Nonstandard Spiral Cone-Beam Scanning Methods, Apparatus and Aplications

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Technology description

Background:
Over the years many advances in computed tomography (CT) scanning have been used for the diagnosis and treatment of coronary artery diseases, congestive heart failure, stroke, and congenital cardiovascular defects. Likewise, the advances in micro-CT methods have been imperative in translating physiological methodologies of mice and rats to treatments in human patients. Advances in volumetric/dynamic reconstruction using spiral cone-beam CT scanners have provided doctors with state of the art 3D/4D images. For instance, the Katsevich algorithm uses principles that every standard spiral used in spiral cone-beam geometry has an exclusive point within it that will correspond to a corresponding PI-line. As a result, the Katsevich algorithm provides important information for biomedical applications such as bolus-chasing angiography and electron-beam CT/micro-CT that utilize exact cone-beam reconstruction algorithms from standard spirals. However, to date no images or data is available from non-standard spiral scans. Such methods are important in avoiding limitations when scanning long objects, for example a human patient, that result in unwanted image artifacts and poor resolution images. Researchers at the University of Iowa have developed methods that successfully quantify non-standard spiral cone beam geometries that produce the highest temporal resolution among all tomographic image scanners.
Technology:
The Katsevich algorithm is based on the mathematical property that in a cylindrical object every point will pass through one PI line and such PI line will pass through an upper and lower boundary of a spherical trajectory. This means that for every "spiral" there exists a minimum detection window for measuring data, referred to as the Tam-Danielsson detection window whose upper and lower boundaries correspond to PI lines. For exact image reconstruction the data is limited to these boundaries and provides for exact and robust reconstruction
ELECTRON-BEAM CT/MICRO-CT (EBCT): Upgrades the current EBCT design to incorporate the spiral cone-beam scanning capability to small animal imaging. Taking advantage of the minimum amount of data needed for exact and robust reconstruction the technology will benefit previously impossible cardiac micro-CT studies in small animals.

Application area

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Provided herein are methods of reconstructing an image from projection data provided by a tomography scanner that is based on geometric optics comprising scanning an object in a cone-beam imaging geometry following a non-standard spiral path or a general piecewise smooth scanning path wherein projection data is generated and reconstructing an image according to a closed-form formula that is either in the filtered backprojection (FBP) or backprojection filtration (or backprojected filtration, BPF) formats. Also provided herein are associated systems and apparatuses for tomographic imaging. Research at the University of Iowa has led to the development of two possible medical applications for non-standard spiral cone-beam scanning: bolus chasing CT angiography and electron beam CT/micro-CT.

Advantages

BOLUS CHASING CT ANGIOGRAPHY: Limitations arise due to the differences in flow velocity of the contrast medium (bolus) from fast to slow as it moves from the torso to the legs. This makes it difficult to match the table movement during scanning with the bolus propagation resulting in poor image quality. Research at the University of Iowa uses a variable pitch approach that synchronizes the table movement with that of a naturally occurring spiral cone-beam scan allowing for full detection within the PI line boundaries of the Tam-Danielsson detection window, and thus providing superior image reconstruction for CT angiography.

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