GE Healthcare

Advanced Dynamic Range Management (DRM) Image Processing Technology for precise imaging

Real-time, on-board DRM image processing capabilities optimize OEC 9900 Elite fluoroscopic images

The expansion of minimally invasive surgical techniques has been a benefit for both the physician and the patient. The breadth of new surgical or endovascular procedures, including AAA and TAA stent graft procedures, vascular access, and cardiac angiography, allows the surgeon to offer new treatment solutions which could provide better outcomes for the patient.

A key foundation for these new techniques is the enhanced ability of the imaging system to "visualize" clearly the patient's anatomy during the procedures. Advancements in digital fluoroscopy, in which X-ray information is digitized and processed with imaging software technology, optimizes fluoroscopic images to help surgeons perform these minimally invasive procedures.

The GE Healthcare OEC 9900 Elite digital mobile imaging system (C-arm) provides more than 100 times the computing power devoted to image processing when compared to previous generations of C-arms. The 9900 Elite C-arm combines processing power with Dynamic Range Management (DRM) image-processing software to provide image quality similar to a fixed room on a mobile platform.

Conventional Image Processing

In traditional image processing, an image is captured and processed as one data source. With normal fluoroscopy images, the visibility of anatomy depends on various densities of anatomical parts that are being imaged.

- Dense body parts, such as large bones or dense body organs, as well as contrast media, surgical instruments and implants are displayed in a darker grayscale image (dark gray to black) after processing.
- Soft tissues and various organs, depending on their size and density, are displayed in lighter grayscale compared to the bones and surgical devices. Air-filled organs such as lungs, large bowels or very thin soft tissues display light gray or white in fluoroscopic images.
- The human eye is limited in regard to the shades of light and dark that can be visualized, even though those areas may contain a lot of key image information.

With conventional image processing, the entire image is processed through one algorithm. Algorithm examples include linear, semi-linear, or curve (gamma) as a function of anatomical profile settings. See examples that follow.

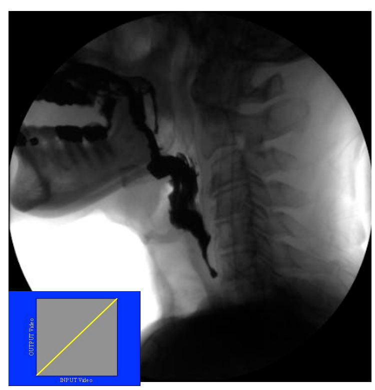

Fig. 1: Lateral neck view processed with linear image-processing algorithm.

Fig. 1 is a lateral view of the neck with barium contrast media, processed with a linear image-processing algorithm.

- The normal grayscale levels are displayed with a linear curve.
- The soft tissues in the front and the back of the spine are visualized in reasonable detail.
- Vertebral bodies of the cervical spine are not well defined, especially in the dense parts of the body and lower neck around the shoulders near the bottom of the image.

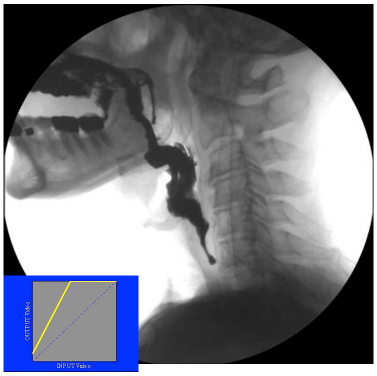

Fig. 2: Lateral neck view processed with semi-linear image-processing algorithm.

Fig. 2 is a simple data transformation using the semi-linear image-processing algorithm.

- Image pixel brightness is increased with a steeper linear transformation and improved visibility of the previously darker region of the anatomy.
- The vertebral bodies - lower spine and shoulder areas - which were not well visualized in the previous image are now clearer.
- Lower-density regions of the neck, larynx and tissues next to the spine, have become saturated to pure white and are difficult to visualize in the image.

The image in Fig. 2 presents better detail than Fig. 1, but it is not optimal.

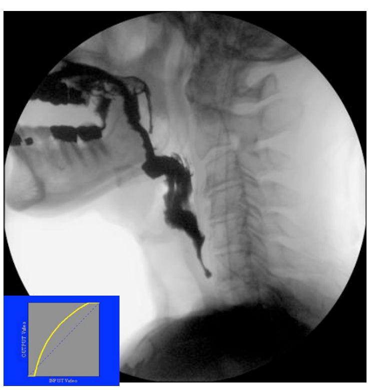

Fig. 3: Lateral neck view processed with curve (gamma) image-processing algorithm.

Fig. 3 uses the curve image-processing algorithm. With this image-processing method, the contrast is increased in some areas and compressed in other areas.

- Improvements in white grayscale areas reduce saturation in the image, allowing soft tissue organs to be better visualized.
- Darker grayscale (dense anatomy) regions of the image maintain high brightness and reduce overall contrast in the vertebral areas.

Again, the curve image-processing algorithm in Fig. 3 represents improved image quality, but still does not represent an optimal image.

Although each image-processing algorithm can improve certain areas of image quality, the conventional image processing method was unable to combine the benefits from all of the various image-processing algorithms to create the optimal image display.

