Advanced image processing with automatic stitching and manual adjustment capabilities produce a composite long-length image without visible seam-line artifacts

Review of Analog Screen-Film Imaging Geometry

Special cassettes and films of extended length are used when imaging a long segment of the human body with the analog screen-film technique. The X-ray source and the cassette are both centered to the anatomical regions to be examined, the X-ray collimator is adjusted to cover the entire imaging area, and then a single X-ray exposure is performed (Figure 1).
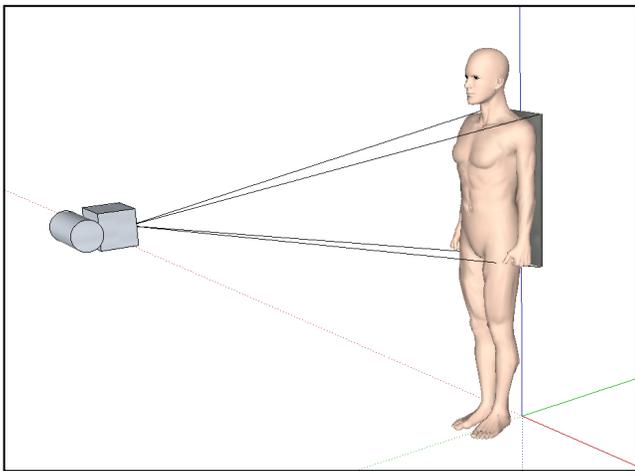
Figure 2a – Source-tilting method, where the X-ray source tilts and aims to the detector

Figure 1 – Imaging with analog screen-film, where a single exposure covers the entire anatomical region

Approaches with Flat-Panel Digital Radiography

Flat-panel digital radiography detectors are usually limited to 43 cm in size. For long-length imaging applications this would require separate exposures to be taken from different regions of the anatomy. In order to create a large, composite image for diagnosis, the individually captured images need to be stitched together.
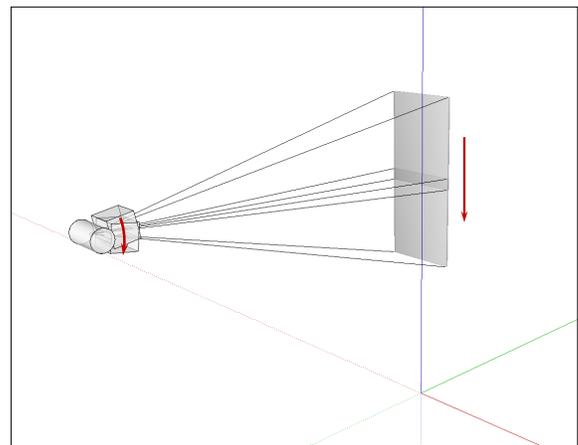
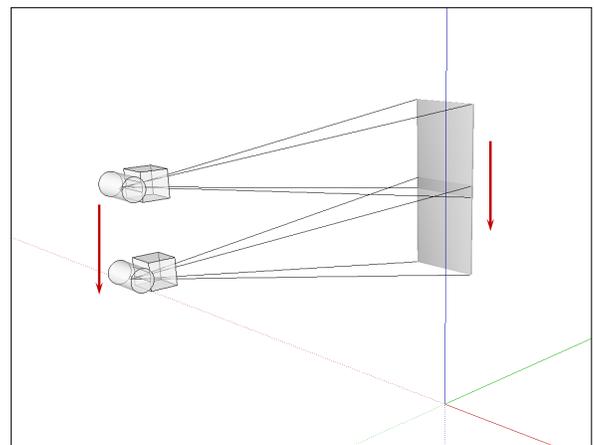**Figure 2b – Source-translation method, where the X-ray source translates during exam**

