_Microsystems) provided a laser mouse with their Sun SPARCstation servers and workstations. However, laser mice did not enter the mainstream market until 2004, when Paul Machin at [Logitech](https://en.wikipedia.org/wiki/Logitech), in partnership with [Avago Technologies](https://en.wikipedia.org/wiki/Avago_Technologies" \o "Avago Technologies) (formerly part of [Agilent Technologies](https://en.wikipedia.org/wiki/Agilent_Technologies)), introduced its *MX 1000* laser mouse. This mouse uses a small infrared laser instead of an LED and has significantly increased the [resolution](https://en.wikipedia.org/wiki/Image_resolution) of the image taken by the mouse. The laser illumination enables superior surface tracking compared to LED-illuminated optical mice.

*Glass laser* mice have the same capability of a laser mouse but can also be used on top of mirror or transparent glass far better. In 2008, Avago introduced laser navigation sensors whose [emitter](https://en.wikipedia.org/wiki/Laser_diode) was integrated into the IC using [VCSEL](https://en.wikipedia.org/wiki/Vertical-cavity_surface-emitting_laser) technology.

In August 2009, Logitech introduced mice with two lasers, to track on glass and glossy surfaces better; they dubbed them "[Darkfield](https://en.wikipedia.org/wiki/Dark_field_microscopy" \o "Dark field microscopy)" laser sensor.[[17]](https://en.wikipedia.org/wiki/Optical_mouse#cite_note-17)

Power

Manufacturers often engineer their optical mice especially battery-powered wireless models—to save power when possible. To do this, the mouse dims or blinks the laser or LED when in standby mode (each mouse has a different standby time). A typical implementation has four power states, where the sensor is pulsed at different rates per second:

* 11500: full on, for accurate response while moving, illumination appears bright.
* 1100: fallback active condition while not moving, illumination appears dull.
* 110: standby
* 12: sleep state

Movement can be detected in any of these states; some mice turn the sensor fully off in the sleep state, requiring a button click to wake.[[18]](https://en.wikipedia.org/wiki/Optical_mouse#cite_note-18)

Optical mice utilizing infrared elements (LEDs or lasers) offer substantial increases in battery life over visible spectrum illumination. Some mice, such as the Logitech V450 848 nm laser mouse, are capable of functioning on two AA batteries for a full year, due to the low power requirements of the infrared laser.

Mice designed for use where low latency and high responsiveness are important, such as in playing [video games](https://en.wikipedia.org/wiki/Video_game), may omit power-saving features and require a wired connection to improve performance. Examples of mice which sacrifice power-saving in favor of performance are the [Logitech G5](https://en.wikipedia.org/wiki/Logitech_G5) and the [Razer](https://en.wikipedia.org/wiki/Razer_USA_Ltd" \o "Razer USA Ltd) Copperhead.