DEFOCUS AMOUNT DETERMINING METHOD AND APPARATUS, DEVICE, AND MEDIUM

TECHNICAL FIELD

[0001] This application relates to the field of laser-based focusing, and in particular, to relates to a defocus amount determining method and apparatus, a device, and a medium.

BACKGROUND

[0002] A laser-based focusing system is configured to implement rapid and accurate focusing by using a laser technology, and is widely used in cameras, smart phones, industrial detection devices, and other fields. This system is usually configured to emit a laser beam onto a target object and calculate a defocus amount (a distance deviation between an actual focal position and an ideal focus position) according to a reflected laser signal, so as to adjust a lens position to an optimal focus according to the defocus amount, thereby achieving focusing. Therefore, in the laser-based focusing system, accurately and rapidly obtaining the defocus amount in laser-based focusing is critical for achieving precise focusing.

[0003] In an existing defocus amount determining method for laser-based focusing, a difference between a centroid of a captured laser image and a centroid of a reference image is taken as a defocus amount in laser-based focusing. In an image scenario with interference (for example, a complex image scenario or an image scenario with noise interference), a captured laser image may have blurring, jitter, and even tilting. As a result, a laser line in the captured laser image is deformed, making it difficult to accurately reflect an actual defocus state by the laser line in the captured laser image. In this case, precision of the defocus amount in laser-based focusing that is obtained in the existing defocus amount determining method is low, and consequently, the laser-based focusing system is inaccurate in focusing, low in a focusing speed, and cannot meet an application scenario (for example, semiconductor detection and panel detection) with a high requirement for imaging quality and focusing efficiency.

SUMMARY

[0004] An objective of this application is to provide a defocus amount determining method and apparatus, a device, and a medium, to resolve the problem that precision of a defocus amount in laser-based focusing that is obtained by an existing defocus amount determining method is low in an image scenario with interference.

[0005] To achieve the above objective, this application provides the following technical

solutions.

[0006] According to a first aspect, this application provide a defocus amount determining method, including:

[0007] obtaining a target laser image, where the target laser image is a laser image that is of a first target object and that is obtained under an actual focusing condition;

[0008] dividing the target laser image based on a division rule to obtain a plurality of first region images, where the division rule refers to dividing a to-be-divided image in a direction perpendicular to a laser line of the to-be-divided image;

[0009] selecting a first region image with a confidence not less than a first threshold according to a confidence of each of the first region images, to obtain a first target region image;

[0010] calculating a defocus amount mean value of all of the first target region images according to a defocus amount of each of the first target region images, to obtain a first defocus amount mean value; and

[0011] determining a defocus amount in laser-based focusing according to the first defocus amount mean value.

[0012] Optionally, the defocus amount determining method further includes:

[0013] calculating a defocus amount of each of the first region images before calculating the defocus amount mean value of all of the first target region images according to the defocus amount of each of the first target region images; and

[0014] extracting, from the defocus amounts of the first region images, the defocus amount of each of the first target region images.

[0015] Optionally, the defocus amount determining method further includes:

[0016] calculating the defocus amount of each of the first target region images before calculating the defocus amount mean value of all of the first target region images according to the defocus amount of each of the first target region images.

[0017] Optionally, the step of determining a defocus amount in laser-based focusing according to the first defocus amount mean value specifically includes:

[0018] using the first defocus amount mean value as the defocus amount in the laser-based focusing.

[0019] Optionally, the step of determining a defocus amount in laser-based focusing according to the first defocus amount mean value specifically includes:

[0020] selecting a first target region image whose defocus amount has a difference with the first defocus amount mean value not greater than a second threshold, to obtain a second target region image;

[0021] extracting, from the defocus amounts of the first region images or the defocus amounts of the first target region images, a defocus amount of each of the second target region images; and

[0022] calculating a defocus amount mean value of all of the second target region images according to the defocus amount of each of the second target region images, to obtain a second defocus amount mean value, and using the second defocus amount mean value as the defocus amount in laser-based focusing.

[0023] Optionally, the defocus amount of each of the first region images or the first target region images is calculated according to the following steps:

[0024] calculating a centroid of each sub-region image and a centroid of a second region image corresponding to the sub-region image by using an image centroid calculation method, where the sub-region image includes the first region image or the first target region image, the second region image is a region image that is obtained by dividing a reference image according to the division rule, and the reference image is a laser image that is of a second target object and that is obtained under an ideal focusing condition; and

[0025] calculating a difference between the centroid of each sub-region image and the centroid of the second region image corresponding to the sub-region image, to obtain a defocus amount of the sub-region image.

