Programa de Doctorado en Ciencias y Technologías Físicas

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Extending the Impact of Computational Imaging Beyond Phone Cameras: Fast Pixel-Programmable Image Sensors - the 'FPGAs' of the Image Sensors World

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Abstract: Next-generation image sensors are the eyes of future smart technologies. Today's smartphone cameras are already very good and inexpensive. This is mainly because they use computational imaging to digitally enhance images by means of software processing. They typically take many shots and combine them into one digitally enhanced image. However, this comes at the expense of low effective speed and high number of computations. In fact, this approach fails in most cost-constrained applications where fast motion or rapidly changing illumination are present, such as drones, automated vehicles, surveillance, robotics and augmented reality. So, next-generation image sensors have to rely on a combination of fast imaging and computation to tolerate motion and maintain the same low cost as that of smartphone sensors.

Our solution is a new class of 'pixel-programmable' image sensors – referred to as coded-exposure-pixel (CEP) image sensors, that are motion tolerant, low-cost, and versatile, and as such are well-suited for robust fast computational imaging. The high exposure rate, with over 30,000 exposures per second, is at least a factor of 100X higher than the best cell phone camera. The readout speed is maintained beneficially low – at the standard video rate. As there is no overly fast video output, no expensive hardware is needed

to handle it, so the cost can be less than 1% of the cost of conventional high-speed cameras. The low rate of the readout also brings the benefits of low power dissipation and low required illumination.

Additionally, our coded sensors are field-programmable and, as a result, are highly flexible in functionality. As opposed to most image sensors that are typically application-specific, our sensors are, to an extent, application-agnostic – acting as the “FPGAs” of the image sensors world. They are reconfigurable by an end-user in the field to implement one of many imaging techniques, simply by changing pixel codes in firmware. A number of fast low-cost computational imaging demonstrations will be described including both single-shot passive imaging (e.g., high-dynamic-range imaging and high-speed imaging) and single-shot active imaging (e.g., spectral imaging, depth-gated imaging, and structured-light / photometric-stereo 3D imaging).

Biography: Roman Genov received the B.S. degree in Electrical Engineering from Rochester Institute of Technology, NY in 1996 and the M.S.E. and Ph.D. degrees in Electrical and Computer Engineering from Johns Hopkins University, Baltimore, MD in 1998 and 2003 respectively.

He is currently a Professor in the Department of Electrical and Computer Engineering at the University of Toronto, Canada, where he is a member of Electronics Group and Biomedical Engineering Group and the Director of Intelligent Sensory Microsystems Laboratory. Dr. Genov’s research interests are primarily in analog and digital integrated circuits and systems for energy-constrained biomedical and consumer sensory applications, such as implantable neural interfaces and computational image sensors.

Dr. Genov is a co-recipient of Jack Kilby Award for Outstanding Student Paper at IEEE International Solid-State Circuits Conference, Best Paper Award of IEEE TRANSACTIONS ON BIOMEDICAL CIRCUITS AND SYSTEMS, Best Paper Award of IEEE Biomedical Circuits and Systems Conference, Best Student Paper Award of IEEE International Symposium on Circuits and Systems, Best Paper Award of IEEE Circuits and Systems Society Sensory Systems Technical Committee, Best Paper Award of IEEE Circuits and Systems Society Biomedical Circuits and Systems Technical Committee, GlobalFoundries Micro-Nanosystems Design Award, Award for Excellence in Microsystems Design Methodology, Brian L. Barge Award for Excellence in Microsystems Integration, MEMSCAP Microsystems Design Award, DALSA Corporation Award for Excellence in Microsystems Innovation, and Canadian Institutes of Health Research Next Generation Award. He was a Technical Program Co-chair at IEEE Biomedical Circuits and Systems Conference, a member of IEEE International Solid-State Circuits Conference International Program Committee, and a member of IEEE European Solid-State Circuits Conference Technical Program Committee. He was also an Associate Editor of IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS-II: EXPRESS BRIEFS and IEEE SIGNAL PROCESSING LETTERS, as well as a Guest Editor for IEEE JOURNAL OF SOLID-STATE CIRCUITS. Currently he is an Associate Editor of IEEE TRANSACTIONS ON BIOMEDICAL CIRCUITS AND SYSTEMS.