Development of the MiX Package for Trinias Angiography Systems

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1. Introduction

The Trinias series of flat panel detector (FPD)-equipped angiography systems includes a small filed-of-view system equipped with an 8 × 8-inch FPD and a system equipped with a 12 × 12-inch FPD that covers the full body. The Trinias series supports interventional procedures by the implementation of original image processing technology **(Fig. 1)**.
Advancements in stents and other interventional procedure devices, and the establishment of a variety of intervention techniques in recent years have brought the demand for high image quality and highly maneuverable angiography systems that support the work of the surgeon, as well as relieving burden on the patient. The recently developed MiX package further enhances the applications of Trinias systems in procedure support. This article describes the details of the MiX package.

Fig. 1 Trinias System (Single-Plane System)

1.1 MiX Package

The MiX package was developed with the aim of providing a "Minimally invasive eXperience (MiX)" in procedures that pose minimal burden and are patient-friendly. The package includes the features shown below.

- A trace mapping function that automatically extracts and displays the outline of blood vessels as an overlay onto the fluoroscopy image
"SCORE Map (TraceMap)"

- A function that displays stents in a fixed position in real time, enhancing system applications in cases of PCI procedure
"SCORE StentView+Plus"

- A 3D application that can link pre-procedure CT images with images from the angiography system during an ongoing procedure
"SCORE Navi+Plus"

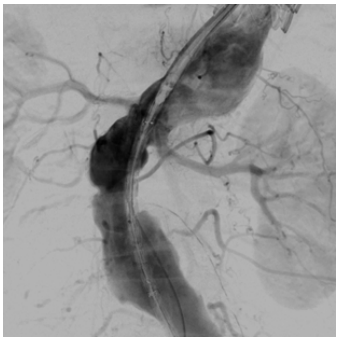
- A C-arm CT function equipped with a new model of FPD that improves low contrast resolution
"SCORE CT"

2. Technology Description

2.1 SCORE Map (TraceMap)

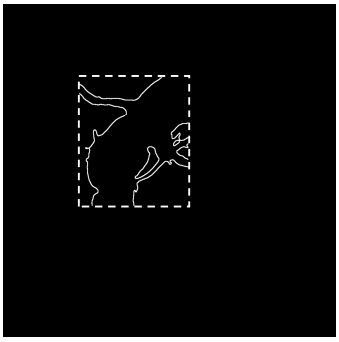
TraceMap is an application that produces an accurate guide for placement of stent grafts as well as a substantial reduction in contrast media usage.
TraceMap enables mapped fluoroscopy by automatically extracting the outline of blood vessels based on DSA images and displaying them overlaid with live fluoroscopy images. This results in a decrease in contrast media usage by precluding the frequent need for contrast media during manipulation and placement of wires and devices, and by showing the position of blood vessel junctions. TraceMap differs from normal inverse display mapped fluoroscopy by clearly displaying the inside of blood vessels on the fluoroscopy image, which supports accurate placement without obstruction of device manipulation.
Furthermore, the mapping region can be narrowed to only show necessary information, and additional positional information required for procedure can

be rendered and overlaid onto the fluoroscopy image. The mapped image can also adjust to changes in field-of-view size, so there is no need to recapture the DSA images.
A summary of the processing and behavior of TraceMap is shown in **Fig. 2**.

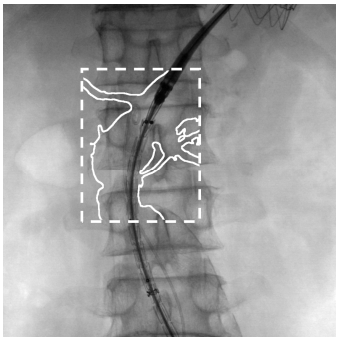


(a) DSA imaging performed, with the image to be used for mapping shown. Peak-hold image processing is used to generate an integrated image of the contrast media.

(b) Blood vessel outline extraction is performed. The size of blood vessels extracted and smoothness and thickness of the outlines are adjustable.



(c) Regions can be selected from the extracted images to remove areas unnecessary to procedure.

