## Digital image processing requirements in fluoroscopy

Addressing these challenges requires new image processing technology that must comply with the real-time requirements of fluoroscopy. To enable consistent use of low-dose settings, this technology must allow efficient noise suppression and correct representation of diagnostic details even at a low dose level.

To address the imperative for correct brightness and contrast, it must provide a robust, fully automatic stabilization of image brightness over time, as well as fast enhancement of the diagnostically important image content. To decrease the physical burden and manage the radiation exposure that long examinations and re-examinations place on patients, it must promote correct image representation that reduces the need for manual adjustments, enabling operators to focus on the patient and the procedure, rather than the device and its settings.

## More clarity and confidence with Dynamic UNIQUE

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| **Radiologist's challenges** | Difficulty distinguishing between very small anatomical structures/ details and noise. Low dose settings add to the difficulty and can result in longer fluoroscopy times and could make diagnosis more challenging. | Difficulty observing the whole image immediately. The eyes must adjust, which adds time to diagnosis and causes eye fatigue. | Difficulty distinguishing small, low-contrast structures from high-contrast structures, possibly resulting in more exposures. |
| **Philips answers** | **Intelligent spatio-temporal noise suppression**<br>• Temporal (inter-frame): Intelligent motion detection for signal averaging in regions without motion<br>• Spatial (intra-frame): Based on a physical noise model for consistent noise suppression | **Temporal brightness stabilization**<br>• Real-time adjustment of contrast and brightness | **Multiscale image enhancement in real-time**<br>• Harmonization of high-contrast and low-contrast structures<br>• Very low computation time for processing every frame |
| **Benefits** | **Reduced noise impression -improved detail visibility**<br>• Anatomical details are preserved in every image<br>• No artifacts of moving structures, no lag effect<br>• No shadows of catheters, tubes and lines<br>• Less risk to miss important details<br>• More confidence | **Optimal image stability for fluoroscopy** and spot images at any time<br>• Comfortable viewing at high quality<br>• Less risk to re-acquire<br>• Fast and stable<br>• Less lost time through less time needed to adapt to the luminosity<br>• Quicker workflow<br>• More confidence<br>• Less tiring for the eyes | **Optimal representation and visibility of diagnostically important information**<br>• Enhancement of diagnostic details<br>• (e.g., small vessels, catheters)<br>• No enhancement artifacts<br>• No image clipping<br>• Less risk to miss important details<br>• More confidence |

With Dynamic UNIQUE, Philips offers a modern, elaborate, multi-scale digital image processing that addresses the diagnostic challenges of fluoroscopic X-ray examinations. Exploiting the speed and performance of modern data processing hardware to permit high-quality image processing in real-time. It features intelligent spatio-temporal noise suppression, temporal brightness stabilization, and real-time multiscale image enhancement.

## Conclusion

Dynamic UNIQUE is a modern image processing technology, designed to support the operator in performing fluoroscopic examinations fast and safely, even at low dose levels.

It meets the challenges of modern fluoroscopy by combining a robust, artifact-free, easy-to-use multiscale image enhancement with intelligent noise suppression. The diagnostic information of each frame is displayed in real time, with great clarity, the correct brightness, and very low latency. The image representation is consistent and stable even when the image content varies rapidly.

This new level of image quality is also available when documenting clinical cases. All Philips fluoroscopy systems equipped with Dynamic UNIQUE offer as a standard feature the ability to record fluoroscopy sequences without restrictions on duration.

References


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* Patent pending.




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Dynamic UNIQUE

Digital fluoroscopy solutions

# Dynamic UNIQUE

# Advanced digital image processing for clinical excellence in fluoroscopy


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**Digital image processing challenges in fluoroscopy**
Modern fluoroscopy poses several challenges for digital image processing. First, low-dose settings are commonly used today in clinical practice (see side box and Ref. 1), particularly for children, who are most sensitive to the damaging effects of ionizing radiation. While a reduction in dose is always desirable[2,3], these settings inevitably result in images with high quantum noise, which may be difficult for radiologists to read.

