CLAIMS

What is claimed is:

1. In a Magnetic Resonance Imaging (MRI) System, a method for improving the quality of spatial frequency spectra generated from a prism acquisition consisting of finely-sampled spatially-encoded magnetic resonance echo data that is one or more repetitions of a one-dimensional frequency encoded signal along an axis of one or more selectively-excited inner-volumes (prism volumes), which are the physical location within the biologic tissue to be analyzed, from which the echo data is generated, comprising;

a) gathering a prism acquisition consisting of one or more individual repetitions of echo data from one or more prism volumes using one or more receiver coils in the Magnetic resonance Imaging (MRI) System;

b) if the prism acquisition consists of multiple repetitions, assessing the patient motion affecting the quality of the prism acquisition by:

i) transforming the echo data gathered in (a) for each prism volume to calculate the variation of signal versus position, termed the prism profile, for each repetition for each receiver coil;

ii) combining the prism profile from a selection of one or more of the receiver coils to produce a combined prism profile for each prism volume and each repetition;

iii) combining the repetitions gathered into blocks of one or more overlapping or adjacent repetitions to produce a series of frames showing the prism profiles for the set of prisms volumes for each block, and using the change in prism profiles between frames to calculate the patient motion which has occurred during the prism acquisition;

iv) using the calculation of patient motion in (iii) to determine whether the calculated motion is below a threshold value, and if so then calculating the spatial frequency spectra from the prism profiles, and if not then the dataset is discarded and indicated to be re-acquired.

2. The method of claim 1 wherein the estimate of motion in (b)(iii) is used to correct for the motion which has occurred during the prism acquisition by spatially shifting

the repetitions of prism profiles relative to one another in (b)(iv) prior to generation of spatial frequency spectra.

3. The method of claim 1 wherein the motion assessment in (b)(iii) is performed by generating plots of the prism profiles for each block, and displaying these as a series of frames, or animation, from which the user can visualize and assess the motion during the prism acquisition.

4. The method of claim 1 wherein the motion assessment in (b)(iii) is performed for one prism volume by generating plots of the prism profile for that prism volume for each block, and displaying each of these frames adjacent to one another to form one representation enabling the motion during the prism acquisition to be visualized.

5. The method of claim 1 wherein in (b)(ii), the receiver coils are combined by:

d) measuring noise data on a set of receiver coils corresponding to the receiver coils used for the prism acquisition in (a);

e) estimating the signal-to-noise ratio (SNR) for each of the receiver coils using the ratio of the prism acquisition echo data acquired in (a) and the noise data acquired in (d) and using the ratio to combine the prism acquisition echo data from receiver coils using diversity combining in order to maximize the final SNR;

f) using the calculation of signal-to-noise ratio for each receiver coil in (b)(ii) to determine whether the prism acquisition has an SNR above a threshold value, and if not then the dataset is discarded and indicated to be re-acquired.

6. The method of claim 5 wherein the measurement of noise data in (d) is performed by blanking the radio frequency amplifiers for each of the receiver coils so that only noise data is gathered.

7. The method of claim 5 wherein the measurement of noise data in (d) is performed by setting the radio frequency transmit voltages to zero so that only noise data is gathered.

8. The method of claim 5 wherein the measurement of noise data in (d) is performed prior to the prism acquisition in (a).

9. The method of claim 5 wherein the measurement of noise data in (d) is performed after the prism acquisition in (a).

10. The method of claim 5 wherein the measurement of noise data in (d) is performed at one or more time points in between the repetitions of the prism acquisition in (a).

11. The method of claim 5 wherein in (e), receiver coils are combined by using Maximal Ratio Combining in order to maximize the final SNR.

12. The method of claim 5 wherein in (e), the receiver coils are combined by using Selection Combining to maximize the final SNR.

13. The method of claim 1 wherein the motion assessment in (b)(iii) is performed by:

d) smoothing the frames in order to reduce the noise in the frames using a spatial filter;

e) taking a sub-region of the frame, where the size of the sub-region is chosen for the local variation in motion typical in that tissue;

f) windowing the sub-regions;

g) for each pair of two frames, computing a two-dimensional cross-correlation of the sub-regions;

h) determining the position of the maximum value of the computed cross-correlation, giving the local shift in x- and y-position for the sub-region of the pair of frames;

i) repeating steps (g) and (h) while translating the sub-regions across and down the frame to build up a map of the local shift versus position for that pair of frames, termed a shift map;

j) repeating steps (e) to (i) for each pair of frames to generate a series of shift maps of locally estimated shifts.

14. The method of claim 13 wherein the calculation of the two-dimensional cross-correlation is performed in frequency-space, rather than position space, so that the

sampling rate of the cross-correlation function in position-space can be varied from the sampling rate of the original data to produce sub-pixel calculations of shifts.

15. The method of claim 13 wherein the locally estimated shifts are compared to a threshold value, and if the local shifts from any of the frames exceed the threshold, the dataset is indicated as having significant motion, so that it may be reacquired by the user while the patient is still within the MRI scanner.

16. The method of claim 13 wherein the locally estimated shifts are displayed to the user as an animation or series of plots so that the user can visualize and assess the local motion.

17. The method of claim 16 wherein the locally estimated shifts for each frame are displayed as a point plotted at the center of the sub-region with a hue/color indicating the direction of the local shift and a value/brightness indicating the magnitude of the shift.

