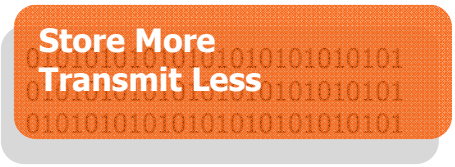
Advanced Solutions for Today's Technology



Over the next 5 years it is projected that up to eighty percent of medical imaging will shift from being analog device based to being produced by digital devices. The amount of data generated by these devices will be enormous and several imaging modalities (CT, MRI, Ultrasound, etc.) also create images in 3D or 4D, thereby increasing the size of the captured data sets even further. This shift will increase the cost and time needed for storage and transmission of the data. Image compression is one option to reduce the size of data sets and it has been incorporated into the industry standard DICOM medical image format.

Lossless (or fully-reversible) compression does not pose any problematic issues. The current state-of-the-art algorithms, such as JPEG2000 reversible compression, are not very efficient and yield limited results. Lossy (or irreversible) compression methods offer the potential to greatly enhance the compression rates, but these methods can create artifacts in the images, potentially leading to misdiagnosis. Lossy compression for medical applications remains controversial in many circles.

ATHENA Symmetry™ Lossless Compression has the potential to reduce the size of medical image data sets by a factor 10 or higher. Current compression technologies, such as JPEG2000 reversible compression, achieve factors between 2:1 to 4:1. ATHENA Symmetry™ can also be transparently used on multi-dimensional data sets or image sequences to achieve even higher rates of compression, and it provides all of the functionality of the interactive JPEG2000 protocol (JPIP), including region-of-interest processing or tiling and incremental decoding.

Based on in-house tests, the compression ratios result with **ATHENA Symmetry**™ versus JPEG2000 on a series of medical images from various sources, our technology achieves compression ratios of two to three times that of JPEG2000 on single 2D images. On 3D data sets, the compression ratios are significantly higher with ATHENA Symmetry™, on the order of 18:1 versus current JPEG2000 results that yield a maximum of 5:1.

ATHENA Speed™ Lossy Compression has the potential to increase the compression rates by an order of magnitude with virtually no loss of diagnostic information. The Canadian Association of Radiologists (CAR) is set to fully endorse the use of lossy compression by the end of 2006. It is anticipated that lossy compression will see increasing usage worldwide in the medical community in the coming years. By combining both ATHENA Speed™ and ATHENA Symmetry™ region-of-interest capabilities, the images could be transmitted using lossy compression and selected portions could be retransmitted with lossless compression to provide more detail when and where needed.

ATHENA Symmetry™ and **ATHENA Speed™** can be implemented by negotiating the private transfer syntax between compatible systems that is currently supported in the DICOM standard. In the case of an incompatible system, a fallback scheme would be implemented whereby raw data or data compressed with a compatible, method such as JPEG2000, would be exchanged. The ATHENA™ Transcoder would then convert the image to the appropriate format for transfer to the requesting workstation. Vendors who adopt ATHENA™ technology can easily demonstrate superior image quality and transmission times between their systems over that of a competitor, while retaining the complete inter-operability with DICOM demands.

An alternate implementation could use the DICOM Application Hosting framework being developed by WG23. This will provide a plug-in standard that enables third-party applications to be hosted on a vendor's medical system. These applications could run on the system, on a server provided by the third-party, or even as a remote service. As an

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example, a workstation could look for a plug-in application that can decode a data set that has been compressed using ATHENA Symmetry™. This would allow for the appropriate codec to be downloaded without transcoding.

Benefits of ATHENA™ Pattern Recognition

Computer Aided Detection for Medical Images

Computer-aided detection and diagnosis (CAD) involves the application of image analysis for medical image interpretation. Radiologists can use the output from a computerized analysis of medical images as a "second opinion" in detecting lesions and in making diagnostic decisions. CAD systems are currently available for several clinical applications including mammography for detecting masses, micro-calcifications and thoracic CT for detecting lung nodules, etc.

The **ATHENA Sentry™** Anomaly Detection functions can detect and process patterns within medical images based on a set of known anomalies; the **ATHENA™** pattern processing engine can then efficiently process an image and highlight regions-of-interest for the radiologists. The technology can be adapted for a variety for medical CAD applications to increase the detection sensitivity without raising the many false positives that are common today with current offerings. ATHENA Sentry™ provides the ability to match medical images with the most relevant cases in a database without requiring the case file images to be decompressed. This can be used to create new CAD applications.

The use of CAD in medicine is expected to grow for many years due to increasing caseloads and also due to the large volumes of data that imaging systems produce. As an example, a thoracic CT scan produces over 200 images for the radiologist to interpret. The automatic detection capabilities of ATHENA Sentry™ will considerably enhance the clinical workflow for radiologists.

Preliminary experiments on the use of **ATHENA Sentry™** Anomaly Detection have generated very promising results. Using a chest X-ray database from the Japanese Radiological Society containing ~250 images (154 nodule images, 93 normal images).

ATHENA Sentry™ Anomaly Detection has also been used to experiment with a database of mammography images from the University of South Florida, which contains over 2500 images organized into categories of normal, cancer and benign. **ATHENA Sentry™** successfully outlined the suspected regions in over 90% of the images.

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