DRM / Precision Image Processing

The OEC 9900 Elite digital mobile imaging system uses its powerful computer to deploy DRM which combines various image algorithms to optimize fluoroscopic images. An incoming image is divided into six different sub-images during image processing. Each sub-image contains different layers of information.

Rather than processing the entire image at once, each anatomical sub-image is processed separately for optimum brightness, contrast and enhancement levels. After processing, all the sub-images are re-combined to create the final image. As a result, the DRM capabilities of the 9900 Elite processes both lower and higher density regions of the anatomical structure effectively, and clearly displays them, in real-time, in a single view.

Using various image processing algorithms (Fig. 4), DRM treats images differently based on their density range. Density range refers to the differences in patient thickness and differences in density (air-filled organ vs. dense bone), which are displayed in various grayscale levels (a range between black and white) in the image. There are literally thousands of grayscale levels, much more than the human eye can distinguish. To display images that a user's eye can see, the 9900 Elite's DRM reduces the density range but maintains high contrast of relevant anatomy for better anatomical visualization.

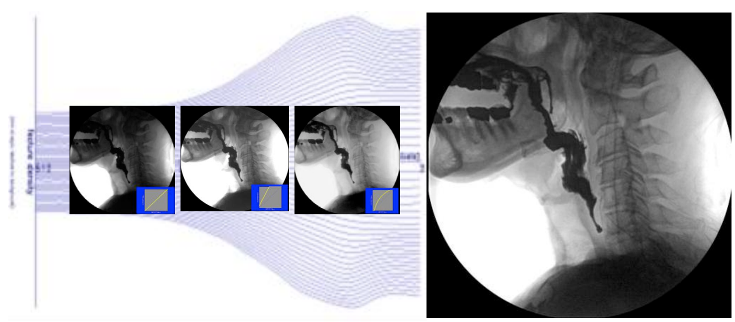

Fig. 4

High-density areas such as the lower neck region (including the lower cervical spine superimposed with the shoulders) tends to be dark in fluoroscopic images. The DRM's image algorithm processes that region of the anatomical structure to be brighter in order to improve visibility of C6-C7 regions and dense cervical vertebral bodies.

Low-density structures such as soft tissues or air-filled organs in the neck are processed with variable curve algorithms to optimize their brightness, contrast and enhance levels without grayscale saturation. Detail of the soft tissue is displayed clearly.

Intermediate density regions such as spinus processes or facet joints of the cervical spine, or dense tissue organs are processed locally to maintain appropriate image display parameters and structural details.

The patented DRM technology applies specific processing algorithms or different "bandwidths," to each incoming image. In short, DRM can accentuate what you want to see and attenuate what you don't need to see.

User Selectable Image Profiles

Working much like a graphic equalizer on a stereo system, the user controls the optimization of image quality by simply selecting a preset imaging profile for the specific application. The 9900 Elite normally defaults to the General profile when the system boots. The General profile can be applied to any imaging procedure with reasonable image quality. However, using the image profiles will optimize image quality and clarity while offering flexible, application-specific processing.

DRM preset profiles include:

- General Profile - enhances small low-contrast features in moving and static anatomy.
- 9800 Profile - emulates the image quality of the 9800 C-arm.
- Ortho Profile - enhances small low-contrast features in moving and static anatomy. This profile highlights bone edges, and improves the high contrast of surgical devices.
- Spine Profile - reduces noise and enhances visibility of larger low-contrast static features. The spine profile emphasizes large bones.
- PVas Profile - peripheral vascular profile improves peripheral vessel visibility in DSA imaging.
- Vascular Profile - enhances contrast of vessels.
- Cardiac Profile - more tolerant to motion, enhances contrast of iodine-filled vessels.
- Bolus Chase Profile (MTS) - suppresses background and isolates small iodine-filled vessels. The patient image is captured with the patented "no-mask" or Motion Tolerant Subtraction technique that allows the user to perform DSA (Digital Subtraction Angiography) imaging while moving the C-arm or patient.

DRM processing is accomplished on the 9900 Elite in real-time with a DRM filter. The filter also allows for adjustments in the final image displays. For example, a patient's body bulk carries little useful information. DRM allows some of its contrast to be reduced, freeing the grayscale range for enhanced visualization of other features. In some applications, bone density may need enhancement. In others, bone density may need attenuation. With soft tissues, many features of clinical interest need more contrast and can be easily adjusted by the user. DRM allows for all of these adjustments. The 9900 Elite conveniently places these modifications in the user's hands.

Conclusion

Today, medical imaging is a standard component across a wide range of medical diagnosis and treatment processes. The detailed vision and vast volume of information that imaging technologies provide physicians have fostered early diagnosis, better therapy, and less disability.

The patented DRM image-processing feature of the 9900 Elite C-arm enhances the clinical diagnostic and treatment processes of fluoroscopic imaging by providing better, application-specific image resolution, a wider dynamic range and better detailing of anatomical visualization. The technology can contribute to higher procedure confidence for surgeons and provide an opportunity to help improve their surgical outcomes.

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