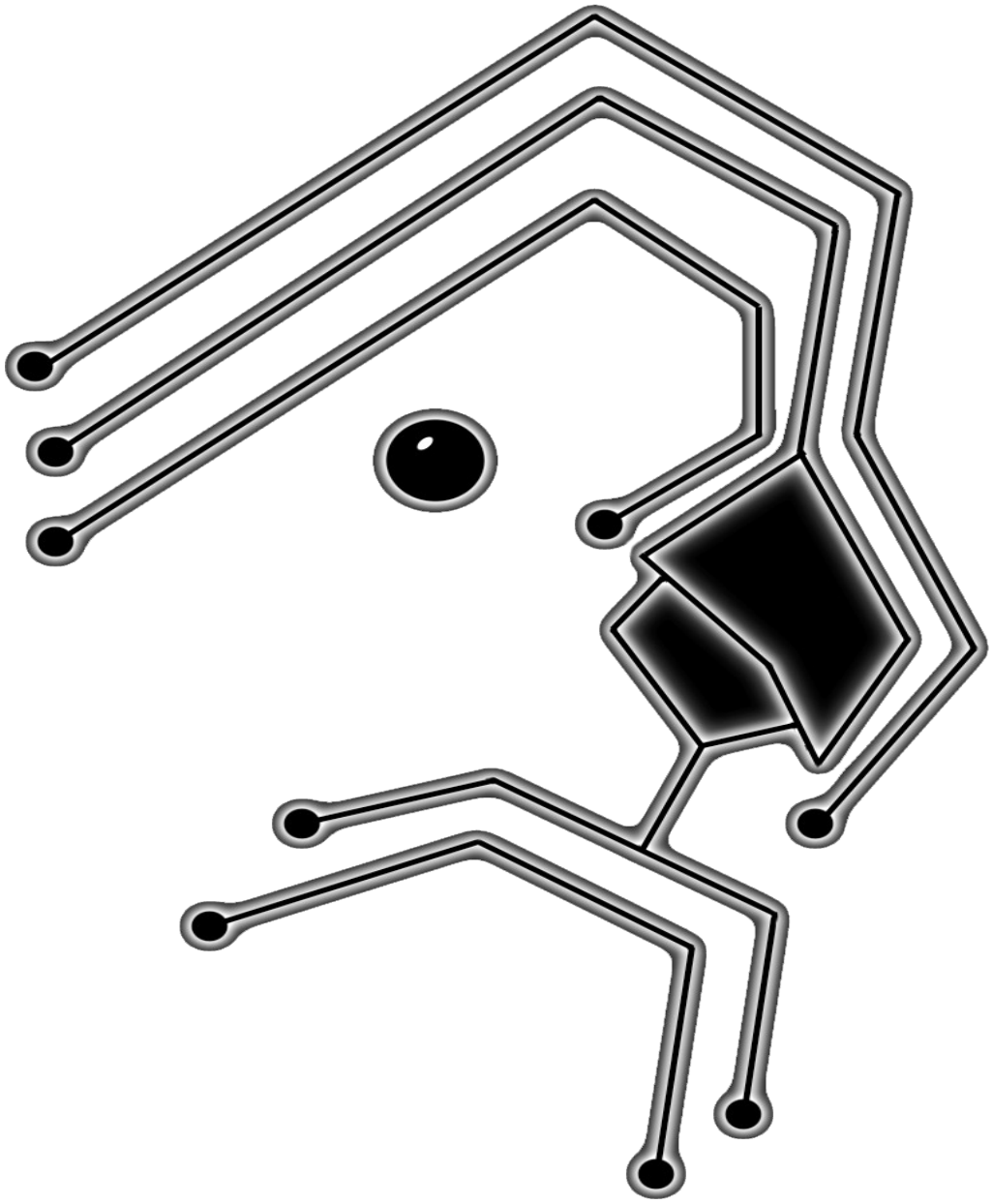
Phase Correlation for Medical Applications



TouitInc.

Application Specific Computing

Using technology as a tool to aid in medical diagnostics can dramatically improve the accuracy of results in order to distinguish between true, false positive and false negative diagnoses. Other benefits include improving the speed of diagnoses as well as help acclimate medical professionals in reading and understanding new medical imaging technologies.

Computer Aided Diagnostics

Touit has developed a technology to significantly enhance computer aided diagnosis (CAD), and is founded in the form of template matching or cross-correlation technology. Specifically, in this case it is called phase correlation. Phase correlation may be interpreted as being analogous to template matching and cross correlation since they are varying names for essentially the same computation. Some of these algorithms are computed slightly differently, with the case of the phase correlation method being computed in the frequency domain versus spatial domain.

The advantage of computing frequency domain cross correlation is speed. A spatial domain cross correlation (or template matching) requires a significantly larger number of multiplications due to the added step of the convolution operation. The convolution, as translated in the frequency domain, is a simple point by point multiplication leading to a large reduction in the required number of multiplications.