Two primary approaches are available to acquire long-length imaging exams with flat-panel detectors (Figures 2a & b). In both methods, the detector moves from one imaging position to the next behind the patient. The difference resides in how the X-ray source moves in order to track and expose the detector. In the source-tilting method, the X-ray source focal-spot position is stationary and centered to the anatomical region being examined. The central X-ray pointing direction varies from one exposure position to the next to deliver the X-rays to the detector. In the source-translation method, the X-ray source focal spot position is not stationary, but translates synchronously with the detector in the detector-motion axis.
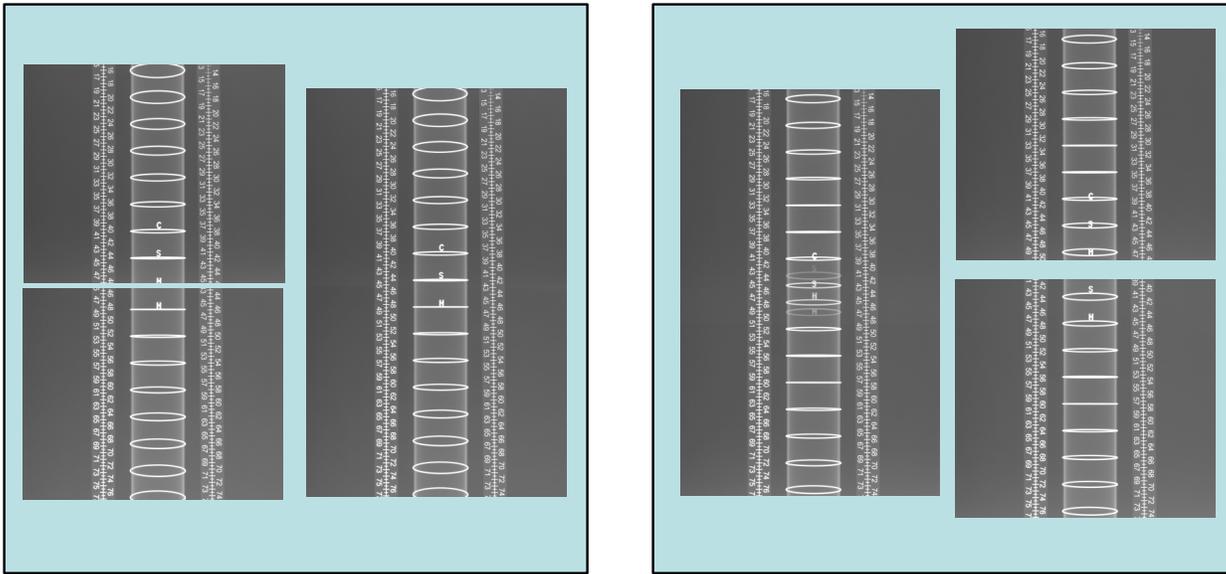

Figure 3 – Individual and stitched image examples captured with the X-ray source-tilting method (left) and with the X-ray source-translation method (right)

The CARESTREAM DR ImageView Long-Length Imaging System adopts the source-tilting method because it completely emulates the analog screen-film imaging geometry. It's also free of the parallax artifact inherent in the source-translation method.

Figure 3 shows two sets of individual and stitched image examples, one captured with the source-tilting method, and the other with the source-translation method. The phantom in the images is made of a plexiglass tube, 75 mm in diameter with copper rings arranged at 25 mm apart. The "CSH" lead markers are placed in the front of the tube (the side closest to the X-ray source), and two radio-opaque rulers are placed in the back as reference for stitching. Perfect stitching is achieved with the source-tilting method but not with the source-translation method. Because of parallax distortion, the source-translation method always introduces severe artifacts and greatly degrades the geometric integrity of the anatomical features in the stitched image, particularly in the stitch overlap regions.

