iTRIM – a New Method for Improving Temporal Resolution in Cardiac Computed Tomography

Iterative techniques can be used to increase temporal resolution, a key parameter in cardiac imaging. On Siemens’ SOMATOM Perspective, iTRIM is used to obtain an effective temporal resolution as low as 195 milliseconds.

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High temporal resolution is one of the most important parameters in cardiac imaging. Utilizing conventional cardiac image reconstruction algorithms, the highest achievable temporal resolution in the isocenter of a CT image is determined by the time the scanner needs to acquire 180° of CT projections, i.e. a half-rotation of a single source scanner. High-end Single Source CT scanners thus owe their good cardiac imaging performance and high temporal resolution to sophisticated and expensive scanner hardware that allows the acquisition system to be rotated faster.

As an alternative to sophisticated hardware designs, image reconstruction algorithms can be used to improve temporal resolution. A long-known method of improving the temporal resolution in slower scanners is multi-segment image reconstruction, utilizing data from more than one cardiac cycle. Taking data from up to two heart beats (bi-segment approaches) is still a reasonable option for improving temporal resolution. For multi-segment approaches that use data from more than two heart cycles, the disadvantages clearly outweigh the benefits. Disadvantages are a sub-optimum dose efficiency, higher overall scan times, and unreliable performance, since even slight motion irregularities between heartbeats can cause image artifacts.

Siemens has therefore developed iTRIM (Iterative Temporal Resolution Improve-
ment Method), which is designed to further reduce the temporal resolution of cardiac CT images on systems not offering the highest possible rotation speeds. This novel iterative image reconstruction algorithm improves the temporal resolution by 20%, effectively reducing motion artifacts in CT images while maintaining a very good overall image quality and low image noise.

iTRIM is based on the observation that the presence of motion artifacts does not significantly change the histogram of a CT image. This information is used to reconstruct an image from less than half a turn of data. First, a partial cardiac scan is performed with weighted filtered back projection (WFBP), resulting in a temporal resolution equivalent to 180° of CT data. For each pixel, the system then computes a histogram within a quadratic region centered on the pixel, as shown in Fig. 1. An iterative reconstruction algorithm is then started, using only a subset of the full 180° cardiac dataset. The size of this subset (e.g. 140°) is adapted to the target temporal resolution. In order to expedite convergence, a normal WFBP image is used as a start image for this iterative algorithm. The iterative loop then consists of two steps: Firstly, the image is updated with the projection data subset defined above using the SART (Simultaneous Algebraic Reconstruction Technique) iterative reconstruction framework. After each SART iteration, an additional step is performed in which the HU value of each pixel is adjusted according to the respective histogram of the lower temporal resolution image: Pixels with an HU value close to a maximum of the histogram are left unchanged. Pixels with an HU value far from any maximum are adjusted slightly towards the closest maximum.

After the iteration has finished, a motion detection technique is used in the final step. The iTRIM image from the final iteration of the iterative reconstruction is combined with the conventional 180° WFBP image. In regions that exhibit motion, the iTRIM image is used as the final image, whereas in static regions the WFBP image is used.

Fig. 2 shows image examples of a cardiac dataset, reconstructed with the typical cardiac WFBP, in direct comparison to an iTRIM reconstruction of the same dataset. The reduction in motion artifacts using the iTRIM algorithm is clearly visible, while maintaining the same noise level and overall image quality (Fig. 2).

As scientifically validated, the temporal resolution of the iTRIM reconstruction technique can enhance the temporal resolution by 20%. On Siemens’ SOMATOM Perspective with a rotation time of 480 ms, this yields an equivalent rotation speed of 390 ms and an effective temporal resolution of 195 ms, far superior to the temporal resolution of 240 ms of the corresponding standard cardiac WFBP reconstruction.

In summary, iTRIM is designed to improve image quality in cardiac imaging for systems not offering the highest rotation speeds by providing a superior temporal resolution compared to conventionally reconstructed CT images, while maintaining the same overall image impression.

References

1 Under FDA review. Not available for sale in the U.S.