[0026] Optionally, the defocus amount determining method further includes:

[0027] before selecting the first region image with the confidence not less than the first threshold according to the confidence of each of the first region images, calculating the confidence of each of the first region images, where the confidence of each of the first region images is a mean squared error of pixel gray values of each of the first region images or a laser line width of the first region image.

[0028] According to a second aspect, a defocus amount determining apparatus is provided, including:

[0029] a capturing module, configured to obtain a target laser image, where the target laser image is a laser image that is of a target object and that is obtained under an actual focusing condition; and

[0030] a processing module, configured to: divide the target laser image based on a division rule to obtain a plurality of first region images, where the division rule refers to dividing a to-be-divided image in a direction perpendicular to a laser line of the to-be-divided image;

[0031] select a first region image with a confidence not less than a first threshold according to a confidence of each of the first region images, to obtain a first target region image, where the

confidence of each of the first region images refers to a laser line width of each of the first region images;

[0032] calculate a defocus amount mean value of all of the first target region images according to a defocus amount of each of the first target region images, to obtain a first defocus amount mean value; and

[0033] determine a defocus amount in laser-based focusing according to the first defocus amount mean value.

[0034] According to a third aspect, this application provides a computer device, including a memory, a processor, and a computer program stored in the memory and executable on the processor, where the processor executes the computer program to perform the steps of the defocus amount determining method according to any one of the items described above.

[0035] According to a fourth aspect, this application provides a computer-readable storage medium. The computer-readable storage medium stores a computer program, and the computer program is executed by a processor to implement the steps of the defocus amount determining method according to any one of the items described above.

[0036] According to specific examples provided in this application, this application discloses the following technical effects:

[0037] According to the defocus amount determining method and apparatus, the device, and the medium provided in this application, the target laser image is obtained, the target laser image is divided into the plurality of first region images according to the division rule, and the first region image with the confidence not less than the preset first threshold is selected according to the confidence of each first region image, to discard a first region image with a confidence less than the first threshold and reserve the first region image with the confidence not less than the first threshold. The confidence being less than the first threshold means that a laser line of the first region image has large deformation, and the confidence being not less than the first threshold means that the laser line of the first region image does not have large deformation. Therefore, compared with the original target laser image, the first region image that has the confidence not less than the first threshold and that is reserved after the first region image with the confidence less than the first threshold is discarded is the first target region image that can precisely reflect an actual defocus state. The defocus amount mean value of all of the first target region images is calculated according to the defocus amount of each first target region image, to obtain the first defocus amount mean value, and the defocus amount in laser-based focusing is determined according to the first defocus amount mean value. Therefore, the defocus amount in laser-based focusing is determined by using an image region that can

precisely reflect the actual defocus state, and precision of the determined defocus amount in laser-based focusing is ensured. In addition, the defocus amount in laser-based focusing is determined according to the first defocus amount mean value, noise interference can be further avoided, and the precision of the determined defocus amount in laser-based focusing is further improved. In conclusion, in embodiments of this application, a problem that the precision of the defocus amount in laser-based focusing that is obtained by an existing defocus amount determining method is low in an image scenario with interference is resolved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0038] To describe the technical solutions in the embodiments of this application or in the conventional technology more clearly, the following briefly describes the accompanying drawings required for the embodiments. Apparently, the accompanying drawings in the following description show merely some embodiments of this application, and a person of ordinary skill in the art may still derive other accompanying drawings from these accompanying drawings without creative efforts.

[0039] FIG. 1 is a schematic flowchart of a defocus amount determining method according to an embodiment of this application;

[0040] FIG. 2 is a schematic diagram of dividing a target laser image according to a division rule according to an embodiment of this application;

[0041] FIG. 3 is a schematic diagram of a functional module of a defocus amount determining apparatus according to an embodiment of this application; and

[0042] FIG. 4 is a schematic diagram of a structure of a computer device according to an embodiment of this application.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0043] The technical solutions in the embodiments of this application are clearly and completely described below with reference to the drawings in the embodiments of this application. Apparently, the described embodiments are only some rather than all of the embodiments of this application. All other embodiments obtained by a person of ordinary skill in the art based on the embodiments of this application without creative efforts shall fall within the protection scope of this application.

