A Method Of Analysing Images

Field of Invention

This invention relates to a method of analysing Magnetic Resonance Imaging (MRI) images, particularly to the use of the MRI signal to separate out the contributions of different chemical species, such as water and fat and proton density fat fraction (PDFF) estimation.

Background of Invention

The data that forms an MRI image is collected in a representation known as k-space; a mathematical process known as Fourier Transform is then applied to this k-space representation in order to yield the MRI image. The Fourier Transform yields values that are complex numbers, comprising a real part $R(x,y)$ and an imaginary part $I(x,y)$. Often, these are combined to form the Magnitude $M(x,y) = \sqrt{R^2(x,y) + I^2(x,y)}$, though there has also been a great deal of previous work using the phase $\phi(x,y) = \arctan(I(x,y)/R(x,y))$. Evidently, the magnitude and phase can be computed from the real and imaginary values; conversely, the real and imaginary values can be calculated from the magnitude and phase values.

The MRI image will be made up of a collection of voxels. The MRI image data can be analysed to determine the amount of water $w(x)$ and the amount of fat $f(x)$ (or other species) for each voxel x, of the image assuming that those are the only types of tissue in that voxel. These values can be used to report a ratio $PDFF(x)$ (proton density fat fraction). The estimation of w, f, $PDFF$ are impacted by the spatially varying field $B_0(x)$ or $\psi(x)$ as given later.

Multi-echo chemical-shift encoded (CSE) water-fat separation MRI methods are increasingly reliable and reproducible for complete fat suppression and for proton density fat fraction (MRI-PDFF) quantification. These methods exploit the differences in the precession frequencies of water and fat to estimate fat content and have been validated against histological steatosis grading and spectroscopy measures (refs 1-23).

To date, most advanced CSE methods are complex-based, in that they use both the magnitude and phase of the MRI signal, and they calculate MRI-PDFF indirectly by first estimating a “field map” or “fieldmap”, which is a measure of (essentially inevitable) B_0