18. In a Magnetic Resonance Imaging (MRI) System, a method for improving the quality of spatial frequency spectra generated from a prism acquisition consisting of finely-sampled spatially-encoded magnetic resonance echo data that is multiple repetitions of a one-dimensional frequency encoded signal along an axis of one or more selectively-excited inner-volumes (prism volumes), which are the physical location within the bioloic tissue to be analyzed, from which the echo data is generated, comprising;

a) gathering a prism acquisition consisting of multiple individual repetitions of echo data from one or more prism volumes using one or more receiver coils in the Magnetic resonance Imaging (MRI) System;

b) assessing the patient motion affecting the quality of the prism acquisition by:

i) transforming the echo data gathered in (a) for each prism volume to calculate the variation of signal versus position, termed the prism profile, for each repetition for each receiver coil;

ii) combining the prism profile from a selection of one or more of the receiver coils to produce a combined prism profile for each prism volume and each repetition;

iii) combining the repetitions gathered into blocks of one or more overlapping or adjacent repetitions to produce a series of frames showing the prism profiles for the set of prisms volumes for each block, and using the change in prism profiles between frames to calculate the patient motion which has occurred during the prism acquisition;

iv) using the calculation of patient motion in (iii) to determine whether the calculated motion is below a threshold value, and if so then calculating the spatial frequency spectra from the prism profiles, and if not then the dataset is discarded and indicated to be re-acquired.

19. The method of claim 18 wherein the estimate of motion in (b)(iii) is used to correct for the motion which has occurred during the prism acquisition by spatially shifting the repetitions of prism profiles relative to one another in (b)(iv) prior to generation of spatial frequency spectra.

20. The method of claim 18 wherein the motion assessment in (b)(iii) is performed by generating plots of the prism profiles for each block, and displaying these as a series of frames, or animation, from which the user can visualize and assess the motion during the prism acquisition.

21. The method of claim 18 wherein the motion assessment in (b)(iii) is performed for one prism volume by generating plots of the prism profile for that prism volume for each block, and displaying each of these frames adjacent to one another to form one representation enabling the motion during the prism acquisition to be visualized.

22. The method of claim 18 wherein in (b)(ii), the receiver coils are combined by:

d) measuring noise data on a set of receiver coils corresponding to the receiver coils used for the prism acquisition in (a);

e) estimating the signal-to-noise ratio (SNR) for each of the receiver coils using the ratio of the prism acquisition echo data acquired in (a) and the noise data acquired in (d) and using the ratio to combine the prism acquisition echo data from receiver coils using diversity combining in order to maximize the final SNR;

f) using the calculation of signal-to-noise ratio for each receiver coil in (b)(ii) to determine whether the prism acquisition has an SNR above a threshold value, and if not then the dataset is discarded and indicated to be re-acquired.

23. The method of claim 22 wherein the measurement of noise data in (d) is performed by blanking the radio frequency amplifiers for each of the receiver coils so that only noise data is gathered.

24. The method of claim 22 wherein the measurement of noise data in (d) is performed by setting the radio frequency transmit voltages to zero so that only noise data is gathered.

25. The method of claim 22 wherein the measurement of noise data in (d) is performed prior to the prism acquisition in (a).

26. The method of claim 22 wherein the measurement of noise data in (d) is performed after the prism acquisition in (a).

27. The method of claim 22 wherein the measurement of noise data in (d) is performed at one or more time points in between the repetitions of the prism acquisition in (a).

28. The method of claim 22 wherein in (e), receiver coils are combined by using Maximal Ratio Combining in order to maximize the final SNR.

29. The method of claim 22 wherein in (e), the receiver coils are combined by using Selection Combining to maximize the final SNR.

30. The method of claim 18 wherein the motion assessment in (b)(iii) is performed by:

d) smoothing the frames in order to reduce the noise in the frames using a spatial filter;

e) taking a sub-region of the frame, where the size of the sub-region is chosen for the local variation in motion typical in that tissue;

f) windowing the sub-regions;

g) for each pair of two frames, computing a two-dimensional cross-correlation of the sub-regions;

h) determining the position of the maximum value of the computed cross-correlation, giving the local shift in x- and y-position for the sub-region of the pair of frames;

i) repeating steps (g) and (h) while translating the sub-regions across and down the frame to build up a map of the local shift versus position for that pair of frames, termed a shift map;

j) repeating steps (e) to (i) for each pair of frames to generate a series of shift maps of locally estimated shifts.

31. The method of claim 30 wherein the calculation of the two-dimensional cross-correlation is performed in frequency-space, rather than position space, so that the sampling rate of the cross-correlation function in position-space can be varied from the sampling rate of the original data to produce sub-pixel calculations of shifts.

32. The method of claim 30 wherein the locally estimated shifts are compared to a threshold value, and if the local shifts from any of the frames exceed the threshold, the dataset is indicated as having significant motion, so that it may be reacquired by the user while the patient is still within the MRI scanner.

33. The method of claim 30 wherein the locally estimated shifts are displayed to the user as an animation or series of plots so that the user can visualize and assess the local motion.

34. The method of claim 33 wherein the locally estimated shifts for each frame are displayed as a point plotted at the center of the sub-region with a hue/color indicating the direction of the local shift and a value/brightness indicating the magnitude of the shift.