[0044] To make the above objectives, features, and advantages of this application more obvious and easier to understand, this application will be further described in detail with reference to the accompanying drawings and specific implementations.

[0045] In an example embodiment, as shown in FIG. 1, a defocus amount determining method is provided, including the following step 101 to step 105.

[0046] In step 101, a target laser image is obtained, where the target laser image is a laser image that is of a first target object and that is obtained under an actual focusing condition.

[0047] In this embodiment of this application, the first target object is an object that needs to be imaged through a target imaging system in an application scenario. The target imaging system is an imaging system that needs to be focused through a laser-based focusing system. For example, in a detection scenario (for example, semiconductor detection and panel detection), a to-be-detected object is the first target object.

[0048] In step 102, the target laser image is divided based on a division rule to obtain a plurality of first region images, where the division rule refers to dividing a to-be-divided image in a direction perpendicular to a laser line of the to-be-divided image.

[0049] In this embodiment of this application, the plurality of first region images do not overlap with each other, and each first region image includes at least one row of pixel points of the target laser image. The to-be-divided image may be divided according to characteristics of a laser line in the to-be-divided image. The characteristics of the laser line include a shape, a brightness, and the like. For example, a region in which laser lines that are focused together are located in the to-be-divided image is classified as an image region, and a region in which divergent laser lines in the to-be-divided image are located is classified as an image region. For another example, regions in which laser lines with different brightnesses are located are classified as different image regions. The to-be-divided image includes the target laser image. A quantity of rows of pixel points included in each first region image is not specifically limited, and may be set according to actual requirements. For example, as shown in FIG. 2, a target laser image obtained at a specific moment is divided into five first region images (with reference numerals of 1, 2, 3, 4, and 5). The black part in the middle is a schematic diagram of a laser line, four dashed lines indicate region division.

[0050] In step 103, a first region image with a confidence not less than a first threshold is selected according to a confidence of each first region image, to obtain a first target region image.

[0051] In this embodiment of this application, the defocus amount is a distance deviation between an actual focus position and an ideal focus position. The first threshold is obtained by debugging within a value range. Specifically, the defocus amount in laser-based focusing under different first thresholds is obtained by using the method in this application. After the laser-based focusing system is configured to perform laser-based focusing on the defocus amount in

laser-based focusing under different first thresholds, target laser images are obtained through the imaging system. A value of a first threshold corresponding to an obtained clearest target laser image is used in this embodiment of this application. The confidence of each first region image is a laser line width of the first region image or a mean squared error of pixel gray values.

[0052] In step 104, a defocus amount mean value of all of the first target region images is calculated according to a defocus amount of each first target region image, to obtain a first defocus amount mean value.

[0053] In step 105, a defocus amount in laser-based focusing is determined according to the first defocus amount mean value.

[0054] In this embodiment of this application, the defocus amount in laser-based focusing is a defocus amount for performing laser-based focusing by the laser-based focusing system.

[0055] According to the foregoing step 101 to step 105, the target laser image is obtained, the target laser image is divided into the plurality of first region images according to the division rule, and the first region image with the confidence not less than the preset first threshold is selected according to the confidence of each first region image, to discard a first region image with a confidence less than the first threshold and reserve the first region image with the confidence not less than the first threshold. The confidence being less than the first threshold means that a laser line of the first region image has large deformation, and the confidence being not less than the first threshold means that the laser line of the first region image does not have large deformation. Therefore, compared with the original target laser image, the first region image that has the confidence not less than the first threshold and that is reserved after the first region image with the confidence less than the first threshold is discarded is the first target region image that can precisely reflect an actual defocus state. The defocus amount mean value of all of the first target region images is calculated according to the defocus amount of each first target region image, to obtain the first defocus amount mean value, and the defocus amount in laser-based focusing is determined according to the first defocus amount mean value. Therefore, the defocus amount in laser-based focusing is determined by using an image region that can precisely reflect the actual defocus state, and precision of the determined defocus amount in laser-based focusing is ensured. In addition, the defocus amount in laser-based focusing is determined according to the first defocus amount mean value, noise interference can be further avoided, and the precision of the determined defocus amount in laser-based focusing is further improved. In conclusion, in embodiments of this application, a problem that the precision of the defocus amount in laser-based focusing that is obtained by an existing defocus amount determining method is low in an image scenario with interference is resolved.

[0056] Optionally, in another embodiment of this application, the defocus amount determining method further includes the following step 201 and step 202.

