Cells as Bits: Biomedical Diagnostics Inspired by Physics and Data Communication Techniques

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Telecommunication systems routinely generate, capture and analyze data at rates exceeding billions of bits per second. Interestingly, the scale of the problem is similar to that of blood analysis. With approximately 1 billion cells per milliliter of blood, detection of a few abnormal cells in a blood sample translates into a "*cell error rate*" of 10^{-12}, a value strangely similar to the *bit error rate* in telecommunication systems.

Motivated by fiber optic communication techniques, a new type of bright-field imaging known as STEAM has demonstrated imaging of cells with record shutter speed and throughput leading to detection of rare breast cancer cells in blood with one-in-a-million sensitivity. A second technique called FIRE is a new approach to fluorescent imaging that is based on wireless communication techniques. FIRE has achieved real-time pixel readout rates one order of magnitude faster than the current gold standard in high-speed fluorescence imaging.

To deal with the massive amount of data generated by these new instruments ("big data") a new physics-based data compression algorithm has been created. The *Anamorphic Stretch Transform* enables a digitizer to capture signals that would otherwise be beyond its bandwidth, and at the same time compresses the digital data size. This method is inspired by operation of Fovea centralis in the human eye and by anamorphic transformation in visual arts.