R/F

Device Enhancement Processing for fluoroscopy (DeEP*)

* Please contact us to check the availability of DeEP in your country.

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1. Introduction

Shimadzu is continuously engaged to improve the quality of fluoroscopy images and reduce radiation dose level with its R/F systems. This article presents a new feature for the SCORE PRO Advance (SPA) fluoroscopic image processing engine, which is called device enhancement processing, or DeEP. DeEP selectively enhances and improves the visibility of devices used in various kinds of examinations and procedures to (1) help procedures progress smoothly and reduced surgical stress, (2) shorten fluoroscopy times and reduced radiation doses to patients and operators, and (3) reduce the necessity of patient repositioning and lessen the burden on the patient.

2. Fluoroscopic Image Processing Engine SCORE PRO Advance

The SPA fluoroscopic image processing engine comes as standard with the SONIALVISION G4 LX edition R/F system **(Fig. 1)** and offers low radiation dose levels and image quality suitable for a variety of examinations. The fluoroscopic image processing technology in SPA was originally developed for Shimadzu angiography systems, and in addition to existing features such as recursive filter processing and multi-frequency processing, introduced two new features in (1) motion tracking noise reduction processing **(Fig. 2)** that reduces noise without generating lag images by detecting movement in localized regions of the image, and (2) object extraction-based edge enhancement processing **(Fig. 3)** that improves image sharpness by selectively processing contour structures. In the past, lag images were caused by the inter-frame processing used to reduce image noise, but SPA minimizes the influence of lag while also offering improved noise reduction and improved visibility of structures. These fluoroscopic image processing features are performed using proprietary high-speed image processing algorithms, which eliminate latency in image displaying that may impede examinations and procedures.

When integrating SPA into its R/F systems, we investigated which imaging parameters were best suited for each type of examination undertaken in the fluoroscopy room, such as detailed imaging of microstructures and natural visualization of the edges of barium contrast medium in upper and lower gastrointestinal studies, clear visualization and suppression of lag arising from guidewire movement in endoscopic retrograde cholangiopancreatography (ERCP) procedures, and