[0057] In step 201, a defocus amount of each first region image is calculated before step 104.

[0058] In step 202, the defocus amount of each first target region image is extracted from the defocus amounts of the first region images.

[0059] In this embodiment of this application, the defocus amount of each first target region image is extracted from the defocus amounts of the first region images. To be specific, the defocus amount of the first region image with the confidence not greater than the first threshold is extracted from the defocus amounts of the first region images.

[0060] Optionally, in another embodiment of this application, the defocus amount determining method further includes the following steps.

[0061] The defocus amount of each first target region image is calculated before step 104.

[0062] Optionally, in another embodiment of this application, the defocus amount of each first region image or first target region image is calculated according to the following step 301 and step 302.

[0063] In step 301, a centroid of each sub-region image and a centroid of a second region image corresponding to the sub-region image are calculated by using an image centroid calculation method, where the sub-region image includes the first region image or the first target region image, the second region image is a region image that is obtained by dividing a reference image according to the division rule, and the reference image is a laser image that is of a second target object and that is obtained under an ideal focusing condition.

[0064] In this embodiment of this application, a to-be-divided image in the division rule includes a reference image. The plurality of second region images do not overlap with each other, and each second region image includes at least one row of pixel points of the target laser image. A size and a division rule of the reference image are consistent with those of the target laser image. The first region images and the second region images that are obtained through division are in a one-to-one correspondence. The one-to-one correspondence means that a quantity of rows of pixel points included in a corresponding first region image and a corresponding second region image, and positions of pixel points in each row are the same. For example, the size of the reference image and the seize of the target laser image are 300*430. If the target laser image is divided into five first region images, the 1st first region image includes pixel points in 1st to 60th rows of the target laser image, the 2nd first region image includes pixel points in 61st to 120th rows of the target laser image, the 3rd first region image includes pixel points in 121st to 180th rows of the target laser image, the 4th first region image includes pixel

points in 181st to 240th rows of the target laser image, and the 5th first region image includes pixel points in 241st to 300th rows of the target laser image. In this case, the reference image is divided into five second region images, the 1st second region image includes pixel points in 1st to 60th rows of the reference image, the 2nd second region image includes pixel points in 61st to 120th rows of the reference image, the 3rd second region image includes pixel points in 121st to 180th rows of the reference image, the 4th second region image includes pixel points in 181st to 240th rows of the reference image, and the 5th second region image includes pixel points in 241st to 300th rows of the reference image.

[0065] The second region image corresponding to each first target region image is a second region image corresponding to the first region image with the confidence not less than the first threshold.

[0066] The second target object is the first target object or a reflector with a flat surface, and is preferably the reflector with a flat surface. The reason is that a form of a laser line in a reference image obtained when the reflector with a flat surface is used as the second target object is better than a form of a laser line in a reference image obtained when the first target object is used as the second target object.

[0067] The centroid of each sub-region image and the centroid of the second region image corresponding to the sub-region image are calculated by using the image centroid calculation method. To be specific, the centroid of each sub-region image and the centroid of the second region image corresponding to the sub-region image are calculated by using the following formula:

$$\bar{x} = \frac{\sum_{x=0}^{W-1}\sum_{y=0}^{H-1} x \bullet p(x,y)}{\sum_{x=0}^{W-1}\sum_{y=0}^{H-1} p(x,y)}$$; and

$$\bar{y} = \frac{\sum_{x=0}^{W-1}\sum_{y=0}^{H-1} y \bullet p(x,y)}{\sum_{x=0}^{W-1}\sum_{y=0}^{H-1} p(x,y)}$$.

[0068] $\bar{x}$ is a horizontal coordinate of a centroid of an image, and $\bar{y}$ is a vertical coordinate of the centroid of the image. The image includes each first target region image or a second region image corresponding to the first target region image. x and y are a horizontal coordinate and a vertical coordinate of a single pixel point of the image. $p(x,y)$ is a gray

value of a single pixel point of the image. W is a width of the image. H is a height of the image. W and H are in a unit of a quantity of pixel points.

[0069] In step 302, a difference between the centroid of each sub-region image and the centroid of the second region image corresponding to the sub-region image is calculated, to obtain a defocus amount of the sub-region image.

[0070] In this embodiment of this application, the difference between centroids of each sub-region image and the second region image corresponding to the sub-region image is calculated. To be specific, the difference between the centroid of each sub-region image and the centroid of the second region image corresponding to the sub-region image is calculated.

