CLAIMS

1. A pupil radius detection method, comprising:

obtaining a to-be-detected pupil radius image, and extracting a region-of-interest image from the to-be-detected pupil radius image;

performing pixel processing on the region-of-interest image to obtain a pupil region image;

extracting a plurality of pupil contours from the pupil region image by using a boundary tracing algorithm;

obtaining a center of the region-of-interest image, a set of minimum enclosing circles of the plurality of pupil contours, and a circle center of each minimum enclosing circle in the set of minimum enclosing circles; and

obtaining a distance between the center and each circle center, selecting a circle center closest to the center, using a minimum enclosing circle corresponding to the closest circle center as a target circle, and using a radius of the target circle as a pupil radius,

wherein after the extracting a plurality of pupil contours from the pupil region image by using a boundary tracing algorithm, the method further comprises:

obtaining a set of pixels of each of the plurality of pupil contours;

sorting pixels in the set of pixels in ascending order of polar angles, wherein pixels having the same polar angle are sorted in ascending order of distances to the bottom leftmost pixel in the set of pixels;

storing sorted pixels by using a structure array, traversing the sorted pixels, and removing a non-vertex pixel to obtain a vertex pixel set; and

performing rotation determining on each vertex pixel in the vertex pixel set, and removing a vertex pixel at which rotation is not performed in a preset direction, to obtain pupil contours after convex hull processing; and

the obtaining a set of minimum enclosing circles of the plurality of pupil contours comprises:

obtaining a set of minimum enclosing circles of the pupil contours obtained after convex hull processing.

2. The method according to claim 1, wherein the performing pixel processing on the region-of-interest image to obtain a pupil region image comprises:

obtaining each pixel value of the region-of-interest image, and performing bitwise NOT processing on each pixel value to obtain each processed pixel value of the region-of-interest image; and

setting a pixel value less than a preset threshold in all the processed pixel values of the region-of-interest image to zero, to obtain the pupil region image.

3. The method according to claim 1, wherein the obtaining a set of minimum enclosing circles of the plurality of pupil contours comprises:

obtaining minimum enclosing circles respectively corresponding to the plurality of pupil contours and radiuses of the minimum enclosing circles; and

removing a minimum enclosing circle whose radius is greater than a preset value from the minimum enclosing circles, to obtain the set of minimum enclosing circles of the pupil contours.

4. The method according to claim 3, wherein the obtaining minimum enclosing circles respectively corresponding to the plurality of pupil contours comprises:

obtaining four pixels at the leftmost, rightmost, topmost, and bottommost of each of the plurality of pupil contours, and obtaining, based on the four pixels, a minimum circle enclosing the four pixels; and

traversing all pixels of the pupil contour, and when all the pixels comprise no pixel located outside a boundary of the minimum circle, determining that the minimum circle is a minimum enclosing circle of the pupil contour.

5. The method according to claim 4, further comprising:

when all the pixels comprise a pixel located outside the boundary of the minimum circle, determining that the minimum circle is not a minimum enclosing circle of the pupil contour;

selecting a pixel farthest from a circle center of the minimum circle from pixels located outside the boundary of the minimum circle, and performing permutation and combination on the selected pixel and any three of the four pixels at the leftmost, rightmost, topmost, and bottommost;

obtaining four pixels after permutation and combination, and obtaining, based on the four pixels obtained after permutation and combination, a candidate minimum circle enclosing the four pixels; and

when a pixel that is not selected for permutation and combination is not located outside a

boundary of the candidate minimum circle, traversing other pixels of the pupil contour, and when the other pixels comprise no pixel located outside the boundary of the candidate minimum circle, determining that the candidate minimum circle is a minimum enclosing circle of the pupil contour.

6. The method according to claim 1, further comprising:

obtaining four pixels for determining a minimum enclosing circle, randomly selecting two of the four pixels to obtain two different pixel combinations, and obtaining two straight lines by using the two different pixel combinations;

separately calculating perpendicular bisectors of the two straight lines, and calculating an intersection point of the two perpendicular bisectors to obtain a circle center of the minimum enclosing circle; and

calculating a distance between the circle center and any one of the four pixels to obtain a radius of the minimum enclosing circle.

