CLAIMS

1. A method of scanning for vascular irregularities in at least one in vivo image acquired in the absence of contrast agent, the method including:

applying a filter to the in vivo image to provide a probability field and a scale field;

performing vessel segmentation on the probably field to extract a vasculature tree from the probability field;

mapping the scale field to the segmented vasculature tree to quantify the geometry of the vasculature tree; and

performing an automated geometric analysis on the calculated geometry to detect irregularities in the vasculature.

2. The method of claim 1, wherein the step of segmenting the vasculature includes performing a region growing operation on the probability field.

3. The method of claim 1 or claim 2, wherein the step of applying a filter to the in vivo image includes applying a shape filter.

4. The method of claim 3, wherein the shape used in the shape filter is a tube and the shape filter is multi-scale shape filter.

5. The method of claim 3 or claim 4, wherein the shape filter is a Hessian-based filter.

6. The method of any one of claims 1 to 5, wherein the step of performing the automated geometric analysis includes comparing the scale at a first position in the vasculature tree to the scale at a second position in the vasculature tree.

7. The method of any one of claims 1 to 5, wherein the step of performing the automated geometric analysis includes calculating the change in scale along a length of a branch in the vasculature tree.

8. The method of any one of claims 1 to 7, including performing automated geometric analysis throughout the entire segmented vasculature tree.

9. The method of any one of claims 1 to 8, including acquiring a three-dimensional in vivo image in the absence of contrast agent.

10. The method of claim 9, including acquiring a three-dimensional in vivo image of the lungs.

11. The method of any one of claims 1 to 10, including scanning for an embolism.

12. The method of any one of claims 1 to 11, including scanning for a vascular irregularity in the lung vasculature.

13. The method of any one of claims 1 to 12, including analysing the geometry to classify segments of the vasculature as normal or irregular.

14. The method of any one of claims 1 to 13, including inverting the image before the filtering step.

15. A method of scanning for vascular irregularities in at least one in vivo image acquired in the absence of contrast agent, the method including:

applying a filter to the in vivo image to provide probability data and a scale data;

performing an automated analysis on the probability field and/or the scale field to detect irregularities in the vasculature.

16. The method according to claim 15, including applying a multi-scale shape filter to the in vivo image.

17. The method according to claim 15 or claim 16, wherein the step of performing the automated analysis includes comparing the scale at a first position to the scale at a second position.

18. The method according to any one of claims 15 to 17, including performing vessel segmentation on the probably field to extract a vasculature tree from the in vivo image.

19. The method according to claim 18, including mapping the scale field to the segmented vasculature tree to quantify the geometry of the vasculature tree.

20. A method of scanning for vascular irregularities in at least one in vivo image acquired in the absence of contrast agent, the method including:

applying a multi-scale shape filter to the in vivo image to provide a probability field and a scale field, the probability field representing the probability that a voxel in the in vivo image is a part of a tubular structure and the scale field representing the filter size that yields the greatest probability that the voxel belongs to a tubular structure; and

performing an automated analysis on the probability field and the scale field to detect irregularities in the vasculature.

21. A method of scanning for a pulmonary embolism in at least one in vivo image acquired in the absence of contrast agent, the method including:

applying a multi-scale shape filter to the in vivo image to provide a probability field and a scale field;

performing vessel segmentation on the probably field to extract a vasculature tree;

mapping the scale field to the segmented vasculature tree to quantify the geometry of the vasculature; and

calculating the change in scale along a length of a branch in the vasculature tree to detect irregularities in the vasculature.

22. A method of scanning for a pulmonary embolism in the lung vasculature in at least one in vivo image acquired in the absence of contrast agent, the method including:

applying a Hessian-based multi-scale shape filter to provide a probability field and a scale field;

segmenting a vascular tree from the probability field by performing a region growing operation on the probability field;

skeletonising the vasculature tree by extracting the centreline of each branch in the vasculature tree;

mapping the scale field to the skeletonised vasculature tree to provide the scale of the vessel at each point in the skeletonised vasculature tree; and

calculating the change in scale along the centreline in a length of a branch in the vasculature tree to detect a pulmonary embolism.

23. A method of detecting an irregularity in lung vasculature, the method comprising the steps of:

(i) providing at least one image of a lung vasculature comprising one or more vessels, the image having been captured *in vivo* in the absence of contrast agent,

(ii) applying a filter to the image to create an output including a probability and scale field for the lung vasculature, and using one or two forms of the output to segment and quantify the geometry of the lung vasculature,

(iii) analysing the output in conjunction with geometric analysis to detect irregularities in the one or more vessels of the lung vasculature.

24. The method according to claim 23 wherein step (ii) comprises one or more of the following sub-steps:

(ii)(a) performing a Hessian-based multi-scale shape filter (as per Frangi 1998) on the image from step (i) to provide a probability field for the lung vasculature,

(ii)(b) carrying out flood-fill selection of the probability field for the lung vasculature to yield a binary image,

(ii)(c) carrying out binary segmentations of the binary image,

(ii)(d) performing vessel centreline extraction from the binary segmentation, and

(ii)(e) associating the scale from the shape filter (filter size which yields greatest probability that any given point on the image belongs to a tubular structure) to each point along the centreline of the vasculature tree to obtain local geometry data.

25. The method according to claim 23 or claim 24 wherein the step of analysing the output includes calculating a change in vessel diameter.

26. The method according to any one of claims 23 to 25 wherein the irregularity comprises one or more pulmonary embolisms.

27. A method of calculating a ventilation/perfusion ratio from at least one in vivo lung image acquired in the absence of contrast agent and a time series of lung images, the method including:

applying a filter to the in vivo lung image to provide a probability field and a scale field;

performing vessel segmentation on the probably field to extract a vasculature tree from the probability field;

mapping the scale field to the segmented vasculature tree to quantify the geometry of the vasculature tree;

measuring the motion of a portion of the lung from the time series of lung images;

comparing the motion of the potion of the lung to the scale of the vasculature in the region of the portion of the lung to obtain a ventilation/perfusion measure.

28. The method of claim 27, including measuring the displacement of the portion of the lung.

29. The method of claim 27 or claim 28, including measuring the expansion of the portion of the lung.

30. The method of any one of claims 27 to 29, including measuring the motion at multiple points in the portion of the lung and averaging the multiple measurements.

31. The method of any one of claims 27 to 29, including measuring the motion of multiple potions of the lung, and performing the comparison at each of the multiple portions.

32. The method of any one of claims 27 to 31, wherein the portion of the lung is defined by a region distal to a selected point in the segmented vasculature.

33. The method as claimed in any one of the preceding claims, wherein the at least one image is any one or any combination of multiple 2D images and / or at least one 3D image.