Video camera that records at the speed of thought

October 12 2009

(PhysOrg.com) -- European researchers who created an ultra-fast, extremely high-resolution video camera have enabled dozens of medical applications, including one scenario that can record 'thought' processes travelling along neurons. This is ingenious science.

The Megaframe project scored a staggering number of breakthroughs to create the world's first 1024 pixel, photon-resolution, million-frame-per-second CMOS camera that puts Europe firmly in the lead for ultra-high speed video cameras.

Their work has pushed the boundaries of CMOS (a type of semiconductor) miniaturisation and sophistication. But it is in the application of their technology that the most stunning impacts of the Megaframe project will be seen, particularly in medical applications.

That is because the camera can detect a single photon at a million times a second, and so it can record molecular processes in unprecedented detail. "We need this sort of detail because biomedical scientists are studying processes at the intra-cellular and molecular levels," underlines Edoardo Charbon, coordinator of the EU-funded Megaframe project.

Ingenious

Scientists have developed extremely ingenious ways to infer or deduce what is happening at the molecular level, and Megaframe could make that process even more detailed. Essentially, scientists use a variety of emissive materials to see what is happening in microscopic biomedical processes.

Take Fluorescence Lifetime Imaging Microscopy (FLIM). Here, a fluorescent material is introduced to the area of interest. Fluorescence has some interesting properties, for example a particular spectrum of emission and a rate of decay.

One particular fluorophore, Oregon Green Bapta (OGB-1), decays at a rate proportionate to the presence of calcium. Interestingly, calcium is an important indicator of neuron activity.

“So it is possible, for example, to go inside neurons and look at their ion channels. These are the channels that allow neurons to communicate with other neurons. And you can basically see the amount of calcium that is present. You can probe optically how neurons communicate with other neurons just by looking at the concentrations of calcium in real time,” explains Charbon.

So scientists can use the OGB-1 to indicate the presence and concentration of calcium, and the whole process can be recorded in ultra-fine detail thanks to single-photon detectors, such as the ones present in the Megaframe camera. The camera is recording at the speed of thought.

“Biomedical scientists could in principle use this microscopic information about calcium to learn about macroscopic conditions like Parkinson’s, or Alzheimer’s or epilepsy,” Charbon stresses.

But that’s just the beginning. Megaframe could have a significant impact on any medical science that uses visible light emissive scanning technologies like FLIM. But it can even have an impact where visible light is not present.

Other apps

Other applications currently under exploration by Megaframe include intracellular DNA sequencing and proteomics, two huge areas for drug discovery, as well as basic scientific research for gene sequencing and protein-folding.

“For example, the camera could be used to detect and display the impact of certain drugs, or certain combinations of drugs, in animal or human models,” Charbon says, adding that they are currently looking at oligonucleotides, which are “very short sequences of DNA mounted directly onto the detectors for labelled and label-free monitoring of the hybridisation process.”

Other areas where Megaframe’s work could boost research results include cell membrane scanning, to discover what bacteria or other material are present, and this research could be extended to look at issues like water purity, and waterborne bacteria.

Exploring further potential

Another very promising technique is the combination of fluorescence imaging with MRI, or magnetic resonance imaging. “In MRI you need very strong magnetic fields in the cavity where you are performing the imaging, up to 10 Tesla, but conventional fluorescence technology won't work in these conditions,” says Charbon.

But Megaframe’s choice of photo detector - the Single-Photon Avalanche Diode (SPAD) - have been tested successfully in fields up to 9.4 Tesla, he reveals.

“Thus, it can be envisaged to have a system where fluorescence-

enhanced imaging and functional MRI may be used simultaneously," Charbon enthuses. "This is very useful in a number of biomedical applications, where one wants to monitor the correlation between the presence of certain molecules in organs, such as the brain, and their function."
Again, pharmacology could benefit from this technique enormously, as well as epidemiological research.

"Our preliminary tests were conducted in an animal MRI, which in general has much higher fields than a human MRI. Human MRI tests will follow," reveals Charbon, adding that the technique has been tested with other SPAD-based microsensors and has yielded good results.

"Even though we have not tested it with the Megaframe chip, it is a guaranteed success because the technology is in principle the same," Charbon predicts.

The Megaframe project has just begun to explore the potential for their camera in biomedical applications, and the list just keeps on growing as their research continues. And that is just in the biomedical field. There are dozens of potential applications in fields as diverse as high-energy physics, entertainment and automotive diagnostics.

The Megaframe project received funding from the FET-Open scheme of the EU's Sixth Framework Programme for research.

This is the second of a three-part special feature on the Megaframe project.
Part 1. Filming photons, one million times a second

More information: www.megaframe.eu/

Provided by ICT Results (news : web)