7. A pupil radius detection apparatus, comprising:

an image extraction module, configured to: obtain a to-be-detected pupil radius image, and extract a region-of-interest image from the to-be-detected pupil radius image;

a pupil image obtaining module, configured to perform pixel processing on the region-of-interest image to obtain a pupil region image;

a pupil contour obtaining module, configured to extract a plurality of pupil contours from the pupil region image by using a boundary tracing algorithm;

a center and circle center obtaining module, configured to obtain a center of the region-of-interest image, a set of minimum enclosing circles of the plurality of pupil contours, and a circle center of each minimum enclosing circle in the set of minimum enclosing circles;

a pupil radius obtaining module, configured to: obtain a distance between the center and each circle center, select a circle center closest to the center, use a minimum enclosing circle corresponding to the closest circle center as a target circle, and use a radius of the target circle as a pupil radius; and

a convex hull processing module, configured to: obtain a set of pixels of each of the plurality of pupil contours; sort pixels in the set of pixels in ascending order of polar angles, where pixels having the same polar angle are sorted in ascending order of distances to the bottom leftmost pixel in the set of pixels; store sorted pixels by using a structure array, traverse the sorted pixels, and remove a non-vertex pixel to obtain a vertex pixel set; and perform rotation

determining on each vertex pixel in the vertex pixel set, and remove a vertex pixel at which rotation is not performed in a preset direction, to obtain pupil contours after convex hull processing,

wherein the center and circle center obtaining module is configured to obtain a set of minimum enclosing circles of the pupil contours obtained after convex hull processing.

8. The apparatus according to claim 7, wherein the pupil image obtaining module is further configured to obtain each pixel value of the region-of-interest image, and perform bitwise NOT processing on each pixel value to obtain each processed pixel value of the region-of-interest image; and

set a pixel value less than a preset threshold in all the processed pixel values of the region-of-interest image to zero, to obtain the pupil region image.

9. A computer device, comprising a memory and one or more processors, wherein the memory stores a computer readable instruction, and when executing the computer readable instruction, the one or more processors perform the following steps:

obtaining a to-be-detected pupil radius image, and extracting a region-of-interest image from the to-be-detected pupil radius image;

performing pixel processing on the region-of-interest image to obtain a pupil region image;

extracting a plurality of pupil contours from the pupil region image by using a boundary tracing algorithm;

obtaining a center of the region-of-interest image, a set of minimum enclosing circles of the plurality of pupil contours, and a circle center of each minimum enclosing circle in the set of minimum enclosing circles; and

obtaining a distance between the center and each circle center, selecting a circle center closest to the center, using a minimum enclosing circle corresponding to the closest circle center as a target circle, and using a radius of the target circle as a pupil radius. wherein when executing the computer readable instruction, the processors further perform the following steps:

obtaining a set of pixels of each of the plurality of pupil contours;

sorting pixels in the set of pixels in ascending order of polar angles, wherein pixels having the same polar angle are sorted in ascending order of distances to the bottom leftmost pixel in the set of pixels;

storing sorted pixels by using a structure array, traversing the sorted pixels, and removing a non-vertex pixel to obtain a vertex pixel set;

performing rotation determining on each vertex pixel in the vertex pixel set, and removing a vertex pixel at which rotation is not performed in a preset direction, to obtain pupil contours after convex hull processing; and

obtaining a set of minimum enclosing circles of the pupil contours obtained after convex hull processing.

10. The computer device according to claim 9, wherein when executing the computer readable instruction, the processors further perform the following steps:

obtaining each pixel value of the region-of-interest image, and performing bitwise NOT processing on each pixel value to obtain each processed pixel value of the region-of-interest image; and

setting a pixel value less than a preset threshold in all the processed pixel values of the region-of-interest image to zero, to obtain the pupil region image.

11. The computer device according to claim 9, wherein when executing the computer readable instruction, the processors further perform the following steps:

obtaining minimum enclosing circles respectively corresponding to the plurality of pupil contours and radiuses of the minimum enclosing circles; and

removing a minimum enclosing circle whose radius is greater than a preset value from the minimum enclosing circles, to obtain the set of minimum enclosing circles of the pupil contours.

