

Claims

1. A method for assessing blood vessel stenosis using image data collected from a subject, said image data representing a vascular structure of the subject, and wherein the method comprises:

5 (a) segmenting, from the image data, a vessel segment representing a segment of a blood vessel,

(b) obtaining, using the image data, a plurality of two-dimensional images of the vessel segment; said plurality of two-dimensional images representing respective cross-sections of the vessel segment,

10 (c) identifying, for each of the plurality of two-dimensional images, a lumen area comprising lumen pixels representing a lumen of the corresponding cross-section, said identifying of each lumen area comprising:

(i) identifying a plurality of diameter lines for the corresponding cross-section,

15 (ii) for each diameter line, obtaining an intensity profile of intensity values for pixels lying on the corresponding diameter line,

(iii) for each diameter line, deriving a gradient profile based on the intensity profile of the corresponding diameter line, the gradient profile representing a first derivative of the intensity profile, and

20 (iv) for each diameter line, identifying lumen boundary pixels for the corresponding lumen area, the lumen boundary pixels corresponding to maxima of the corresponding gradient profile,

(d) obtaining a quantitative measure using the lumen areas of successive cross-sections of the vessel segment, and

(e) assessing blood vessel stenosis using the quantitative measure.

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2. The method according to claim 1, wherein the quantitative measure is indicative of an area of stenosis (AS) for at least one of the cross-sections of the vessel segment, the AS being a numerical value derived from the quantitative measure.

3. The method according to claim 1 or claim 2, wherein operation (d) comprises obtaining a first profile of sizes of the lumen areas for the plurality of two-dimensional images corresponding to the successive cross-sections of the vessel segment.

5 4. The method according to claim 3, further comprising deriving, using the first profile, a size of a restored lumen area for each said cross-section.

5. The method according to claim 4, further comprising obtaining, using the first profile, a second profile of the derived sizes of the restored lumen areas along the successive cross-
10 sections of the vessel segment.

6. The method according to claim 5, comprising employing a linear fitting of the first profile to derive the sizes of the restored lumen areas and to obtain the second profile.

15 7. The method according to claim 5 or claim 6, further comprising calculating a ratio of the size of the lumen area and that of the restored lumen area for at least one of the cross-sections of the vessel segment.

8. The method according to any one of claims 1 to 7, further comprising identifying, from
20 the plurality of images, a sub-set of images using the quantitative measure, said sub-set of images corresponding to cross-sections of vessel segment which contain stenosis.

9. The method according to any one of claims 1 to 8, wherein the method further comprises identifying a centerline for the vessel segment, said cross-sections being orthogonal
25 to the centerline.

10. The method according to claim 9, further comprising extracting a minimal path within the vessel segment by minimizing a cost function defining a path connecting two ends of the vessel segment, wherein the centreline is identified based on the minimal path.

11. The method according to anyone of claims 1 to 10, further comprising ellipse fitting of the lumen boundary pixels to obtain the lumen area.

12. The method according to claim 11, further comprising applying a deformable model to the ellipse-fitted lumen area.

13. The method according to any one of claims 1 to 12, wherein operation (a) comprises extracting a principle direction of a geometrically tubular structure thereby segmenting the vessel segment.

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14. The method according to any one of claims 1 to 13, wherein the image data is computed tomography angiography (CTA) data.

15. A computer system for assessing blood vessel stenosis using image data collected from a subject, said image data representing a vascular structure of the subject, wherein the computer system comprises:

an image segmentation module configured to segment, from the image data, a vessel segment representing a segment of a blood vessel,

an image generation module configured to obtain, using the image data, a plurality of two-dimensional images of the vessel segment; said plurality of two-dimensional images representing respective cross-sections of the vessel segment, and

an image analysis module configured to:

(a) identify, for each of the plurality of two-dimensional images, a lumen area comprising lumen pixels representing a lumen of the corresponding cross-section, said identifying of each lumen area comprising:

(i) identifying a plurality of diameter lines for the corresponding cross-section,

(ii) for each diameter line, obtaining an intensity profile of intensity values for pixels lying on the corresponding diameter line,

(iii) for each diameter line, deriving a gradient profile based on the intensity profile of the corresponding diameter line, the gradient profile representing a first derivative of the intensity profile, and

5 (iv) for each diameter line, identifying lumen boundary pixels for the corresponding lumen area, the lumen boundary pixels corresponding to maxima of the corresponding gradient profile,

(b) obtain a quantitative measure using the lumen areas of successive cross-sections of the vessel segment, and

(c) assess blood vessel stenosis using the quantitative measure.

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16. A computer program product, such as a tangible recording medium, storing program instructions operative, when performed by a processor, to cause the processor to perform a method according to any of claims 1 to 14.

15 17. A method for assessing blood vessel stenosis using image data collected from a subject, said image data comprising a plurality of two-dimensional images representing respective cross-sections of a vessel segment, the method comprising:

(a) identifying, for each of the plurality of two-dimensional images, a lumen area comprising lumen pixels representing a lumen of the corresponding cross-section, said identifying of each
20 lumen area comprising:

(i) identifying a plurality of diameter lines for the corresponding cross-section,

(ii) for each diameter line, obtaining an intensity profile of intensity values for pixels lying on the corresponding diameter line,

25 (iii) for each diameter line, deriving a gradient profile based on the intensity profile of the corresponding diameter line, the gradient profile representing a first derivative of the intensity profile, and

(iv) for each diameter line, identifying lumen boundary pixels for the corresponding lumen area, the lumen boundary pixels corresponding to maxima of the corresponding gradient profile,

(b) obtaining a quantitative measure using the lumen areas of successive cross-sections of the vessel segment, and

(c) assessing blood vessel stenosis using the quantitative measure.

5 18. A computer system for assessing blood vessel stenosis using image data collected from a subject, image data comprising a plurality of two-dimensional images representing respective cross-sections of a vessel segment, wherein the computer system comprises an image analysis module configured to:

10 (a) identify, for each of the plurality of two-dimensional images, a lumen area comprising lumen pixels representing a lumen of the corresponding cross-section, said identifying of each lumen area comprising:

(i) identifying a plurality of diameter lines for the corresponding cross-section,

(ii) for each diameter line, obtaining an intensity profile of intensity values for pixels lying on the corresponding diameter line,

15 (iii) for each diameter line, deriving a gradient profile based on the intensity profile of the corresponding diameter line, the gradient profile representing a first derivative of the intensity profile, and

20 (iv) for each diameter line, identifying lumen boundary pixels for the corresponding lumen area, the lumen boundary pixels corresponding to maxima of the corresponding gradient profile,

(b) obtain a quantitative measure using the lumen areas of successive cross-sections of the vessel segment, and

(c) assess blood vessel stenosis using the quantitative measure.