[0071] Optionally, in another embodiment of this application, the determining a defocus amount in laser-based focusing according to the first defocus amount mean value specifically includes the following steps.

[0072] The first defocus amount mean value is used as the defocus amount in the laser-based focusing.

[0073] Optionally, in another embodiment of this application, the determining a defocus amount in laser-based focusing according to the first defocus amount mean value specifically includes the following step 401 to step 403.

[0074] In step 401, a first target region image whose defocus amount has a difference with the first defocus amount mean value not greater than a second threshold is selected, to obtain a second target region image.

[0075] In this embodiment of this application, the second threshold is obtained by debugging within a value range. Specifically, the defocus amount in laser-based focusing under a same first threshold and different second thresholds is obtained by using the method in this application. After the laser-based focusing system is configured to perform laser-based focusing on the defocus amount in laser-based focusing under the same first threshold and different second thresholds, target laser images are obtained through the imaging system. A value of a second threshold corresponding to an obtained clearest target laser image is used in this embodiment of this application.

[0076] In step 402, a defocus amount of each second target region image is extracted from the defocus amounts of the first region images or the defocus amounts of the first target region images.

[0077] In this embodiment of this application, the defocus amount of each second target region image is extracted from the defocus amounts of the first region images. To be specific, a

defocus amount of a first region image with a confidence not less than the first threshold and a difference between the defocus amount and the first defocus amount mean value not greater than the second threshold is extracted from the defocus amounts of the first region images. The defocus amount of each second target region image is extracted from the defocus amount of the first target region image. To be specific, a defocus amount of a first target region image with a difference between the defocus amount and the first defocus amount mean value not greater than the second threshold is extracted from the defocus amount of the first target region image.

[0078] In step 403, a defocus amount mean value of all of the second target region images is calculated according to the defocus amount of each second target region image, to obtain a second defocus amount mean value, and the second defocus amount mean value is used as the defocus amount in laser-based focusing.

[0079] In this embodiment of this application, the first target region image with the difference between the defocus amount and the first defocus amount mean value greater than the second threshold is further discarded, and the first target region image with the difference between the defocus amount and the first defocus amount mean value not greater than the second threshold is reserved. A laser line in the first target region image with the difference between the defocus amount and the first defocus amount mean value greater than the second threshold has specific deformation, and a laser line in the first target region image with the difference between the defocus amount and the first defocus amount mean value not greater than the second threshold basically has no deformation. Compared with the first region image with the confidence not smaller than the first threshold, the first target region image that has the difference between the defocus amount and the first defocus amount mean value not greater than the second threshold and that is reserved after the first target region image with the difference between the defocus amount and the first defocus amount mean value greater than the second threshold is discarded can precisely reflect an actual defocus state. The defocus amount mean value of all of the second target region images is calculated, to obtain the second defocus amount mean value, and the second defocus amount mean value is used as the defocus amount in laser-based focusing. Therefore, the defocus amount in laser-based focusing is determined by using an image region that can precisely reflect the actual defocus state, and precision of the determined defocus amount in laser-based focusing is further ensured. In addition, the defocus amount in laser-based focusing is determined according to the second defocus amount mean value, noise interference can be further avoided, and the precision of the determined defocus amount in laser-based focusing is further improved.

[0080] Optionally, in another embodiment of this application, the dividing a to-be-divided image in a direction perpendicular to a laser line of the to-be-divided image includes the following step 501 to step 503.

[0081] In step 501, the to-be-divided image is preprocessed.

[0082] In this embodiment of this application, the to-be-divided image includes the target laser image or the reference image. Pre-processing includes gray-level conversion, filtering, and the like, to reduce noises and enhance characteristics of the laser line.

[0083] In step 502, edges of a laser line of the pre-processed to-be-divided image are identified by using an edge detection algorithm, and boundaries on the two sides of the laser line are extracted.

[0084] In this embodiment of this application, a position of the laser line can be determined by identifying the boundaries on the two sides, in a length direction, of the laser line of the pre-processed to-be-divided image.

[0085] In step 503, the to-be-divided image is divided into a plurality of slices in a direction perpendicular to the laser line according to the boundaries on the two sides of the laser line, where each slice is one first region image or one second region image.

[0086] Optionally, in another embodiment of this application, the defocus amount determining method further includes the following steps.

[0087] A confidence of each first region image is calculated before step 102.