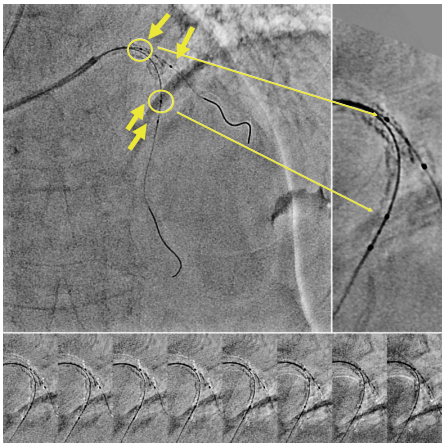


(d) The generated image of the blood vessel is displayed overlaid onto the fluoroscopy image.

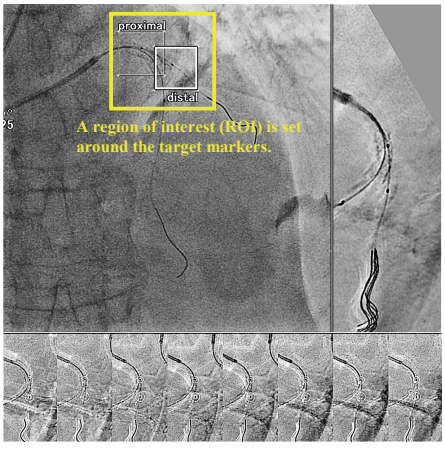
Fig. 2 Summary of TraceMap

2.2 SCORE StentView+Plus

SCORE StentView is cardiovascular interventional procedure support software for PCI applications that improves the visibility of in-place stents through the enhancement of weak stent image signals by real-time position-matching and averaging processing.
SCORE StentView detects in real time markers on devices that move with the pulse beat, and creates a fixed and enhanced image of the stent based on the position of those markers. When there are multiple devices and 3 or more markers or structures that resemble markers in the filed-of-view, SCORE StentView is sometimes unable to display enhanced images of the target device. SCORE StentView+Plus is capable of dealing with these cases, and widens substantially the range of applications of its use.
An example of using SCORE StentView+Plus in a case that includes multiple markers within the image, which has previously caused inconsistent marker detection, is shown as follows **(Fig. 3)**.



The image contains 4 markers. Previous SCORE StentView was incapable of consistent marker detection in this case.



Using SCORE StentView+Plus allows for consistent detection of the target markers by creating a region of interest around the target markers.

Fig. 3 Example Application of SCORE StentView+Plus

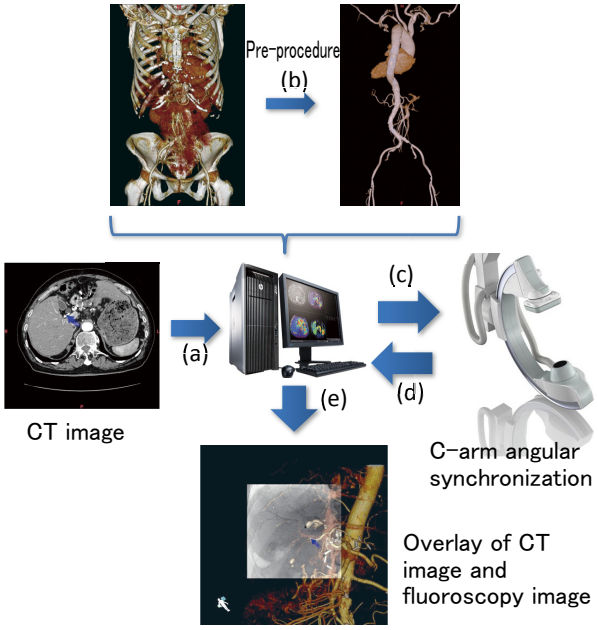
In this case there are 4 markers in the image. The previous SCORE StentView detected 2 out of the 4 markers as target markers and sometimes detected different markers in different frames, resulting in inconsistent stent image enhancement. The new SCORE StentView+Plus has the ability to specify a region of interest (ROI) around target markers, so the same markers are detected in each frame and consistent image enhancement is maintained.
When selecting the ROI, a proximal/distal direction can be specified, allowing the operator to specify the orientation in which the enhanced stent view is displayed on-screen.

