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On the mathematical foundations of computational photography: The flutter shutter

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Computational photography is at the junction of algorithms, sensors and modern optics. It aims to create new types of photographs and to allow photographers to acquire better images, new type of images or images we could never observe before. Digital cameras count at each pixel sensor i.e. the number of photons emitted by the observed scene during an interval of time called exposure time. With a passive camera, the only way to safely increase the signal to noise ratio (SNR) is to accumulate more photons by increasing the exposure time. Unfortunately, this also increases the chance of either the camera or the scene moving during the exposure process, resulting in motion blur that severely lessens the SNR of the image. This talk is about a revolutionary camera concept called "flutter shutter". Flutter shutter cameras promised to increase the image quality (SNR) when photographing moving objects. Yet, these new camera designs raise theoretical, practical and numerical questions such as: What is the optimal camera design? Can a flutter shutter indefinitely increase the SNR by an increased exposure time? Is the flutter shutter more efficient depending on the observations conditions (scene lighting, camera-scene velocity, …)? What are the most suitable algorithms to treat the data acquired by these cameras? This talk gives a simple formalism that permits to answer the questions on these recent camera designs. (The theory is also proved to be valid for the "motion invariant photography": the only other competitor of the flutter shutter.)

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High-power pulsed semiconductor lasers

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Over the past 15 years, vertical external cavity surface emitting lasers (VECSELs, a.k.a. optically pumped semiconductor lasers, or "OPSLs") have demonstrated remarkable powers over vast wavelengths from the near-UV to the short-wave infrared spectral regimes directly. Moreover, inclusion of intra-cavity nonlinear crystals has extended this region across the deep-UV through the mid-wave infrared spectrum. Utilization of other intracavity nonlinear elements such as saturable absorbers can additionally facilitate large peak-power pulses through passive mode-locking. This technique has been demonstrated and may have uses in applications such as high pulse-repetition-frequency clocks and cavity ring-down spectroscopy. Although mode-locking enables high peak power pulses, picosecond pulse lengths typically limit the pulse energy to below a nanojoule. With the advent of intracavity polarization control, it may be possible to achieve higher orders of magnitude pulse energy synergies. This approach relies on storing energy in the laser cavity rather than in the gain like solid state lasers. Like passive mode-locking, peak power can be electrically tunable through the pump power, however unlike passive mode-locking, the pulse train can be tuned electronically and is not limited to periodic pulses. Using such a technique, we can also access pulse timescales that are between the traditional gain-switched pulses on the microsecond scale and the mode-locked pulses that are nominally a picosecond long. This presentation will review our research in the area of pulsed VECSELs.

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