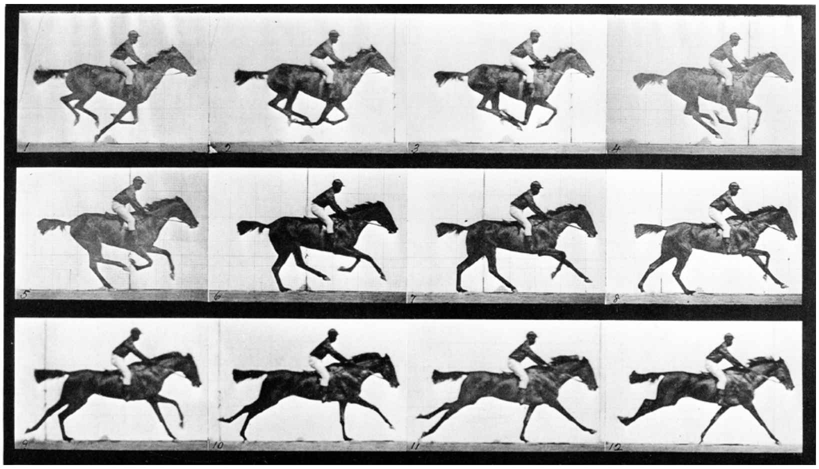
Early Ultrafast Photography

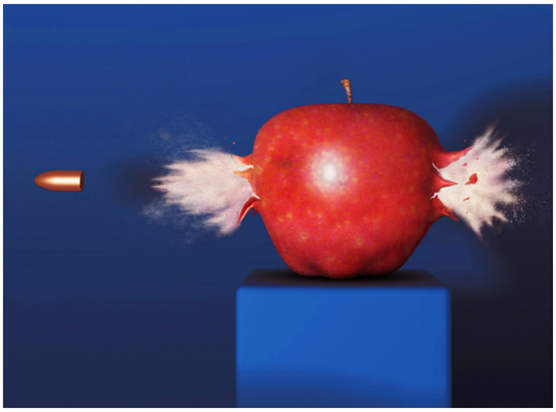
Since the dawn of the medium, photographers have been fascinated by the possibilities of capturing rapid motion in one frozen frame.



Eadweard Muybridge/Library of Congress

1878: Off to the races

Photography was a relatively new phenomenon in the 1870s, and multisecond shutter speeds were the norm—until Eadweard Muybridge developed an innovative stop-action photography technique. By arranging 12 cameras along a race track with trip wires, Muybridge took 12 photos in rapid succession—one twenty-fifth of a second apart, with the shutter speeds less than 1/2000 s. The shots revealed that a horse is completely airborne for a brief moment while galloping.



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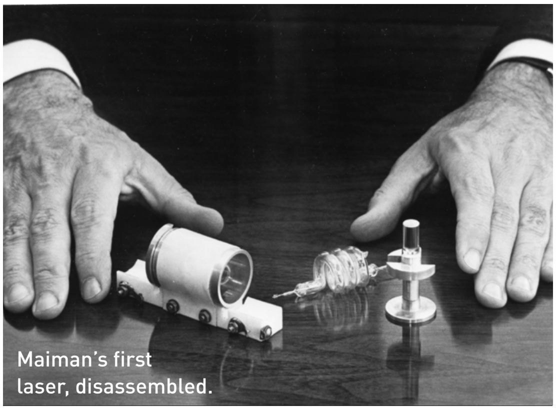
1931: Stroboscopic photography

MIT electrical engineering professor Harold Edgerton took the stroboscope—which produces short repetitive flashes of light—from the lab and combined the technology with the camera, laying the groundwork for the modern electric flash. The high-speed bursts of light from electrically controlled neon tubes allowed him to capture fast-event photography, such as a bullet piercing an apple, and to overcome the mechanical restrictions of the camera shutter.



Maiman's first laser, disassembled.

