

Claims

1. A method of quantifying changes in a visceral organ of a human subject, the method comprising:

- 5 acquiring a first medical MRI scan at a first timepoint, the first medical scan being part of a first dataset and comprising a first set of voxels, the first medical scan comprising a first image of a visceral organ;
- 10 acquiring a second medical MRI scan at a second timepoint, the second medical scan being part of a second dataset and comprising a second set of voxels, the second medical scan comprising a second image of the visceral organ, and wherein the second timepoint may be before or after the first timepoint;
- 15 whereby each voxel in the first and second set of voxels provides either:
quantitative T1 values; quantitative T2* values; cT1 values that are based on T1 values using T2* as a correction; or PDFF values; or a combination of T1, T2* and/or PDFF values;
- 20 parcellating at least part of the first image of the visceral organ into a first set of subregions based on image content, each subregion of the first set of subregions being defined by a regional representation comprising a plurality of voxels of the first set of voxels, and being non-overlapping with other subregions of the first set of subregions;
- 25 aligning the first medical scan and the second medical scan, before or after parcellating the first image of the visceral organ;
- parcellating at least part of the second image of the visceral organ into a second set of subregions, each subregion of the second set of subregions being defined by a regional representation comprising a plurality of voxels of the second set of voxels, and being
- 30 non-overlapping with other subregions of the second set of subregions;
- wherein parcellating at least part of the second image of the visceral organ is based on the first set of subregions;

evaluating a metric for a subregion in the first image of the visceral organ to provide a first value of the metric, and evaluating the metric for a corresponding subregion in the second image of the visceral organ to provide a second value of the metric;

- 5 evaluating a difference between the first value of the metric and the second value of the metric, being a difference for the subregion in either: the T1 values; the T2* values; the cT1 values; or the PDFF values, thereby providing a measure of a change that has occurred in the subregion between the first timepoint and the second timepoint.

- 10 2. A method of quantifying changes in a visceral organ of a human subject, the method comprising:

acquiring a first medical MRI scan at a first timepoint, the first medical scan being part of a first dataset and comprising a first set of voxels, the first medical scan comprising a
15 first image of a visceral organ;

acquiring a second medical MRI scan at a second timepoint, the second medical scan being part of a second dataset and comprising a second set of voxels, the second medical scan comprising a second image of the visceral organ;

20 whereby each voxel in the first and second set of voxels provides either:
quantitative T1 values; quantitative T2* values; cT1 values that are based on T1 values using T2* as a correction; or PDFF values; or a combination of T1, T2* and/or PDFF values;

25 aligning the first medical scan and the second medical scan, and then parcellating the first image of the visceral organ and the second image of the visceral organ jointly, based on image content for at least part of the first image of the visceral organ and the second image of the visceral organ;

30 whereby:

parcellating the first image of the visceral organ provides a first set of subregions, each subregion of the first set of subregions being defined by a first regional representation comprising a plurality of voxels, and being non-overlapping with
35 other subregions of the first set of subregions;

parcellating the second image of the visceral organ provides a second set of subregions, each subregion of the second set of subregions being defined by a second regional representation comprising a plurality of voxels, and being non-overlapping with other subregions of the second set of subregions; and
5 the first set of subregions and the second set of subregions correspond;

evaluating a metric for a subregion in the first image of the visceral organ to provide a first value of the metric, and evaluating the metric for a corresponding subregion in the second image of the visceral organ to provide a second value of the metric;

10 evaluating a difference between the first value of the metric and the second value of the metric, being a difference for the subregion in either: the T1 values; the T2* values; the cT1 values; or the PDFF values, thereby providing a measure of a change that has occurred in the subregion between the first timepoint and the second timepoint.

15 3. The method of claim 1 or claim 2, wherein:

the first dataset is one of a 3D volumetric image, a stack of 2D image slices; and

20 the second dataset is one of a 3D volumetric image, a stack of 2D image slices.

4. The method of claim 1 or claim 2,

wherein the first medical scan is a first slice from the first dataset, and the second
25 medical scan is a second slice from the second dataset; and

and further comprising:

30 deriving the first image of the visceral organ by segmenting parts of the first slice that show the visceral organ from other parts of the first slice; and

deriving the second medical scan of the visceral organ by segmenting parts of the second slice that show the visceral organ from other parts of the second slice.

5. The method of claim 1 or claim 2, wherein parcellating at least part of the visceral organ, based on the image content, comprises:

parcellating based on intensities of the first set of voxels and/or intensities of the second set of voxels.

6. The method of claim 1 or claim 2, wherein parcellating the first image of the visceral organ and/or the second image of the visceral organ:

creating a piece-wise constant representation of the visceral organ, whereby each subregion is locally similar.

7. The method of claim 4, wherein parcellating the first image of the visceral organ and/or the second image of the visceral organ further comprises superpixel clustering within the visceral organ, after the segmenting.

8. The method of claim 1 or claim 2, wherein parcellating the first image of the visceral organ and/or the second image of the visceral organ further comprises creating a representation of local similarity within the visceral organ, wherein similarity is defined on the basis of either:

multiple imaging modalities; or
texture.