2.3 SCORE Navi+Plus

SCORE Navi is an application that supports procedure by allowing the overlay of fluoroscopy images with C-arm CT images or 3D-reconstructed images using a 3D workstation. SCORE Navi+Plus is an improvement of SCORE Navi, and has been developed to allow the import of pre-procedure MDCT images into the Trinias system 3D workstation and navigation of these images during an ongoing procedure. The application imports MDCT images to support pre-procedure planning through the automatic extraction and analysis of locations that require procedure, and acts as a guide during ongoing procedures for positional matching and overlay of fluoroscopy images with angular synchronization of the C-arm. This provides the benefit of seamless processing from pre-procedure planning to navigation during the procedure. A summary of this application is shown in **Fig. 4**.
Procedures can be performed while referencing pre-procedure MDCT images overlaid according to position with C-arm CT images. This allows for easier understanding of the 3D alignment of blood vessels, and also supports interventions by allowing overlay of fluoroscopy images when required.

2.4 Improvement of SCORE CT

The MiX package is equipped with a new FPD model that improves on the previous 14 bit SCORE CT image processing with 16 bit image processing **(Fig. 5)**. Using 16 bit image processing results in 4 times the number of gray scale, and improved low contrast resolution for image reconstruction.
The move to 16 bit also increases the amount of data by 4 times, but the system has been designed to keep the time from exposure to reconstruction the same as the previous 14 bit system.
A comparison of the new FPD model and previous FPD model using a phantom to evaluate low contrast resolution is shown in **Fig. 6**. The images show that visibility in low contrast areas is improved compared to the previous FPD model. This improvement in image quality is expected to find application in areas that demand low contrast resolution, such as to confirm bleeding or stent placement in the head.



Images provided by Yamato Takada Municipal Hospital

Fig. 4 Summary of SCORE Navi+Plus
- **(a)** Import of CT images to 3D workstation
- **(b)** Automatic extraction of just the area for procedure by the 3D workstation
- **(c)** Movement of C-arm to angle planned for MDCT images
- **(d)** MDCT image displayed aligned with C-arm angle
- **(e)** Overlay of fluoroscopy images and CT images in real time during fluoroscopy

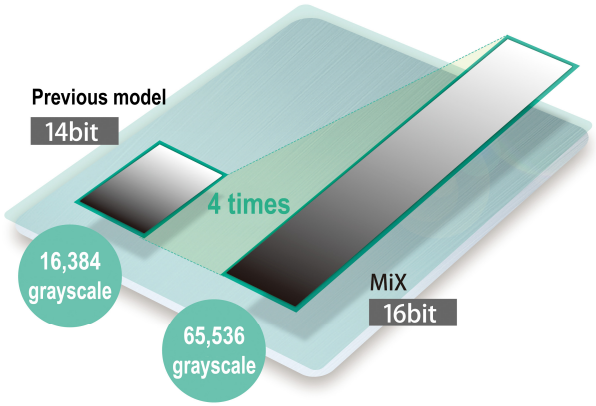


Fig. 5 SCORE CT Improvements

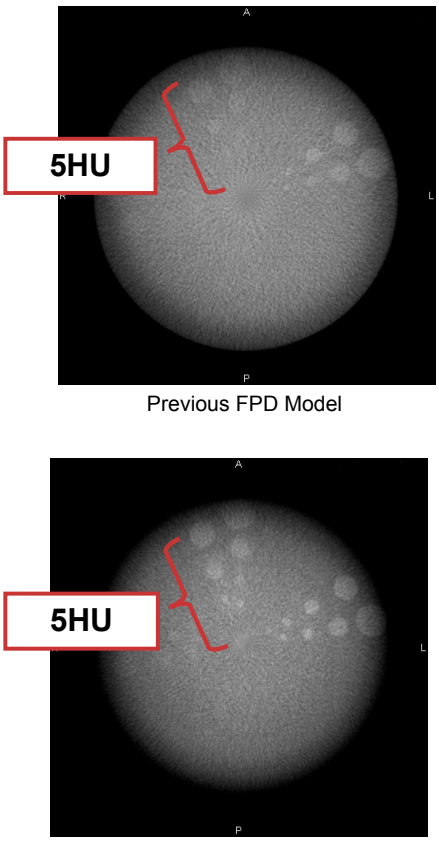


Fig. 6 Experimental Comparison of SCORE CT Low Contrast Resolution

3. Conclusion

The Trinias system MiX package described in this article has been developed to focus on minimally invasive interventional procedures. The developments employ technology that communicates with other modalities, technology that communicates with other systems and images in case of C-arm CT images, and digital image processing technology that improves the speed of image processing, all of which support a diverse array of interventional procedures. This article concludes with the hope our customers will find these new technologies useful. Finally, we also wish to use this opportunity to express our gratitude to the various people who have cooperated in product development.