Purpose: To demonstrate a novel theorem relating the spatial frequency domain partial derivatives; to show that using autocalibrating signals images can be unwrapped using k space partial derivatives and noise amplification in SENSE reconstruction can be reduced without making any assumptions on the characteristics of images to be reconstructed.
Methods: Phantom and human brain images were acquired using a standard GE 3.0 Tesla Excite scanner (General Electric, Waukesha, WI) equipped with eight receive channels. Standard eight-channel receive-only head coils and a transmit body coil were used for image data acquisition.
Results: As a proof of concept, a gradient echo phantom image was reconstructed in k space using 20 ACS lines for R=2. Partial derivatives for No. 63, 64, 65, 66, and 67 ky lines were measured by fitting the five tightly spaced ky points at each (x,ky) coordinate to a third order polynomial. Two sets of aliased images were obtained: a conventional one described by a sum of products between spin density and coil sensitivity and a new one described by a sum of products among spin density, coil sensitivity and y ordinate of the aliased pixel. There are no visible reconstruction artifacts in the unwrapped individual coil images. In image domain, the new contraints derived from k space partial derivatives were used to improve the conditioning of SENSE encoding matrices. The derivative constraints are different from regularization, the latter leads to loss in spatial resolution. For an MPRAGE brain image with R=6 the first order derivatives alone was found to reduce the largest SENSE g factor by 61% (from 23.1 to 8.9).
Conclusions:Derivatives in k space can be used for parallel imaging reconstruction in both k space and image domains.

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