Second, because fluoroscopy means live viewing, relevant diagnostic information in the images must be visible straightaway at the correct level of brightness and contrast. Furthermore, because the human eye is very sensitive to temporal variations, the contrast and brightness impression must be stable over time. This is particularly challenging in view of the rapid temporal variations occurring in fluoroscopy, particularly with respect to:

- The body region under examination, e.g. when examining the esophagus
- The field-of-view, e.g. when moving the patient or modifying the collimated area
- Areas of direct radiation
- The distribution of the contrast agent
- The dose level

Third, diagnostically relevant details such as catheters or small vessels must be visible with great clarity, even in challenging viewing conditions with large variations in tissue radio-density. Clarity is essential to reduce exam length and dose, and is particularly important for pediatric patients, as well as for those who are immobile or very sick.

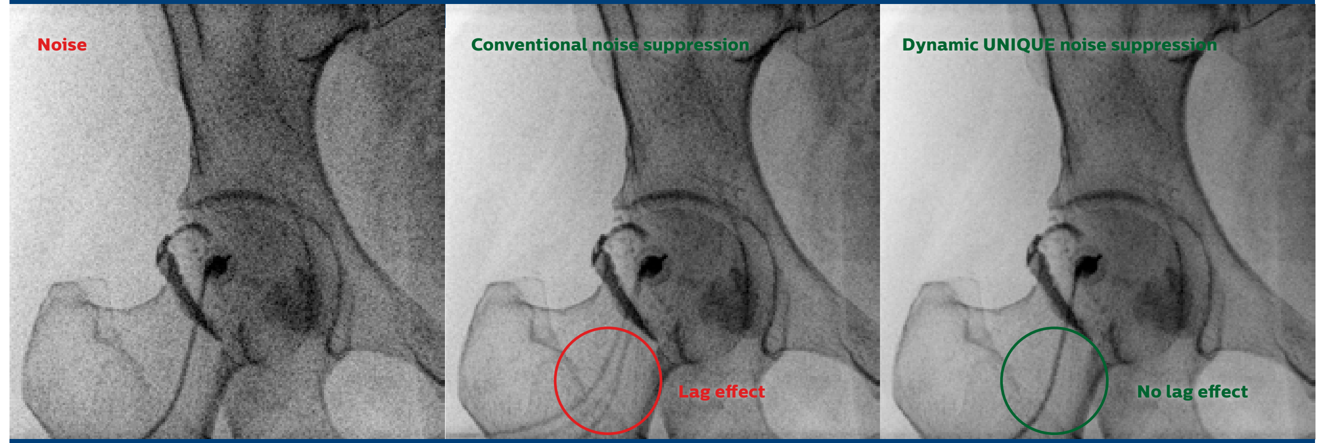
**Low-dose fluoroscopy with unrivaled Philips GCF technology**
During the past two decades, the dose level in fluoroscopy has been reduced to only a fraction of the level needed with continuous fluoroscopy[4,5,6]. This was achieved by hardware innovations enabling *pulsed fluoroscopy*. In the beginning, two variants existed: *generator-pulsed* and *grid-pulsed* fluoro. Both techniques include after-pulse adjustments for exposure optimization. A second major breakthrough happened in 1995, when Philips introduced in-pulse control for *grid-controlled* fluoroscopy (GCF) for the first time. GCF enables independent optimization of each pulse in real time by fast readout of the dose rate signal[7]. Even today, Philips is the only vendor offering this technology.

### Intelligent spatio-temporal noise suppression
Dynamic UNIQUE combines noise suppression by temporal averaging (inter-frame) and spatial noise suppression (intra-frame).

#### Temporal noise suppression
Temporal averaging, which accumulates the dose of successive frames, results in a depiction of static anatomical structures that mimics high-dose acquisition. However, it may fail in areas of motion. Dynamic UNIQUE suppresses temporal averaging when movement is detected, preventing lag and shadowing of moving structures.

