

SONIALVISION G4

Development of New SUREngine FAST Fluoroscopic Image Processing Technology for Gastroenterological Endoscopy

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1. Introduction

The Shimadzu SONIALVISION G4 is a X-ray fluoroscopy system equipped with a large field of view and high image quality flat panel detector. The G4's excellent image quality and ease of operation make it ideal for a range of applications, including tomosynthesis and bone mineral density measurement, and its usefulness in a wide range of clinical applications has earned high praise (Fig. 1).

We developed a new SUREngine FAST fluoroscopic image processing technology that enables technicians to perform fluoroscopy with reduced radiation and is ideal for use with increasingly common gastroenterological endoscopy. This article describes the technology and its applications.



Fig.1 SONIALVISION G4

2. Background

X-ray fluoroscopy systems used during endoscopic examinations and procedures for pancreatic and biliary system disorders require visibility of guide wires and other devices and it is important to reduce exposure dose to patients and medical

personnel because these procedures sometimes take a long time.

X-ray images are made by irradiating a human body with X-rays, collecting the transmitted rays, and converting them into an image, but natural variation in X-ray emission appears as noise and reduces the image clarity. When the exposure dose is reduced to minimize exposure levels, the noise component of the transmitted X-rays is increased. Minimizing the noise while achieving high image quality and lowering exposure levels at the same time is the main challenge for the systems.

Although recursive filters, which have been used to reduce noise in X-ray images, eliminate randomly generated noise by temporally integrating the images, they do this at the same spatial coordinates, which means that any movement in the subject creates image lags and reduces visual clarity. If a simple smoothing filter, such as a Gaussian filter, is used, it reduces the noise but decreases the image resolution also.

3. SUREngine FAST Characteristics

SUREngine FAST uses an auto filter function to reduce exposure dose and a new real-time image processing technology to reduce image lags and noise.

3.1 Use of an Auto Filter to Reduce Exposure Dose

A common way to reduce patient exposure dose is to use Beam Hardening Filters. The G4 has an auto filter function that automatically switches between 4 types of filters built into the collimator to suit the fluoroscopic and radiographic conditions. Filter thicker than normal is selected for this time to meet the requirements of gastroenterological endoscopic examinations and procedures, and this filter enables maintaining the amount of X-rays entering the detector while keeping the patient exposure

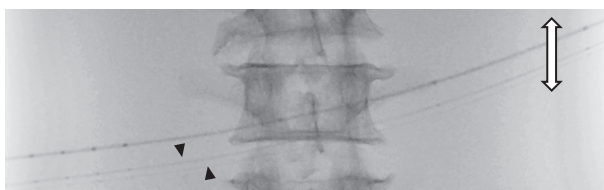
dose low. We also created new fluoroscopic tube voltage/current and image processing parameters. These parameters are bundled into presets to easily select the most appropriate parameters for each examination.

3.2 New Real-time Image Processing to Reduce Noise and Image Lag

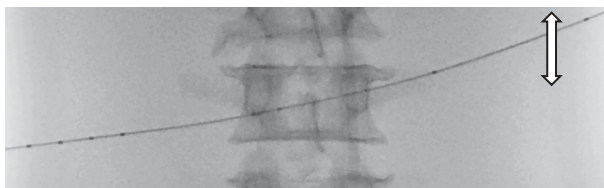
We equipped the G4 with new edge-preserving smoothing filter processing technology to reduce noise while maintaining image sharpness of guide wires and other small devices during fluoroscopy. SUREngine FAST can reduce noise while preserving the edge contrast of an object by separating it from the background and performing weighted addition. By combining this method with our existing frequency separation noise filter, it has become possible to clearly reveal moving objects while reducing background noise without image lags.

Figure 2 shows a guide wire being moved up and down over a lumbar phantom. When a recursive filter is used, image lags from 1 or 2 frames prior appear ((a) indicated by ▲), and the visibility of the guide wire is decreased. With SUREngine FAST (b), the guide wire is clearly shown with good contrast without any image lags.

The maximum pulse rate in pulsed fluoroscopy is 30 fps (or one image every 33 ms), so although this kind of image processing requires complicated calculations to be performed at high speed, the G4 achieved lag-free real-time image processing by mounting a Shimadzu dedicated high-speed image processing board.



