ULTRAFAST IMAGING

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MIT's new camera can shoot one trillion frames per second. That camera allows to create a slow-motion video of a burst of light traveling.

Can we track each one of that enormous number of the technology world's innovations? Literally every moment the science thought is being refined, new ideas get born and a new thing appears: large or small, exquisite and functional or obviously ridiculous, they seem to pour out of the horn of plenty. The Moore's Law ascribes such an incredible development rate to the contemporary world that it's difficult to imagine.

Nevertheless, perfect things don't stay unnoticed among the masses and sometimes even find their application in daily life.

Everyone has got used to the so called "time warp" shoots. Their shoot frequency usually overcomes the amount of ten, or twenty, or even a hundred thousand frames per second. It is mostly considered to be some kind of a limit, but in fact that is very far from the truth.

Dr. Ramesh Raskar in the MIT Media Lab with the colleagues from his Camera Culture laboratory and in cooperation with the Bawendi Group created a unique system; it is a camera with the trillion fps – 580 billions, to be precise. It means, each frame exposition lasts 1,71 ps. The new camera shoots an ultrafast light impulse passing through the transparent bottle like ordinary rapid high-fps cameras shoot a bullet penetrating the apple: slowly, fluently, in infinitesimal details.

To compare, the previous ultrafast camera produced a bit more than 6 million frames per second.

Raskar's system is based on the streak-camera technology. The method isn't much complicated for understanding. Extremely short laser impulse passes through the streak-like objective and beats out electrons from the photocathode. The electrons, in their turn, perpendicularly skew under the influence of the rapidly changing electric field and travel to the detector. It results in the two-dimensional Cartesian image, where one axis accords the streak and the other one illustrates arriving time, the moment of diverging. However, it's important to remember: the streak objective fixates a line, thus outputting images correspond to one-dimensional shots in fact.

But it's a serious drawback in a video camera. To produce their super-slow-motion videos, Velten and his colleagues – Media Lab associate professor Ramesh Raskar and professor of chemistry Moungi Bawendi – must perform the same experiment repeatedly, continually repositioning the streak camera to gradually build up a two-dimensional image. It takes only a nanosecond for light to traverse the bottle, for example, but it takes about an hour to collect all the data necessary for the final video. For that reason, Raskar calls the new system "the world's slowest fastest camera."

Because the ultrafast-imaging system requires multiple passes to produce its videos, it can't record events that aren't precisely repeatable. Any practical applications will probably involve cases where the way in which light scatters is itself a source of useful information. Those cases may, however, include analyses of the physical structures of manufactured materials and biological tissues – "like ultrasound with light," Raskar said.

Raskar considers possible applications of his invention:"Such a camera can be useful in medical imaging, industrial or scientific use, and in future even for consumer photography. In medical imaging now we can do ultrasound with light because we can analyze how light will scatter inside the body. In industrial imaging we can use the scattered light to analyze different defects in materials. And in consumer photography we are always fascinated with creating lighting effects that appear to come from sophisticated light sources but, because we can watch photons slowly moving through the space, we can analyze the transport, the movement of these photons and create new photographs as if we had created those expensive light sources in a studio".

Andreas Velten calls it the "ultimate" in slow motion: "There's nothing in the universe that looks fast to this camera," he said. The inventors were inspired by slow motions of flying bullets from the past decades. Then the photoflash stopped the moment. Nowadays nothing has changed – the flash has just become millions times shorter.

References:

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