

CLAIMS

What is claimed is:

5 1. A computer-implemented method of assessing fibrosis in a tissue sample using at least one processor, the method comprising:

 obtaining a stained image of a stained tissue sample, the stained tissue sample being stained in relation to collagen therein;

 producing a plurality of different types of collagen images corresponding to
10 a plurality of different types of collagen, respectively, based on the stained image, the plurality of different types of collagen images comprise a first type of collagen image corresponding to a first type of collagen, a second type of collagen image corresponding to a second type of collagen, and a third type of collagen image corresponding to a third type of collagen;

15 providing the plurality of different types of collagen images as input images to a deep neural network to output a plurality of quantitative fibrosis values corresponding to the plurality of different types of collagen, respectively, wherein the plurality of quantitative fibrosis values comprise a first quantitative fibrosis value corresponding to the first type of collagen, a second quantitative fibrosis value corresponding to the second type of collagen, and a third quantitative fibrosis
20 value corresponding to the third type of collagen; and

 determining a degree of fibrosis in the stained tissue sample based on the plurality of quantitative fibrosis values corresponding to the plurality of different types of collagen, respectively.

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 2. The method of claim 1, wherein said producing a plurality of different types of collagen images comprises:

 producing a first image corresponding to tissue in the stained image; and

 producing a second image corresponding to collagen in the stained image.

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3. The method of claim 2, wherein said producing a plurality of different types of collagen images further comprises:

producing a third image corresponding to portal tracts and central veins in the first image.

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4. The method of claim 3, wherein said producing a plurality of different types of collagen images further comprises:

producing a first binarized image based on the second image;

producing a second binarized image based on the third image; and

10 producing the plurality of different types of collagen images based on the first and second binarized images.

5. The method of claim 4, wherein the first and second images are produced based on K-mean clustering.

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6. The method of claim 4, wherein said producing the plurality of different types of collagen images based on the first and second binarized images comprises:

producing the first type of collagen image based on collagen in the first binarized image satisfying a predetermined size condition;

20 producing the second type of collagen image based on collagen in the first binarized image satisfying a predetermined distance condition with respect to a boundary of the portal tracts and the central veins in the second binarized image; and

25 producing the third type of collagen image based on collagen in the first binarized image that does not satisfy the predetermined size condition and the predetermined distance condition.

7. The method of claim 1, wherein the plurality of different types of collagen comprises portal collagen, fibrillar collagen and septal collagen.

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8. The method of claim 1, wherein the degree of fibrosis in the tissue sample

is determined based on the plurality of quantitative fibrosis values corresponding to the plurality of different types of collagen, respectively, using a multinomial logistic regression.

9. The method of claim 1, wherein the deep neural network comprises a plurality of deep neural sub-networks corresponding to the plurality of different types of collagen respectively, wherein each deep neural sub-network of the plurality of deep neural sub-networks is configured to output a quantitative fibrosis value in relation to a respective type of collagen.

10. A system for assessing fibrosis in a tissue sample, the system comprising:
a memory; and
at least one processor communicatively coupled to the memory and configured to:

obtain a stained image of a stained tissue sample, the stained tissue sample being stained in relation to collagen therein;

produce a plurality of different types of collagen images corresponding to a plurality of different types of collagen, respectively, based on the stained image, the plurality of different types of collagen images comprise a first type of collagen image corresponding to a first type of collagen, a second type of collagen image corresponding to a second type of collagen, and a third type of collagen image corresponding to a third type of collagen;

provide the plurality of different types of collagen images as input images to a deep neural network to output a plurality of quantitative fibrosis values corresponding to the plurality of different types of collagen, respectively, wherein the plurality of quantitative fibrosis values comprise a first quantitative fibrosis value corresponding to the first type of collagen, a second quantitative fibrosis value corresponding to the second type of collagen, and a third quantitative fibrosis value corresponding to the third type of collagen; and

determine a degree of fibrosis in the stained tissue sample based on

the plurality of quantitative fibrosis values corresponding to the plurality of different types of collagen, respectively.

11. The system according to claim 10, wherein said produce a plurality of
5 different types of collagen images comprises:
producing a first image corresponding to tissue in the stained image; and
producing a second image corresponding to collagen in the stained image.

12. The system according to claim 11, wherein said produce a plurality of
10 different types of collagen images further comprises:
producing a third image corresponding to portal tracts and central veins in
the first image.

13. The system according to claim 12, wherein said produce a plurality of
15 different types of collagen images further comprises:
producing a first binarized image based on the second image;
producing a second binarized image based on the third image; and
producing the plurality of different types of collagen images based on the
first and second binarized images.

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14. The system according to claim 13, wherein the first and second images are
produced based on K-mean clustering.

15. The system according to claim 13, wherein said produce the plurality of
25 different types of collagen images based on the first and second binarized images
comprises:

producing the first type of collagen image based on collagen in the first
binarized image satisfying a predetermined size condition;
producing the second type of collagen image based on collagen in the first
30 binarized image satisfying a predetermined distance condition with respect to a

boundary of the portal tract and/or the central vein in the second binarized image;
and

producing the third type of collagen image based on collagen in the first
binarized image that does not satisfy the predetermined size condition and the
predetermined distance condition.

16. The system according to claim 10, wherein the plurality of different types
of collagen comprises portal collagen, fibrillar collagen and septal collagen.

17. The system according to claim 10, wherein the degree of fibrosis in the
tissue sample is determined based on the plurality of quantitative fibrosis values
corresponding to the plurality of different types of collagen, respectively, using a
multinomial logistic regression.

18. A computer program product, embodied in one or more non-transitory
computer-readable storage mediums, comprising instructions executable by at least
one processor to perform a method of assessing fibrosis in a tissue sample, the
method comprising:

obtaining a stained image of a stained tissue sample, the stained tissue
sample being stained in relation to collagen therein;

producing a plurality of different types of collagen images corresponding to
a plurality of different types of collagen, respectively, based on the stained image,
the plurality of different types of collagen images comprise a first type of collagen
image corresponding to a first type of collagen, a second type of collagen image
corresponding to a second type of collagen, and a third type of collagen image
corresponding to a third type of collagen;

providing the plurality of different types of collagen images as input images
to a deep neural network to output a plurality of quantitative fibrosis values
corresponding to the plurality of different types of collagen, respectively, wherein
the plurality of quantitative fibrosis values comprise a first quantitative fibrosis
value corresponding to the first type of collagen, a second quantitative fibrosis

value corresponding to the second type of collagen, and a third quantitative fibrosis value corresponding to the third type of collagen; and

determining a degree of fibrosis in the stained tissue sample based on the plurality of quantitative fibrosis values corresponding to the plurality of different types of collagen, respectively.

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