(a) Without SUREngine FAST



(b) With SUREngine FAST

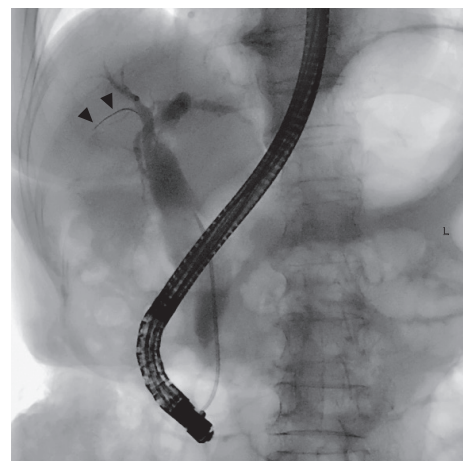
Fig.2 SUREngine FAST to Reduce Noise

3.3 Clinical Imaging Applications

Figure 3 shows images produced by the G4 during endoscopic retrograde cholangiopancreatography (ERCP). An image lag generated by a recursive filter during conventional processing can be seen at the end of the guide wire ((a) indicated by ▲). With SUREngine FAST (pulse rate of 15 fps), although the use of a filter enables the dose to be reduced to 40 % of the level compared with conventional processing, noise and image lags are minimized, and the movement of the end of the guide wire can be clearly observed ((b) indicated by ▲).



(a) Conventional Processing



(b) SUREngine FAST
(40 % of Conventional Processing)

Fig.3 Clinical Imaging Applications

The pulsed fluoroscopy rate can be halved to 7.5 fps for procedures that do not involve much movement, which can reduce the dose by 80 % (**Fig. 4**).

The G4's buttons on the operation console can be customized with frequently used functions (**Fig. 5**). These can be used to adjust the balance between exposure dose and temporal resolution by raising or lowering the pulsed fluoroscopy rate (fps).

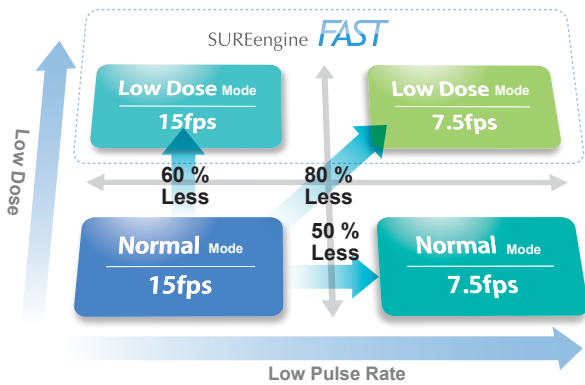


Fig.4 SUREngine FAST to Reduce Exposure Dose

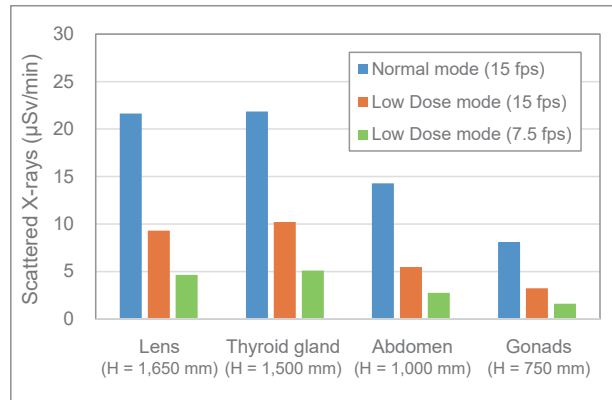


Fig.6 Reducing Technician Exposure Dose



Fig.5 Use of the Key Customization Function to Change the Pulsed Fluoroscopy Rate

3.4 Reducing Technician Exposure Dose

Figure 6 illustrates the measured amount of scattered radiation to which technicians are exposed during ERCP. Fluoroscopy was performed on a human phantom that simulated a patient undergoing ERCP. The scattered radiation doses to which the lenses, thyroid gland, abdomen, and gonads of a technician standing beside the patient would be exposed were measured.

The scattered X-ray dose to which technicians would be exposed is reduced by 60 % in SUREngine FAST Low Dose mode at 15 fps, and by 80 % at 7.5 fps, which is the same amount of reduction to patients.

4. Conclusion

SUREngine FAST is a new fluoroscopic image processing technology developed for decreasing exposure dose and increasing image quality during fluoroscopy mainly for gastroenterological endoscopy and its procedures. We hope that this technology can contribute to reducing the exposure dose to which patients and medical staff are exposed and to shortening of procedure times, which will increase the treatment efficiency by improving fluoroscopic image quality.

Acknowledgments

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