CT / Scientific Review

3D Landmark Scan: The Future of Diagnostic CT Planning

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Before a diagnostic CT scan acquisition, one or multiple X-ray images (localizers) are acquired to aid in the selection of the region to be scanned and to allow for the automatic modulation of the tube current. These localizers need to be informative and of sufficient quality to allow for an accurate selection of the patient's field of view (FoV) and scan range, to avoid an under- and over-exposure of the patient. Importantly, they should deliver a negligible absorbed dose to the patient. Following the ALARA principle, this ultra-low dose (ULD) requirement is essential, as these images are typically only used for the aforementioned purposes and do not take part in the clinical decision-making process of patient management. Therefore, the dose requirements for this type of images are especially strict.

Traditionally, localizers take the form of one or two planar X-ray images. The acquisition of a single localizer – typically in the antero–posterior direction – yields, obviously, a very low nominal radiation dose. However, due to the difficulty in determining the correct exposure parameters if the patient is not perfectly centered in the scanner, it could often result in the acquisition of an under- or over-exposed CT image [1]. Using two localizers (acquired along the antero-posterior and lateral directions) helps mitigate this issue. In fact, adding a second perpendicular view results in additional information on patient attenuation, which in turn yields a more accurate estimation of the patient body composition. Consequently, it yields a more accurate modulation of the tube current to be used during the diagnostic CT exam. Under this premise, if additional views were to be added, the accuracy would likely increase further, thanks to the even more precise information on patient's body composition that could be retrieved.

The solution developed by Canon pushes this concept to the limit: acquiring a sufficient number of views to result in a full three-dimensional (3D) image. This approach (3D Landmark Scan) involves a 120 kV helical acquisition with SilverBeam filtration – another Canon technology that achieves ULD capabilities by hardening the X-ray beam entering the patient body. This ULD 3D image is immediately reconstructed and displayed on the scan console, and is coupled with an Artificial Intelligence (AI)-based software that automatically identifies over 100 anatomical landmarks throughout the patient's body (Anatomical Landmark Detection, ALD).

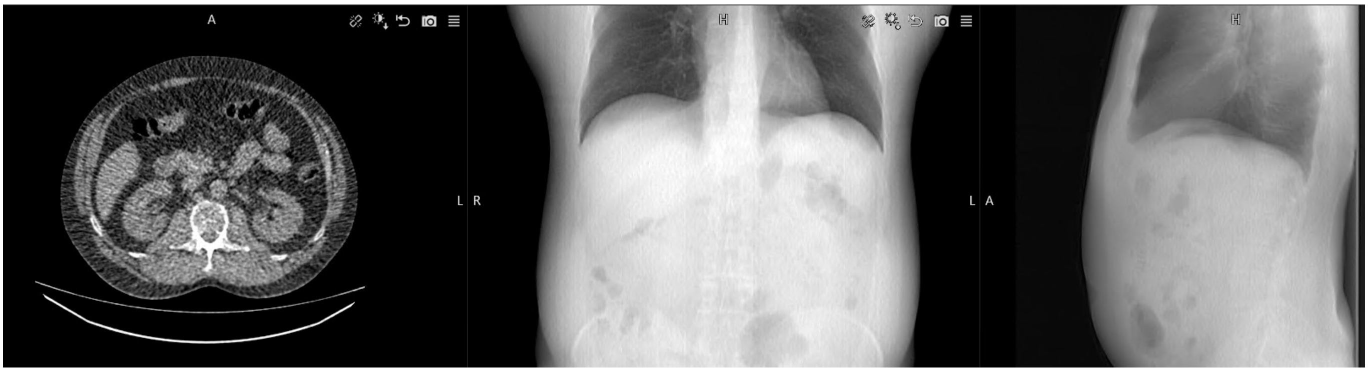
This approach has several advantages. The access to the full 3D patient information improves the understanding of the patient's body composition, optimizing the tube current modulation and avoiding under- or over-estimation of the scan acquisition length, and hence resulting in a more accurate CT scan. These advantages were demonstrated in scientific literature, where Golbus et al. showed how the 3D Landmark Scan and the ALD result in more consistent imaging of patients, and avoid over-estimation of the scan acquisition length in chest, abdomen, and pelvis, also in patients with a large body mass index (BMI) [2]. This, together with the high dose efficiency of the Canon CT detector, allows for a significant reduction of the radiation dose delivered during the diagnostic CT examination (dose reduction larger than 23%) [2].

In addition to its dose-saving capabilities, this technology can also aid in patient positioning. Thanks to the 3D visualization of the patient's body and its anatomical landmarks, positioning at the isocenter of the scanner becomes easier. This not only allows for faster workflow [3] and faster and easier training of radiographers, but also eases the achievement of optimal image quality in the subsequent diagnostic CT image.

Although it provides a full 3D image, the 3D Landmark Scan results in lower organ dose and lower effective dose compared to any pair of 2D localizers. This was demonstrated by Oostveen et al. for a range of BMIs using computational anthropomorphic phantoms [4]. Considering that a pair of 2D localizers can contribute up to 20% of the total effective dose delivered to a patient [5], the authors conclude that using the 3D Landmark Scan can reduce the overall effective dose of a diagnostic CT examination.

The potential of the 3D Landmark Scan could also extend beyond its primary application as a localizer. In fact, thanks to its 3D nature, to the SilverBeam technology, and to the possibility of being retrospectively reconstructed with Canon's iterative and deep learning reconstructions (Adaptive Iterative Dose Reduction 3D [AIDR 3D] and Advanced intelligent Clear-IQ Engine, [AiCE]), it may prove to be useful for specific clinical tasks.

As an example, Golbus et al. showed its usefulness in estimating the coronary artery calcium, avoiding ECG gating, and without the need for a diagnostic CT image [6]. This example represents an exciting opportunity for overall dose reduction, workflow improvement, and cost saving, and might pave the way for the introduction of the 3D Landmark Scan in an increasing number of clinical applications in the future. These may include, for example, ULD CT fluoroscopy, pre-planning for interventional procedures, ULD pre-contrast imaging, virtual colonoscopy, kidney stone imaging, and ULD chest imaging.



Example of 3D Landmark Scan for a CT abdomen acquisition. The 3D Landmark Scan is automatically displayed as a 3D image (transverse slices), and as two intensity projections in the antero-posterior and lateral views. The 3D Landmark Scan was acquired with 120 kV and 50 mA (CTDIvol 0.2 mGy).

References

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