#### Spatial noise suppression*
In moving regions of the image and if the sequences are very short, Dynamic UNIQUE applies spatial noise suppression. It uses a physical noise model to assess the contrast-to-noise ratio, which allows for structure-adaptive noise suppression within a single frame. The strength of the spatial noise suppression is adapted to the strength of the temporal noise reduction in adjacent areas. As a result, the image noise level is kept consistently low over the entire image.

**Figure 1: Example of spatio-temporal noise suppression.**



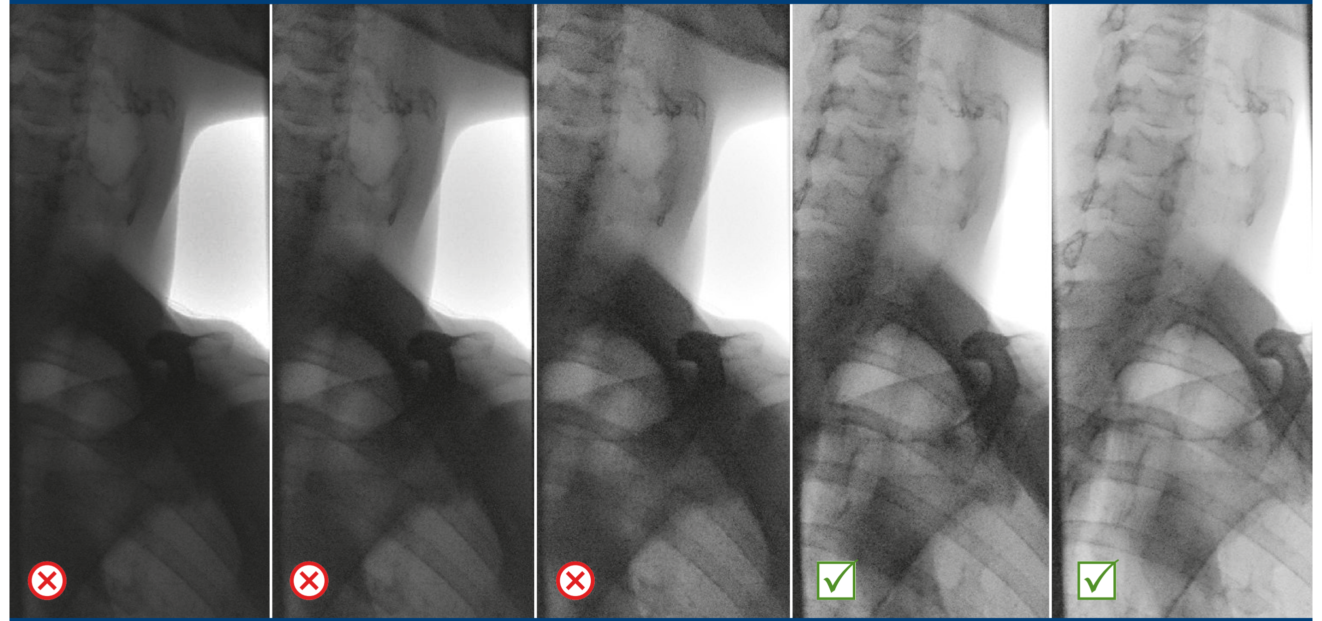

Original image without noise suppression.

Noise suppression by simple temporal averaging produces a strong lag artifact of the moving catheter such that the actual catheter position cannot be determined.

