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Computed Tomography-based Kymogram Calculation and Detection

Summary

Over the last six years cardiac CT has proven to have an enormous potential to be used for the early detection of risks to suffer from coronary heart disease as well as giving a threedimensional insight into a patient's cardiovascular system without the use of an interventional technique. The process of phase-correlated image reconstruction which is necessary for this kind of image acquisition is based on a synchronization signal providing information on the phase of the cardiac cycle. Instead of using the patient's ECG acquired at scan time, we introduce the kymogram as a synchronization signal directly derived from the raw data.

The initial step of the kymogram calculation is to compute the in plain center of mass and sample it over the entire scan. Since the resulting signal consists of more than just the heart motion we show different approaches for the necessary filtering procedure. The validation of the kymogram calculation is performed by feeding synthetic input signals into the filter and detection pipeline while gradually adding processing steps to it. The results are judged on the basis of a calculated lag function indicating the phase shift of the known input function and the received output signal. As the kymogram competes to a certain extent with the ECG in its role as a trigger signal for phase-correlated CT image reconstruction we are interested in the correspondent of a K–K based phase value in the ECG. Our study of 30 patient data sets acquired on the Sensation 16 CT scanner with a variety of heart rates based on the implemented algorithm reveals an equivalence of a specific K–K and the corresponding R–R phase. The kymogram signal therefore may serve as a source of information on the specific heart phase.

Although the main focus of this work is on cardiac data, a strong positive effect on the image quality of ECG-less acquired CT lung images can be shown for the pericardial region. For the majority of the analyzed data sets the pulmonary tissue neighboring the heart suffers from motion artifacts caused by the cardiac activity during scan time when using a standard reconstruction technique. With the use of a kymogram-based phase-correlated reconstruction algorithm it is possible to reduce these artifacts resulting in a significantly improved image quality of the pericardial lung tissue. These results are confirmed by concluded clinical studies as well as by ongoing projects.

Information similar to an ECG can be extracted from the raw data of a cardiac CT scan and the derived signal correlates well with an ECG signal acquired at scan time. It can therefore serve as a synchronization signal mandatory for phase-correlated CT image reconstruction. The strength of the kymogram is its direct correspondence to the anatomical setting compared to the global information of the ECG signal. A steady heart rate is a positive prerequisite for the calculation of a kymogram that leads to reconstructed images of good quality. To a certain extent the kymogram is able to handle arrhythmic cardiac activities but similar to the ECG it does not always perform well in these cases.