Corning Inc., courtesy of AIP Emilio Segrè Visual Archives, Hecht Collection

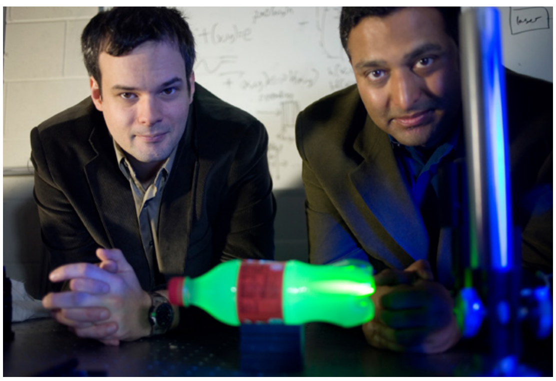
1962: Faster with the streak camera

Streak photography is another form of older high-speed photography, one that employs slits instead of a camera shutter. Early mechanical versions used rotating mirror systems to take high-speed images of ultrafast processes, such as for ballistics. Photoelectric streak cameras can act as time-resolved detectors for measuring ultrafast light phenomena, such as the streak camera used to study the coherent radiation from a ruby laser in 1962—the same type of laser that Theodore Maiman demonstrated for the first time just two years earlier.

now

Capturing Light in Slow Motion

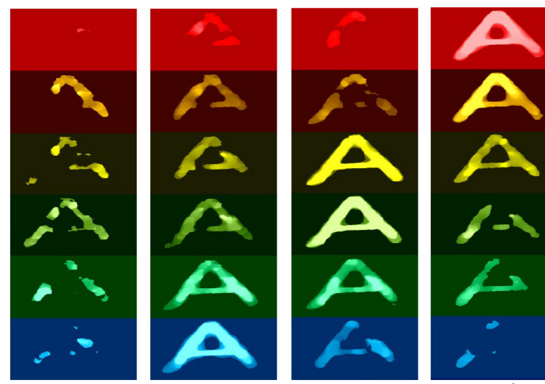
As lasers and electron sources explore shorter and shorter timescales, optical imaging continues to develop to characterize ultrafast events, often in a single shot.



A. Velten and R. Raskar, MIT/Photo by M. Scott Brauer

2018: Folding time

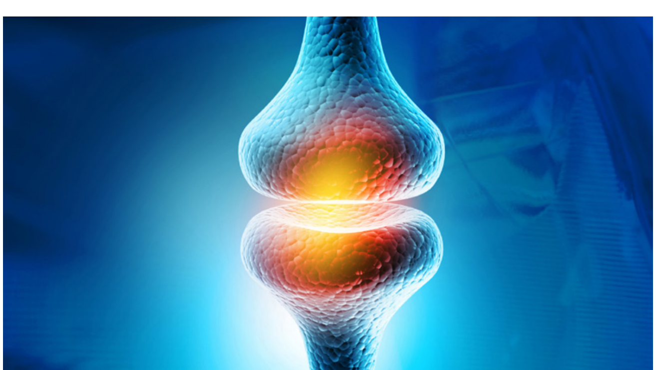
Researchers in the U.S. have exploited time as an extra dimension in the optical design of ultrafast cameras. Using a technique it calls "time-folded optics," the team folded large spaces in time using mirrors inside the lens system to reflect light signals, allowing for new time- or depth-sensitive camera capabilities that aren't possible with conventional camera optics. The team believes the method could have a broad impact in time-resolved imaging and depth-sensing optics.



Reprinted fig. 3d, permission from Y. Lu et al., Phys. Rev. Lett., **122**, 193904 (2019).

2019: CUST photography

Despite recent advances, it's been tough to image non-repeatable ultrafast processes, such as laser surgery or laser–tissue interaction. Researchers in China have developed a relatively low-cost imaging technique, compressed ultrafast spectral–temporal (CUST) photography, that they say can record transient, highly complex and non-repetitive events with ultrahigh spectral or temporal resolution, a large frame number and femtosecond-scale speed.



Getty Images

2020: Trillions and transparency

In 2018, a U.S.–Canadian team created the world's fastest camera—able to take 10 trillion pictures per second in a single shot, thanks to the combination of streak imaging and compressed sensing. This year, Caltech, USA, researchers updated the device for a new application. By combining the previous system with phase-contrast microscopy, the technique was adapted to image ultrafast phenomena in transparent materials—including shockwaves and possibly even signals traveling through neurons—at a rate of up to a trillion pictures per second.

Ultrafast forward

Ultrafast photography is widely used both for scientific and industrial applications to visualize events on the shortest of time scales. As technology continues to improve and get more precise, there must be corresponding progress in the techniques for recording images in real time at a very high temporal resolution and spatial resolution. These data can offer insights into the mysterious interactions between light and matter, with applications across many fields.