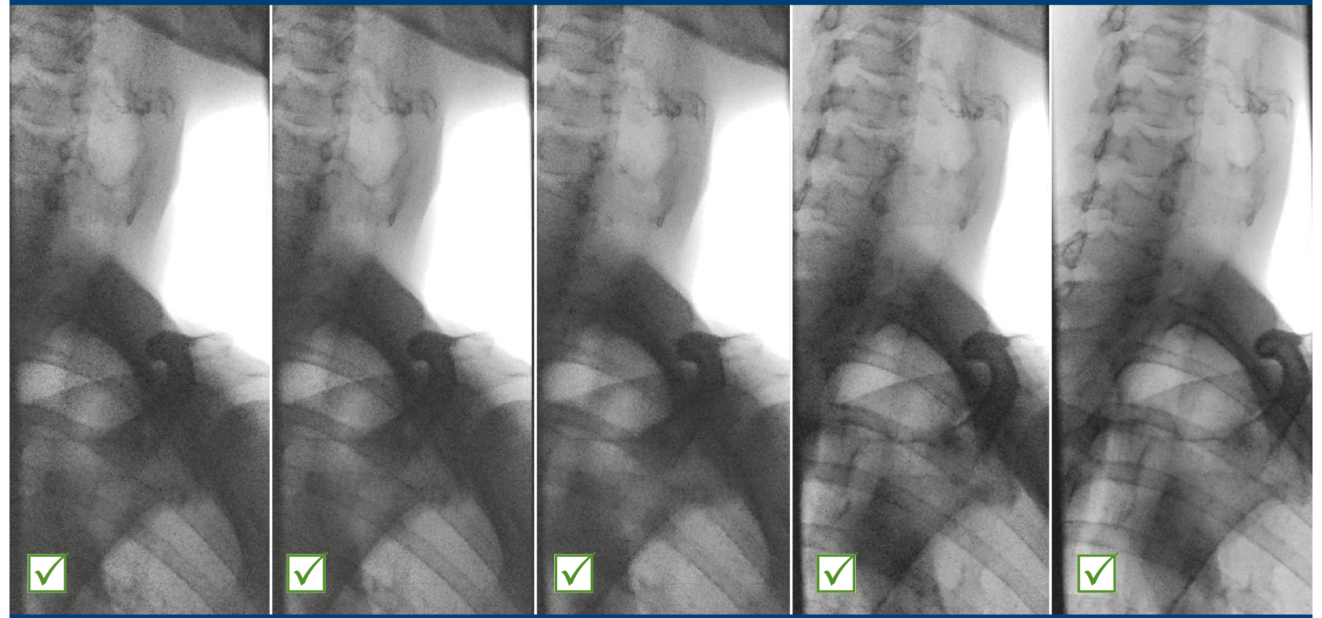
Dynamic UNIQUE reduces noise efficiently through the intelligent combination of spatial and temporal noise suppression, without image lag.

### Temporal brightness stabilization
When the dose level or the field-of-view is modified (e.g., by modifying its size, by shifting it from the body center to the periphery, or by moving the patient), Dynamic UNIQUE automatically determines the signal level in the anatomical region and maps it to an appropriate brightness level. Areas of direct radiation are reliably detected and excluded from the brightness adjustment*. In contrast, simpler methods include areas of direct radiation in adjustments, resulting in dark images and obscured anatomy, as well as annoying flickering.