Fig.1 SONIALVISION™ G4 LX edition

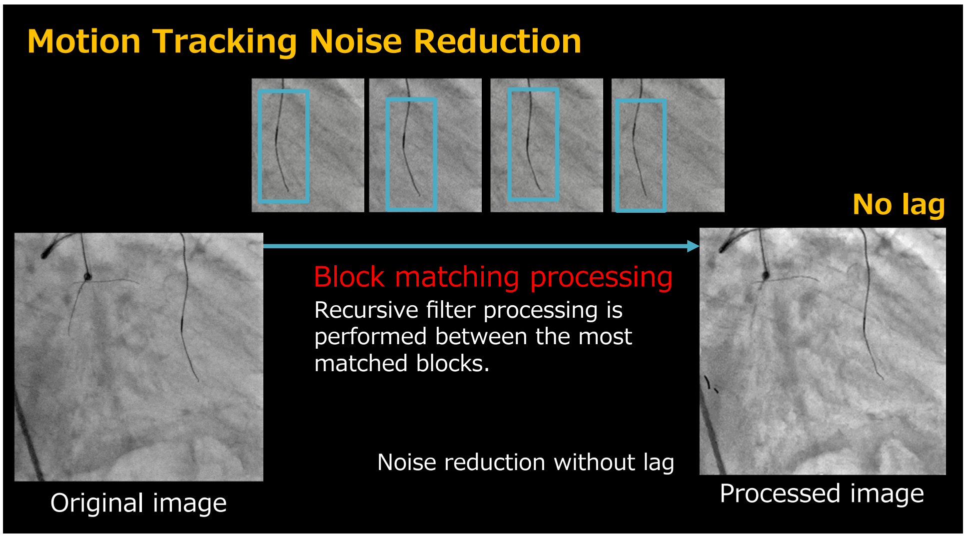


Fig.2 Motion Tracking Noise Reduction

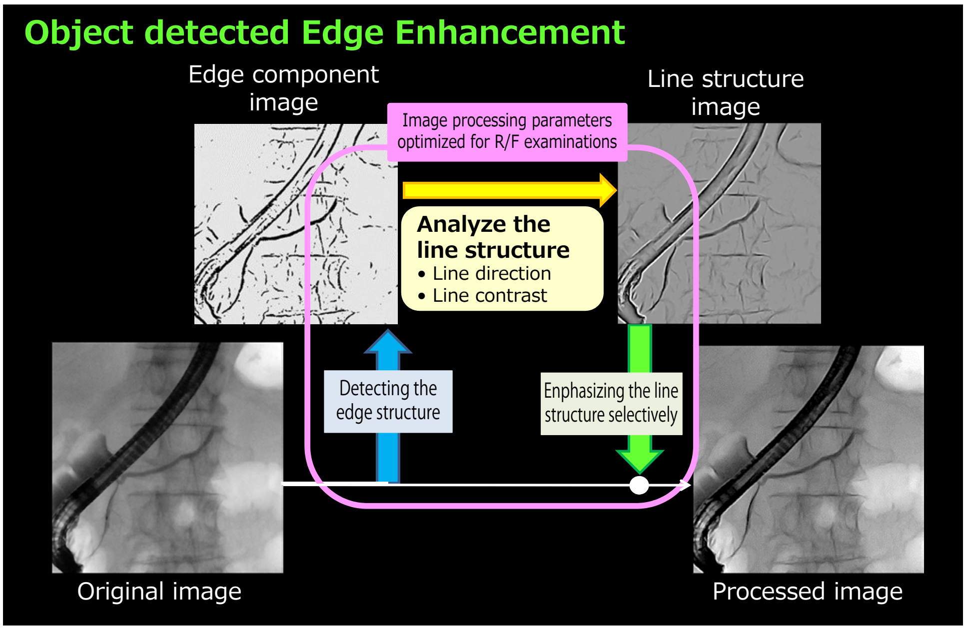


Fig.3 Object Extraction-based Edge Enhancement

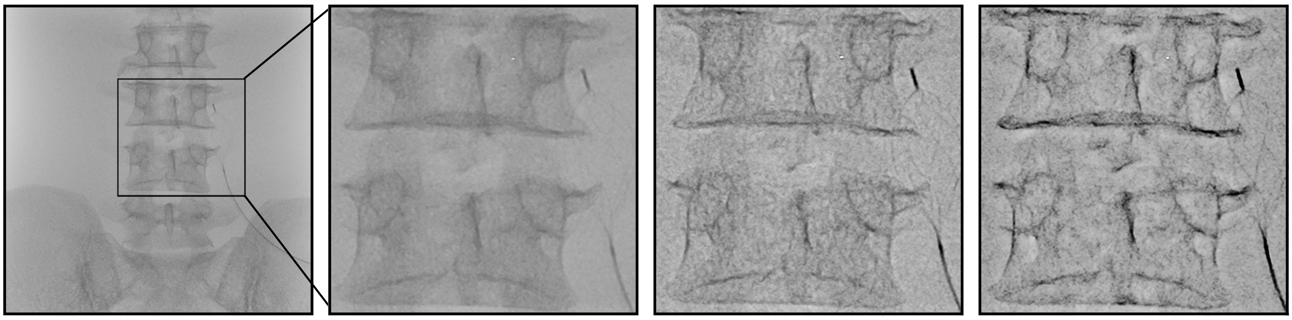
reduced granularity at low radiation dose images for pediatric or gynecological studies. The improvements in fluoroscopy image quality provided by SPA allowed images to be acquired at around 40 % of the radiation dose level of previous methods while maintaining image quality. The significant lag reduction achieved by SPA also allowed pulse rates to be lowered without loss of visibility for even lower radiation dose levels in certain fluoroscopic examinations and procedures.[1, 2, 3]

3. Device Enhancement Processing (DeEP)

DeEP was developed by re-engineering the object-extraction edge enhancement algorithm in SPA for devices used in ERCP procedures. Based on the low-noise/low-lag fluoroscopy images produced by the motion tracking noise reduction feature in SPA, the target frequency bandwidths and density difference thresholds in extraction of edge structures were examined, and the performance for detection and imaging of thin devices or devices made of materials with low radiopacity was increased to achieve higher device visibility without increasing the fluoroscopic X-ray dose.