9. The method of claim 1, wherein the step of aligning comprises either:

aligning image content-derived information that defines the first medical scan and the second medical scan;

aligning image content-derived information that defines first image of the visceral organ and the second image of the visceral organ; or

using a transformation to explicitly align:

points that lie on boundaries of subregion(s); and/or
points that lie on a boundary of the visceral organ.

10. The method of claim 1 or claim 2, wherein the first time point and the second time point are separated by sufficient time for the visceral organ to have undergone either a change in shape, or a change in the characteristics of at least one subregion.

5 11. The method of claim 1 or claim 2, wherein the metric is a summary statistic of spatial texture across at least one subregion.

12. The method of claim 1 or claim 2, further comprising:

10 evaluating the metric for a plurality of subregions of the first image of the visceral organ and for corresponding subregions of the second image of the visceral organ;

evaluating the difference between the first value of the metric and the second value of the metric for each subregion, to thereby provide a plurality of difference values; and

15 plotting the plurality of difference values on either a graph or on a spatial plot of the subregions, whereby the graph or spatial plot provides a visual projection of changes in each subregion between the first timepoint and the second timepoint.

20 13. The method of claim 12, further comprising:

acquiring a third medical scan of the visceral organ at a third timepoint, the third medical scan comprising a third image of a visceral organ;

25 repeating the method steps of claim 1 or claim 2 for the third medical scan and at least one of the first medical scan and the second medical scan; and

plotting difference values for the metric between the first, second and third images of the visceral organ, either on a graph or on a spatial plot, to provide a visual projection of
30 changes that have occurred in subregions between the first, second and third timepoints.

14. The method of claim 1 or claim 2, further comprising:

35 defining a threshold of change;

comparing the difference between the first value of the metric and the second value of the metric against the threshold of change for at least one subregion, thereby identifying whether the threshold of change has been exceeded for the at least one subregion; and

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displaying the first medical scan or the second medical scan with an overlay showing subregions for which the metric has exceeded the threshold of change.

15. The method of claim 14, further comprising:

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calculating a percentage of the visceral organ that has undergone a change that exceeds the threshold of change.

16. The method of claim 13, further comprising:

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defining a threshold of change;

comparing differences between the first, second and third values of the metric against the threshold of change for the subregions, thereby identifying whether the threshold of change has been exceeded for the subregions;

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calculating a percentage of the visceral organ that has undergone a change that exceeds the threshold of change, for the second and/or third medical scans; and

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plotting the percentages of the visceral organ that have undergone the change that exceeds the threshold of change for the second and/or third medical scans.

17. A medical scanning system comprising:

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a medical MRI imaging device, the medical imaging device configured to:
acquire a first medical scan of a human subject at a first timepoint, the first medical scan being part of a first dataset and comprising a first set of voxels, the first medical scan comprising a first image of a visceral organ;

acquire a second medical scan of the human subject at a second timepoint, the second medical scan being part of a second dataset and comprising a second set of voxels, the second medical scan comprising a second image of the visceral organ, and wherein the second timepoint may be before or after the first timepoint;

- 5 whereby each voxel in the first and second set of voxels provides either:
quantitative T1 values; quantitative T2* values; cT1 values that are based on T1 values using T2* as a correction; or PDFF values; or a combination of T1, T2* and/or PDFF values;

and

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a processor, the processor configured to quantify changes in the visceral organ by:

- parcellating at least part of the first image of the visceral organ into a first set of subregions based on image content, each subregion of the first set of subregions being
15 defined by a regional representation comprising a plurality of voxels, and being non-overlapping with other subregions of the first set of subregions;

aligning the first medical scan and the second medical scan, before or after parcellating the first image of the visceral organ;

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parcellating at least part of the second image of the visceral organ into a second set of subregions, each subregion of the second set of subregions being defined by a regional representation comprising a plurality of voxels of the second set of voxels, and being non-overlapping with other subregions of the second set of subregions;

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wherein parcellating at least part of the second image of the visceral is based on the first set of subregions;

- evaluating a metric for a subregion in the first image of the visceral organ to provide a
30 first value of the metric, and evaluating the metric for a corresponding subregion in the second image of the visceral organ to provide a second value of the metric;

evaluating a difference between the first value of the metric and the second value of the metric, being a difference for the subregion in either: the T1 values; the T2* values; the

cT1 values; or the PDFF values, thereby providing a measure of a change that has occurred in the subregion between the first timepoint and the second timepoint.

18. A non-transitory computer program product having executable program code stored
5 therein, the program code operable for quantifying changes in a visceral organ in accordance with the method of any of claims 1-16.

19. The non-transitory computer program product of Claim 18, wherein the non-
transitory computer program product comprises at least one from a group including: a
10 hard disk, a CD-ROM, an optical storage device, a magnetic storage device, a Read Only Memory, ROM, a Programmable Read Only Memory, PROM, an Erasable Programmable Read Only Memory, EPROM, an Electrically Erasable Programmable Read Only Memory, EEPROM, and a Flash memory.