To operate in the frequency domain, Touit has developed a highly parallel, high speed 2D FFT architecture that has incorporated the phase correlation algorithm. This enables a very high speed process to correlate many images per second. Touit's technology for the 2D FFT incorporating the phase correlation algorithm is done in hardware, such as a low-cost high-performance FPGA, as opposed to performing the 2D FFT on a standard PC or DSP computing system.

Depending on the specific configuration, Touit's technology can achieve up to several orders of magnitude performance improvement over those other standard computing systems. With such low throughput on standard computing systems, the frequency domain computation for 2D signals (as is the case with images), has often been overlooked and its spatial domain counterparts (including template matching and cross correlation) have been more widely used. Today's low-cost high-performance FPGAs, coupled with Touit's phase correlation technology, enables the medical industry to instead adopt and use the frequency domain computation with all of its inherent advantages.

The template matching technique has been proven in the medical industry to work in diagnoses of common ailments such as tumors, brain MRIs, mammograms for breast cancer, etc. Over time, these techniques have been used to build a database of images (Touit tests with the DDSM: Digital Database for Screening Mammography) depicting normal, benign and cancerous tumor profiles. This database of images becomes your templates, or knowledge base. In order to make an accurate diagnosis, this database of known images are then compared to search images of unknown specimens. This is done with a very high degree of accuracy and can be significantly improved with the capability to parse through an even larger knowledge base. The capability provided by Touit's phase correlation technology makes it possible to search through a larger database in less time. This creates an even more accurate diagnosis and the capability to diagnose more patients.

The ability to greatly improve the accuracy in diagnoses in an economic and feasible manner is highly desirable. The statistics for cases of mis-diagnosis, both for false positives and false negatives, is unsettlingly high. The current mindset within the industry is to err on the side of caution as it is less costly to have a false positive than a false negative. For example, despite this cautionary approach, at least one in ten mammography cases is incorrectly diagnosed as a false negative, resulting in an obviously problematic and many times traumatic situation for everyone involved.

Multi-Dimensional Imaging

New imaging equipment with 3D and 4D capable scanning systems are commercially available. However, one of the main hindrances to widespread adoption of such systems is training medical staff to properly read and interpret the data from the images they are seeing. Touit's technology may help speed up the introduction of newer equipment that integrates newer technologies.

Again, because Touit's technology is so fast and can correlate so many images per second, it can allow for real-time correlation, essentially brute forcing the computation in the newer imaging systems. For example, instead of having to use a very complex and computationally expensive spatial domain algorithm on the 3D and 4D data, this multidimensional data can be broken up into 2D slices and use Touit's technology to correlate it. This renders the exact same results as examining the entire image directly in 3D or 4D, since Touit's technology can process such large amounts of data in real-time.

The addition of real-time correlation in medical imaging systems to allow the examination of 3D and 4D images presents significant benefits to all involved, and thus can help guide medical professionals in the use and adoption of these new technologies.

Multi-Modal Imaging

Touit's phase correlation technology is also an excellent tool for image registration. There are two basic categories of medical images: 1. functional images which provide physiological information, such as SPECT or PET scans; 2. anatomical images which show the anatomic structure of the body such as X-ray, MRI, Ultrasound or CT.

Medical images of differing formats are aligned via phase correlation to create a complete view of the area of interest; helping the medical professional to identify normal and abnormal characteristics, both clarifying and speeding the process of diagnosis.

Touit's Echelon

Echelon is a real-time image processing board designed and created by Touit which combines Touit's technology and a high-performance low-cost FPGA, such as the Lattice ECP3 or Xilinx Spartan 6. The overall implementation is highly configurable to the user, allowing both real-time correlation mode and image database search correlation mode. Both modes make use of up to 8GB of DDR2 memory modules, which can be segmented into multiple image search databases or knowledge bases where searches can be configured to selectively correlate against.

In real-time correlation mode, the images can be loaded into the image correlation engine via a frame grabber. Multiple frame grabber options are available:

- 4 channel ADS930 ADC
- Camera Link
- GigE Vision
- Custom image acquisition interface.

In database correlation mode, images can be loaded through the x1 PCI Express port in the image correlation engine, which in some applications may be fast enough to be considered real-time.

Echelon is capable of performing 140,000, 64 x 64 pixel image correlations per second. Larger images can be segmented and then processed (e.g. 1024 x 1024 pixel images at 564 per second). With Touit's technology, expanding Echelon to more powerful implementations to improve throughput performance on larger sized images may be done with optional higher performance FPGAs such as Xilinx's Virtex.

Software

Echelon includes a Python module for easy interfacing. This allows the device to be accessed via the Python command interpreter providing Echelon users with a platform or environment that can support experimentation and algorithm trade-offs.

Python is the interface of choice because it is an open source interactive programming environment with a wide selection of open source libraries, particularly NumPy and SciPy for matrix and signal processing operations. Together these software tools provide an easy to use platform from which the application and image databases can quickly be tested and demonstrated.

Touit provides device drivers for both Windows and Linux. For easy application interfacing C API's are also included.