12. The computer device according to claim 11, wherein when executing the computer readable instruction, the processors further perform the following steps:

obtaining four pixels at the leftmost, rightmost, topmost, and bottommost of each of the plurality of pupil contours, and obtaining, based on the four pixels, a minimum circle enclosing the four pixels; and

traversing all pixels of the pupil contour, and when all the pixels comprise no pixel located outside a boundary of the minimum circle, determining that the minimum circle is a minimum enclosing circle of the pupil contour.

13. The computer device according to claim 12, wherein when executing the computer readable instruction, the processors further perform the following steps:

when all the pixels comprise a pixel located outside the boundary of the minimum circle, determining that the minimum circle is not a minimum enclosing circle of the pupil contour;

selecting a pixel farthest from a circle center of the minimum circle from pixels located outside the boundary of the minimum circle, and performing permutation and combination on the selected pixel and any three of the four pixels at the leftmost, rightmost, topmost, and bottommost;

obtaining four pixels after permutation and combination, and obtaining, based on the four pixels obtained after permutation and combination, a candidate minimum circle enclosing the four pixels; and

when a pixel that is not selected for permutation and combination is not located outside a boundary of the candidate minimum circle, traversing other pixels of the pupil contour, and when the other pixels comprise no pixel located outside the boundary of the candidate minimum circle, determining that the candidate minimum circle is a minimum enclosing circle of the pupil contour.

14. One or more non-volatile computer readable storage media storing computer readable instructions, wherein when executing the computer readable instructions, one or more processors perform the following steps:

obtaining a to-be-detected pupil radius image, and extracting a region-of-interest image from the to-be-detected pupil radius image;

performing pixel processing on the region-of-interest image to obtain a pupil region image;

extracting a plurality of pupil contours from the pupil region image by using a boundary tracing algorithm;

obtaining a center of the region-of-interest image, a set of minimum enclosing circles of the plurality of pupil contours, and a circle center of each minimum enclosing circle in the set of minimum enclosing circles; and

obtaining a distance between the center and each circle center, selecting a circle center closest to the center, using a minimum enclosing circle corresponding to the closest circle center as a target circle, and using a radius of the target circle as a pupil radius. wherein when executing the computer readable instructions, the processors further perform the following steps:

obtaining a set of pixels of each of the plurality of pupil contours;

sorting pixels in the set of pixels in ascending order of polar angles, wherein pixels having the same polar angle are sorted in ascending order of distances to the bottom leftmost pixel in the set of pixels;

storing sorted pixels by using a structure array, traversing the sorted pixels, and removing a non-vertex pixel to obtain a vertex pixel set;

performing rotation determining on each vertex pixel in the vertex pixel set, and removing a vertex pixel at which rotation is not performed in a preset direction, to obtain pupil contours after convex hull processing; and

obtaining a set of minimum enclosing circles of the pupil contours obtained after convex hull processing.

15. The storage media according to claim 14, wherein when executing the computer readable instructions, the processors further perform the following steps:

obtaining each pixel value of the region-of-interest image, and performing bitwise NOT processing on each pixel value to obtain each processed pixel value of the region-of-interest image; and

setting a pixel value less than a preset threshold in all the processed pixel values of the region-of-interest image to zero, to obtain the pupil region image.

16. The storage media according to claim 14, wherein when executing the computer readable instructions, the processors further perform the following steps:

obtaining minimum enclosing circles respectively corresponding to the plurality of pupil contours and radiuses of the minimum enclosing circles; and

removing a minimum enclosing circle whose radius is greater than a preset value from the minimum enclosing circles, to obtain the set of minimum enclosing circles of the pupil contours.

17. The storage media according to claim 16, wherein when executing the computer readable instructions, the processors further perform the following steps:

obtaining four pixels at the leftmost, rightmost, topmost, and bottommost of each of the plurality of pupil contours, and obtaining, based on the four pixels, a minimum circle enclosing the four pixels; and

traversing all pixels of the pupil contour, and when all the pixels comprise no pixel located outside a boundary of the minimum circle, determining that the minimum circle is a minimum enclosing circle of the pupil contour.