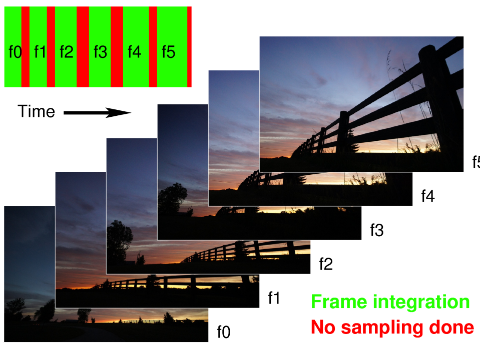
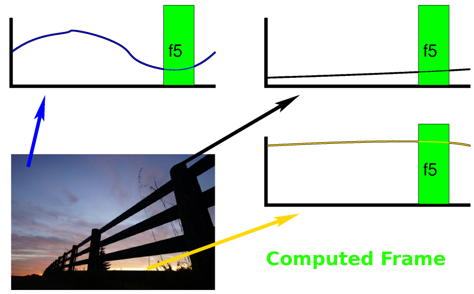
Time Domain Continuous Imaging



Traditional Image Capture



Time Domain Continuous Imaging

TIME DOMAIN CONTINUOUS IMAGING doesn't sound like supercomputing. It is about a new type of imaging sensor and processing – processing that ideally would use *millions* to *billions* of processing elements on the sensor chip.

Exposing Like Film: With film, there was no choice but to expose all points in the frame for the same photon integration (shutter speed or Tv) period. Physically moving the film to the next frame also forces temporal gaps between frames. Why should digital cameras mimic that behavior?

Massively Parallel Sensel Processing: Since 2003, we've been quietly working on a better approach called TIME DOMAIN CONTINUOUS IMAGING:

- Use different integration (exposure) periods for sensels, ideally directly obtaining a digital value for the time taken to collect enough photons to achieve the target accuracy in the presence of (e.g., photon shot) noise
- If possible, deliberately skew sampling of individual sensels in time to allow improved temporal interpolation
- For each pixel, computationally derive a smooth function for how light intensity varies over time and output the (compressed) waveform

Thus, each sensel independently senses photons essentially all the time, and the digitized and computationally compressed waveforms for all pixels are output.

Benefits: Why bother with TDCI? Because it can do things no frame-based still or video imager can:

- HDR (High Dynamic Range) with integration period <, =, or > exposure interval: never lose data to overexposure, temporally interpolate underexposed pixels
- Exposure interval can be smoothly adjusted after capture: virtual shutter speed is independent of exposure, can nudge exposure interval forward/backward to get the precise moment with zero "shutter lag"
- Framerate-independent movies: no more "stutter" in displaying at cinematic (24FPS), PAL (25FPS), and NTSC (59.94 fields/s) framerates
- Artifact-free movie pans and motion in general: computationally integrating means no temporal gaps between frames (e.g., no "jumping" objects in movie pans)

Technology: In order to do this, we need to be able to place a programmable processing element under each sensel. The key is programmable NANOCONTROLLERS with low enough circuit complexity to do this – no more than a few hundred transistors/processor. We have talked about our NANOCONTROLLER architecture and compiler infrastructure in various publications over the past decade.

The second trick is placing sensels over nanocontrollers. There are very few examples of placing digital circuitry under sensels of any type. However, at the University of Kentucky we have fabricated solar cells over digital logic. Our proposed sensor is essentially a segmented solar cell fabricated over a massively-parallel nanocontroller computer. Our current goal is production of a low-cost 500MP large-format (4x5) TDCI sensor. We expect it to be capable of full-resolution HDR imaging at the equivalent of 1000FPS.

There are also "low-hanging fruits" in the form of methods we're prototyping now that allow conventional sensors to approximate TDCI... including a simple demonstration in our SC13 research exhibit.

For More Information: Our first publication giving details about TDCI will be presented at the IS&T/SPIE Electronic Imaging conference in February 2014. We are seeking collaborators and support to further develop and bring this technology to market.

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