Two types of DeEP fluoroscopy images are available in addition to SPA fluoroscopy images that already have a proven track record in the field. DeEP_High images are primarily intended for extracting and enhancing thin devices and DeEP_Low enhances devices while preserving background contrast information including contrast media and bones. Operators can switch between these DeEP fluoroscopy image settings during an examination to suit the procedure or point in the procedure. Images of a simulated ERCP setup **(Fig. 4 and Fig. 5)** show that DeEP improves the visibility of a stone retrieval basket and guidewires surrounded by contrast medium, including parts of these devices that overlapped bone. Evaluation in clinical cases has shown that fluoroscopy images enhanced by DeEP provide the following benefits during actual clinical ERCP procedures: faster device manipulation due to improved guidewire visibility, improved marker visibility that helps when deciding the position of stent placement and verifying stent deployment, easier confirmation of stent and mesh deployment, and easier monitoring of stone crushing.[4)]

Images in simulation of peripherally inserted central catheter (PICC) setup **(Fig. 6)** were acquired to examine the feasibility of applying DeEP to other than ERCP examinations and procedures. The images show that DeEP improved the visibility of a guidewire overlapping the mediastinum. DeEP also



(a) SPA fluoroscopy image **(b)** SPA fluoroscopy image **(c)** DeEP_Low fluoroscopy image **(d)** DeEP_High fluoroscopy image

Fig.4 Example DeEP fluoroscopy images (1). Stone retrieval basket (Ni-Ti) placed on lumbar phantom (PBU-3).
(a) SPA fluoroscopy image (full 12-inch field of view); **(b)**, **(c)**, and **(d)** are cropped from the center of image **(a)**. "Normal Dose" fluoroscopy dose mode used in all images.

(a) SPA fluoroscopy image **(b)** SPA fluoroscopy image **(c)** DeEP_Low fluoroscopy image **(d)** DeEP_High fluoroscopy image

Fig.5 Example DeEP fluoroscopy images (2). Guidewires placed over lumbar phantom and tubes filled with contrast medium.
(contrast medium: 300 stock solution, tube id: 4, 6, and 9 mm, guidewire od: 0.014 inches, lumbar phantom: PBU-3).

(a) SPA fluoroscopy image **(b)** DeEP_Low fluoroscopy image **(c)** DeEP_High fluoroscopy image

Fig.6 Example DeEP fluoroscopy images (3). Guidewire placed over chest phantom.
(guidewire O.D.: 0.025 inches, chest phantom: N-1).

increases influence of dynamic range compression, which should prove useful for reducing the influence of thoracic air space and abdominal intestinal gas during fluoroscopy.

4. Conclusion

This article introduces the DeEP device enhancement processing feature included in the SONIALVISION G4 LX edition. The improvements in device visibility achieved by DeEP is expected to (1) help procedures progress smoothly and reduced surgical stress, (2) shorten fluoroscopy times and reduced radiation doses to patients and operators, and (3) reduce the necessity of patient repositioning and lessen the burden on the patient. While taking on valuable feedback from a diverse range of health care professionals, We will continue its research into improving the visibility of all kinds of ERCP devices and applications for this technology in other than ERCP examinations and procedures, continuing to evolve its products for better medical care.

Finally, I would like to thank everyone at the Department of Gastroenterology, digestive Disease Center at Kyoto Katsura Hospital, the Department of Radiology at Kyoto Katsura Hospital, and the Department of Endoscopy at The Jikei University School of Medicine for their valuable cooperation and advice regarding the review of DeEP fluoroscopy images.

References

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