Imaging technique lets ordinary cameras capture high-speed images of crack formation

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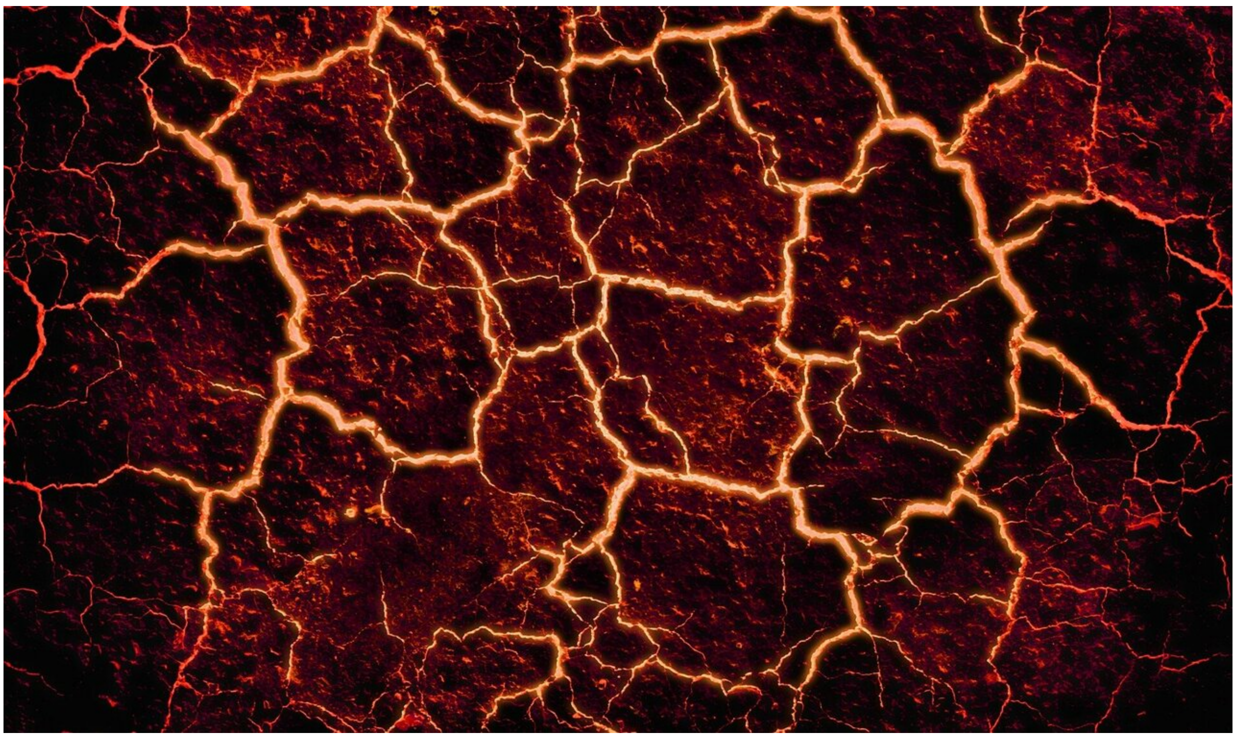

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Direct imaging of dynamic cracks as they occur can tell us a great deal about the physics of fracturing and properties of fracturing materials, which would benefit many fields ranging from materials science to engineering to construction. However, the fracturing process happens in the blink of an eye, with dynamic cracks propagating through several centimeters of some soft materials in only one-tenth of a second. High-speed cameras can be used to directly image dynamic cracking in some materials, but such equipment is expensive and can be difficult to use in some situations or with certain materials.

At the 2019 American Physical Society March Meeting in Boston, John Kolinski of the Ecole Polytechnique Federale de Lausanne in Lausanne, Switzerland, will present a new imaging technique known as the virtual frame technique that he and colleagues Samuel Dillavou and Shmuel Rubinstein of Harvard University developed that enables ordinary digital cameras to capture millions of frames per second for several seconds while maintaining high spatial resolution. He will also participate in a press conference describing the work. Information for logging on to watch and ask questions remotely is included at the end of this news release.

The virtual frame technique uses a camera sensor's bit depth, the amount of information the sensor can obtain, to dramatically increase frame rate. Cracking and many other physical processes are binary; for example, material is either cracked or not cracked. Thus, only two bits are needed to image a crack. An image sensor with a bit depth of 16 bits has more than 65,000 color or grayscale values, meaning it is possible to produce thousands of virtual frames during a single exposure. Using precise camera timing and a short pulse of intense light can increase frame rates even further. "In a recent study using the virtual frame technique, we obtain virtual frame rates exceeding 60 million per second using precise time-gating and a camera sensor with substantial bit-depth," Kolinski said.

Using the virtual frame technique, virtually any camera can directly image dynamic cracks as they form. Additionally, it can be used to study other fast physical processes that happen at interfaces between solids and fluids such as wetting that occurs when a liquid drop hits a material surface. The only requirement is that the solid be opaque, whether it's a construction material or soft substance such as a polymer. "Essentially any material could be imaged with the virtual frame technique," Kolinski said.

The researchers have tested the virtual frame technique using several types of cameras with different sensitivities and bit depths ranging from sophisticated high-speed and high-end consumer cameras to smartphone cameras. Each type of camera was able to achieve much higher frame rates using the virtual frame technique, which Kolinski said might lead to its use in future mobile device apps that could measure material properties.

This new imaging technique promises an easier way to study fracturing and other fast physical processes at material interfaces. Using ordinary consumer cameras to capture thousands or more frames per second makes it possible to study fracture toughness and other properties of construction materials, and if used in mobile apps one day, the new technique could complement or even replace expensive testing hardware with a piece of software.

More information: The 2019 APS March Meeting presentation "The Virtual Frame Technique (VFT): direct imaging of fast cracks in soft elastomers," by Samuel Dillavou, Shmuel Rubinstein and John Kolinski, will take place Monday, March 4, at 10:00 a.m. in room 162B of the Boston Convention and Exhibition Center. Abstract: meetings.aps.org/Meeting/MAR19/Session/A30.7

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