[0088] In this embodiment of this application, the confidence of each first region image is a mean squared error of pixel gray values of the first region image or a laser line width of the first region image. The mean squared error of pixel gray values of each first region image is an average value of sum of squared differences between gray values of all pixel points of the first region image and an average gray value of the first region image. Variation in the mean squared error can reveal uniformity of gray values within the laser line and boundary sharpness of the laser line. Generally, a narrower laser line indicates a higher contrast. A fiercer gray change of the boundary of the laser line indicates a higher mean squared error.

[0089] Optionally, in another embodiment of this application, to improve accuracy of the confidence, the laser line width of each first region image is calculated according to the following step 601 to step 603.

[0090] In step 601, binarization is performed on each first region image according to the boundaries on the two sides of the laser line of the first region image, to obtain a binary image.

[0091] In step 602, connected component analysis is performed on each binary image to find all connected components of the binary image, and identify a connected component that can

represent the laser line from the all connected components.

[0092] In step 603, a width of the connected component that can represent the laser line in each binary image is measured to obtain a laser line width of each first region image.

[0093] In this embodiment of this application, the laser line width is measured in a plurality of manners. For example, contours of the laser line are extracted from the connected component that represents the laser line by using a contour extraction method, and the laser line width is estimated by calculating a distance between corresponding two points on the contours. For another example, a quantity of pixels belonging to the laser line in each pixel row perpendicular to the laser line is counted by using a pixel-based method. A maximum value or a mean value of the quantities may be the laser line width.

[0094] Optionally, in another embodiment of this application, the defocus amount determining method further includes the following steps.

[0095] Focusing data is determined according to defocus amount in laser-based focusing.

[0096] A laser focusing system is controlled to perform laser-based focusing according to the focusing data.

[0097] In this embodiment of this application, that a laser-based focusing system is controlled to perform laser-based focusing according to the focusing data means that a mechanical apparatus (for example, a motor) of the laser-based focusing system is controlled according to the focusing data to move a lens to an appropriate position, to complete an auto-focus process.

[0098] Based on a same inventive concept, an embodiment of this application further provides a defocus amount determining apparatus for implementation of the defocus amount determining method. Implementation solutions provided by the apparatus for resolving the problems are similar with the implementation solutions recorded in the method, and therefore, specific limitations in apparatus embodiments for determining one or more pieces of defocus amount provided below, refer to the limitations on the defocus amount determining method mentioned above. Details are not described herein again.

[0099] In an example embodiment, as shown in FIG. 3, a defocus amount determining apparatus 80 is provided, including a capturing module 801 and a processing module 802.

[0100] The capturing module 801 is configured to obtain a target laser image, where the target laser image is a laser image that is of a target object and that is obtained under an actual focusing condition.

[0101] The processing module 802 is configured to: divide the target laser image based on a division rule to obtain a plurality of first region images, where the division rule refers to dividing a to-be-divided image in a direction parallel to a laser line of the to-be-divided image;

[0102] select a first region image with a confidence not less than a first threshold according to a confidence of each first region image, to obtain a first target region image, where the confidence of each first region image refers to a laser line width of the first region image;

[0103] calculate a defocus amount mean value of all of the first target region images according to a defocus amount of each first target region image, to obtain a first defocus amount mean value; and

[0104] determine a defocus amount in laser-based focusing according to the first defocus amount mean value.

[0105] Optionally, in another embodiment of this application, the processing module 802 is further configured to calculate a defocus amount of each first region image before calculating the defocus amount mean value of all of the first target region images according to the defocus amount of each first target region image; and

[0106] extract, from the defocus amounts of the first region images, the defocus amount of each first target region image.

[0107] Optionally, in another embodiment of this application, the processing module 802 is further configured to: calculate the defocus amount of each first target region image before calculating the defocus amount mean value of all of the first target region images according to the defocus amount of each first target region image.

[0108] Optionally, in another embodiment of this application, the processing module 802 is further configured to calculate the defocus amount of each first region image or each first target region image according to the following steps.

[0109] A centroid of each sub-region image and a centroid of a second region image corresponding to the sub-region image are calculated by using an image centroid calculation method, where the sub-region image includes the first region image or the first target region image, the second region image is a region image that is obtained by dividing a reference image according to the division rule, and the reference image is a laser image that is of a target object and that is obtained under an ideal focusing condition.

[0110] A difference between the centroid of each sub-region image and the centroid of the second region image corresponding to the sub-region image is calculated, to obtain a defocus amount of the sub-region image.