**Figure 2: Example of brightness stabilization in a moving patient.**



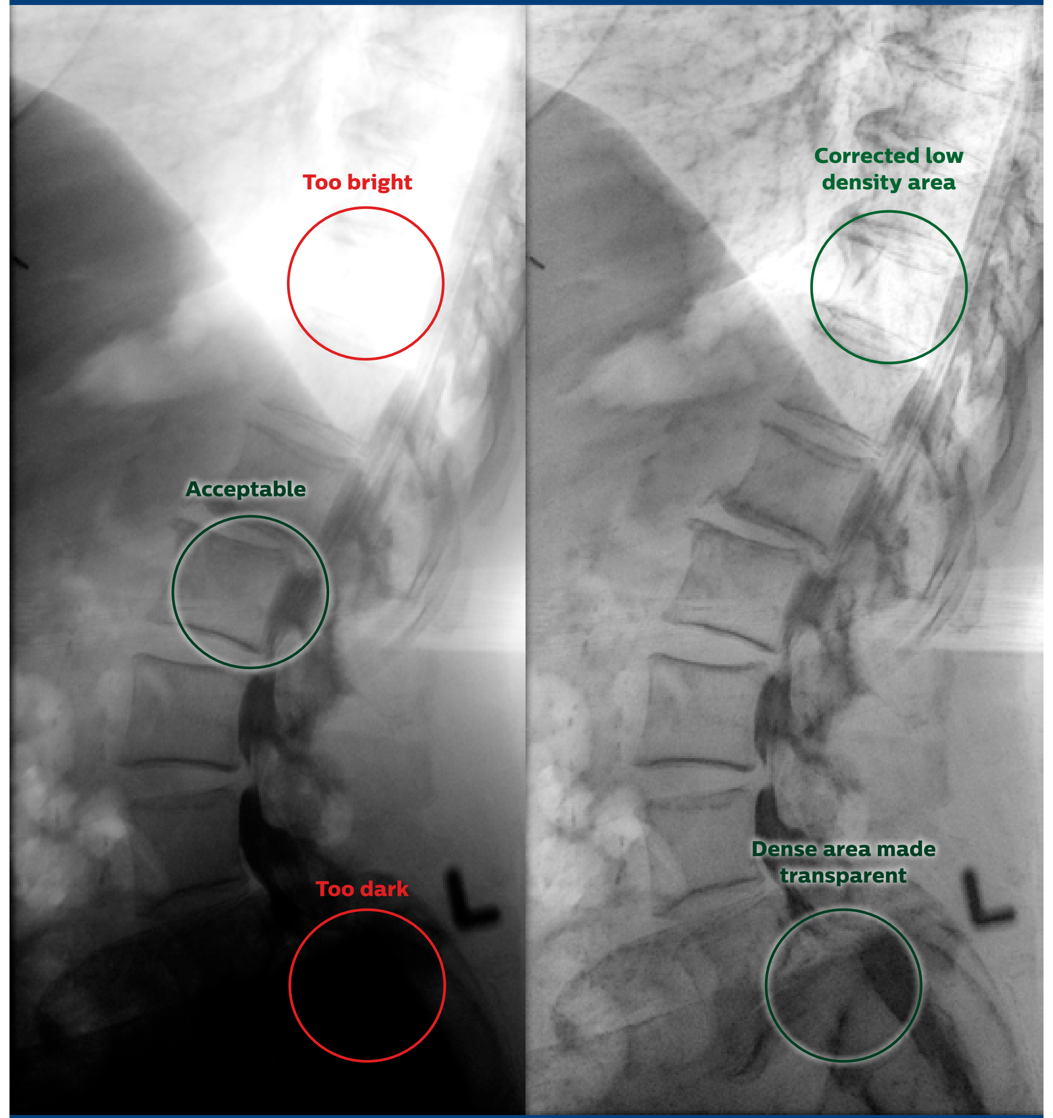
Fluoroscopy sequence without temporal brightness stabilization. The anatomical details are visible only after correct positioning of the anatomy.



Dynamic UNIQUE determines the signal level in the anatomical region reliably detecting areas of direct radiation. It maps this signal level to an appropriate brightness level regardless of positioning.

### Real-time multiscale image enhancement
Dynamic UNIQUE is a second-generation multiscale image enhancement that provides a high level of detail, according to the diagnostic need, in real time. Each and every single frame is fully processed, without significant additional computation time (below 14 ms for fluoroscopy, below 55 ms for exposures), even at very high frame rates (up to 30 fps). Therefore, the diagnostically important image content is optimally enhanced according to the clinical task. Dynamic UNIQUE features a perfect harmonization of areas filled with contrast agent, soft tissue, and bones, even in challenging viewing conditions with large variations of the radio-density of the tissue. Contrary to traditional multiscale enhancement algorithms, the novel Dynamic UNIQUE processing strictly separates global and local contrast enhancement, preventing undesired enhancement artifacts*. If desired, it is easily customizable according to the diagnostic need..

**Figure 3: Example of representation of the diagnostic details for a lateral myelography.**




Dose-proportional detector values are mapped to gray values without real-time multiscale image processing. Image information is lost in the dark and bright areas.

Dynamic UNIQUE provides a much higher level of detail in all image areas in real-time.