Automatic Image Stitching and Overlap Blending

The CARESTREAM DR ImageView Long-Length Imaging System automatically stitches the captured images with high geometric accuracy. The major operation steps are shown in Figure 4. In the detector motion axis, a high-precision hardware encoder reports the exact detector travel distance between exposures. In the direction transverse to the detector motion axis, sophisticated software algorithms automatically analyze the anatomical edge features in the overlap regions to find the best alignment between any two adjacent images. The total stitch error has been demonstrated to be less than 5 image pixels under stringent exposure conditions, which is equivalent to less than 0.7 mm.
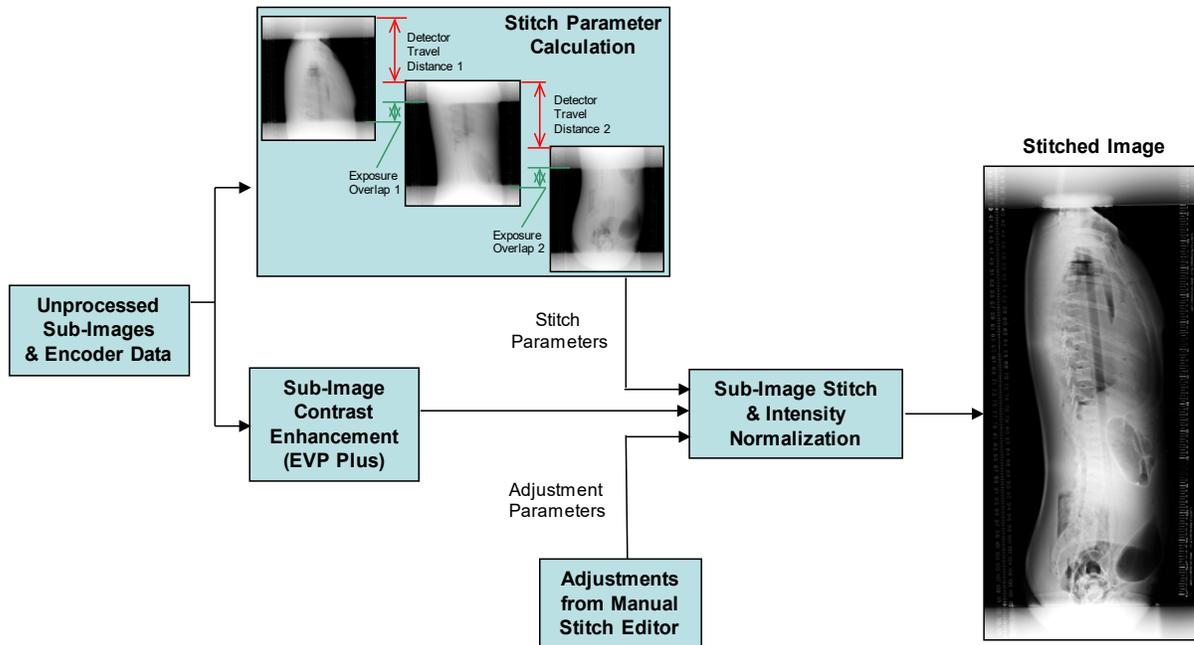
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Figure 4 – Image stitch algorithm flowchart

Automatic exposure control (AEC) can be used during the long-length imaging exams in order to apply just the right amount of exposure to each particular anatomical region at the minimally required image quality. The resultant exposure levels of the individual images, however, may vary dramatically from one anatomical region to the other. The CARESTREAM ImageView EVP Plus Software automatically adjusts the exposure discrepancies and compensates for the latitude differences, therefore providing the best image presentation that is individually optimized for each image and its corresponding anatomical region.

The image-processing algorithm stitches the individually optimized, display-presentation-ready images together to create a smooth and seamless composite image for diagnosis. Each image is first decomposed into a series of multi-resolution spatial-frequency pyramid bands representing anatomical features of different sizes. Image-blending starts with stitching the lowest bands for the coarsest features, followed by upscaling for the finer features, until all the bands are stitched. The seam line between any two images is naturally blended without any visible artifacts during this process.

Manual-Image Stitching

The CARESTREAM DR ImageView Long-Length Imaging System allows users to manually adjust and fine-tune the stitch positions after the automatic stitch operation (Figure 5). This can help to compensate for patients' small movements during the exam and to avoid retaking exposures.
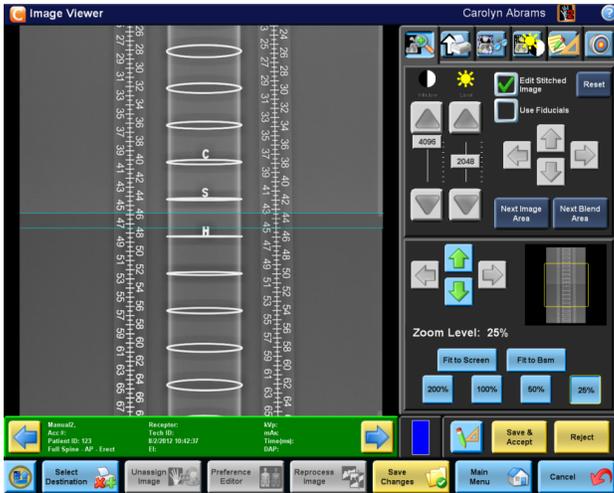
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Figure 5 – User interface, integrated manual-stitch software

The manual-stitch option is also very useful when the high-precision hardware encoder is not installed with the system.

In this case the software starts with the automatic stitching algorithm to estimate the best stitch position in both the detector motion axis and the transverse axis, in order to provide an initial high-quality, stitched composite image to the user. The user can either confirm the stitched result or make small manual adjustments, if necessary.

Conclusion

The CARESTREAM DR ImageView Long-Length Imaging System uses the source-tilting method to capture artifact-free long-length images. Automatic stitching provides highly accurate alignment, and advanced image processing produces a composite image with no visible seam-line artifacts. Manual adjustment of the stitching is possible to compensate for patients' small movements or the lack of a system hardware encoder.