[0111] In this embodiment of this application, for relevant descriptions of the step of calculating a centroid of each sub-region image and a centroid of a second region image corresponding to the sub-region image by using an image centroid calculation method, refer to the above method embodiments. Details are not described herein again.

[0112] Optionally, in another embodiment of this application, the processing module 802 is further configured to use the first defocus amount mean value as the defocus amount in the laser-based focusing.

[0113] Optionally, in another embodiment of this application, the processing module 802 is further configured to: select a first target region image whose defocus amount has a difference with the first defocus amount mean value not greater than a second threshold, to obtain a second target region image;

[0114] extract, from the defocus amounts of the first region images or the defocus amounts of the first target region images, a defocus amount of each second target region image; and

[0115] calculate a defocus amount mean value of all of the second target region images according to the defocus amount of each second target region image, to obtain a second defocus amount mean value, and use the second defocus amount mean value as the defocus amount in laser-based focusing.

[0116] Optionally, in another embodiment of this application, the processing module 802 is further configured to: pre-process the to-be-divided image, where the to-be-divided image includes the target laser image or the reference image;

[0117] identify edges of a laser line of the pre-processed to-be-divided image by using an edge detection algorithm, and extract boundaries on the two sides of the laser line; and

[0118] divide the to-be-divided image into a plurality of slices in a direction perpendicular to the laser line according to the boundaries on the two sides of the laser line, where each slice is one first region image or one second region image.

[0119] In this embodiment of this application, pre-processing includes gray-level conversion, filtering, and the like, to reduce noises and enhance characteristics of the laser line. A position of the laser line can be determined by identifying the boundaries on the two sides, in a length direction, of the laser line of the pre-processed to-be-divided image.

[0120] Optionally, in another embodiment of this application, the processing module 802 is further configured to calculate the confidence of each first region image before dividing the target laser image according to the division rule to obtain the plurality of first region images.

[0121] Optionally, in another embodiment of this application, the processing module 802 is further configured to calculate a laser line width of each first region image according to the following steps.

[0122] Binarization is performed on each first region image according to the boundaries on the two sides of the laser line of the first region image, to obtain a binary image.

[0123] Connected component analysis is performed on each binary image to find all connected

components of the binary image, and a connected component that can represent the laser line is identified from the all connected components.

[0124] A width of the connected component that can represent the laser line in each binary image is measured to obtain a laser line width of each first region image.

[0125] Optionally, in another embodiment of this application, the processing module 802 is further configured to determine focusing data according to the defocus amount in laser-based focusing.

[0126] Optionally, in another embodiment of this application, the defocus amount determining apparatus 80 further includes a data communication module 803 and a control module 804.

[0127] The data communication module 803 is configured to send focusing data.

[0128] The control module 804 is configured to control a laser-based focusing system according to the received focusing data to perform laser-based focusing. For related descriptions, refer to descriptions in the above method embodiment. Details are not described herein again.

[0129] In an example embodiment, a computer device is provided. The computer device may be a server or terminal, and an internal structure thereof may be as shown in FIG. 4. The computer device includes a processor, a memory, an input/output (I/O) interface and a communication interface. The processor, the memory, and the input/output interface are connected through a system bus, and the communication interface is connected to the system bus through the I/O interface. The processor of the computer apparatus is configured to provide computing and control capabilities. The memory of the computer device includes a non-volatile storage medium and an internal memory. The non-volatile storage medium stores an operating system, a computer program, and a database. The internal memory provides an environment for operation of the operating system and the computer program in the non-volatile storage medium. The database of the computer device is configured to store data of a defocus amount determining method. The I/O interface of the computer apparatus is configured to exchange information between the processor and an external apparatus. The communication interface of the computer device is configured to communicate with an external terminal through a network. When the computer program is executed by the processor, a defocus amount determining method is implemented.

[0130] Those skilled in the art may understand that the structure shown in FIG. 4 is only a block diagram of a part of the structure related to the solutions of this application and does not constitute a limitation on a computer device to which the solutions of this application are applied. Specifically, the computer device may include more or fewer components than those

shown in the figure, or combine some components, or have different component arrangements.

[0131] In an example embodiment, a computer device is further provided, including a memory and a processor, where the memory stores a computer program, and the computer program is executed by the processor to implement the steps of the above method embodiment.

[0132] In an example embodiment, a computer-readable storage medium is provided. The computer-readable storage medium stores a computer program, and the computer program is executed by a processor to implement the steps of the above method embodiment.

[0133] In an example embodiment, a computer program product is provided. The computer program product includes a computer program, and the computer program is executed by a processor to implement the steps of the above method embodiment.

[0134] It is to be noted that user information (including but not limited to user device information, user personal information, and the like) and data (including but not limited to data for analysis, data for storage, data for exhibition and the like) in this application are information and data authorized by a user or fully authorized by each party, and relevant data shall be acquired, used and processed according to relevant regulations.

[0135] Those of ordinary skill in the art may understand that all or some of the procedures in the method of the foregoing embodiments may be implemented by a computer program instructing related hardware. The computer program may be stored in a non-volatile computer-readable storage medium. When the computer program is executed, the procedures in the embodiments of the foregoing method may be performed. Any reference to a memory, a database, or other media used in the embodiments of this application may include at least one of a non-volatile memory and a volatile memory. The non-volatile memory may include a read-only memory (ROM), a magnetic tape, a floppy disk, a flash memory, an optical memory, a high-density embedded non-volatile memory, a resistive random access memory (ReRAM), a magnetoresistive random access memory (MRAM), a ferroelectric random access memory (FRAM), a phase change memory (PCM), a graphene memory, etc. The volatile memory may include a random access memory (RAM) or an external cache memory. As an illustration rather than a limitation, the RAM may be in various forms, such as a static random access memory (SRAM) or a dynamic random access memory (DRAM).

[0136] The database in the embodiments of this application may include at least one of a relational database and a non-relational database. The non-relational database may include a distributed database based on a blockchain, but is not limited thereto. The processor in the embodiments of this application may be a general-purpose processor, a central processing unit, a graphics processing unit, a digital signal processor, a programmable logic device, and a data

processing logic device based on quantum computing, but is not limited thereto.

[0137] The technical characteristics of the above embodiments can be employed in arbitrary combinations. To provide a concise description of these embodiments, all possible combinations of all the technical characteristics of the above embodiments may not be described; however, these combinations of the technical characteristics should be construed as falling within the scope defined by the specification as long as no contradiction occurs.

[0138] Several examples are used herein for illustration of the principles and implementations of this application. The description of the foregoing examples is used to help illustrate the method of this application and the core principles thereof. In addition, those of ordinary skill in the art can make various modifications in terms of specific implementations and scope of application in accordance with the teachings of this application. In conclusion, the content of the present specification shall not be construed as a limitation to this application.

WHAT IS CLAIMED IS:

1. A defocus amount determining method, wherein the defocus amount determining method comprises:

obtaining a target laser image, wherein the target laser image is a laser image that is of a first target object and that is obtained under an actual focusing condition;

dividing the target laser image based on a division rule to obtain a plurality of first region images, wherein the division rule refers to dividing a to-be-divided image in a direction perpendicular to a laser line of the to-be-divided image;

selecting a first region image with a confidence not less than a first threshold according to a confidence of each of the first region images, to obtain a first target region image;

calculating a defocus amount mean value of all of the first target region images according to a defocus amount of each of the first target region images, to obtain a first defocus amount mean value; and

determining a defocus amount in laser-based focusing according to the first defocus amount mean value.

2. The defocus amount determining method according to claim 1, further comprising:

calculating a defocus amount of each of the first region images before calculating the defocus amount mean value of all of the first target region images according to the defocus amount of each of the first target region images; and

extracting, from the defocus amounts of the first region images, the defocus amount of each of the first target region images.

3. The defocus amount determining method according to claim 1, further comprising:

calculating the defocus amount of each of the first target region images before calculating the defocus amount mean value of all of the first target region images according to the defocus amount of each of the first target region images.

4. The defocus amount determining method according to claim 1, wherein the step of determining a defocus amount in laser-based focusing according to the first defocus amount mean value specifically comprises:

using the first defocus amount mean value as the defocus amount in the laser-based focusing.

5. The defocus amount determining method according to claim 1, wherein the step of determining a defocus amount in laser-based focusing according to the first defocus amount mean value specifically comprises:

selecting a first target region image whose defocus amount has a difference with the first defocus amount mean value not greater than a second threshold, to obtain a second target region image;

extracting, from the defocus amounts of the first region images or the defocus amounts of the first target region images, a defocus amount of each of the second target region images; and

calculating a defocus amount mean value of all of the second target region images according to the defocus amount of each of the second target region images, to obtain a second defocus amount mean value, and using the second defocus amount mean value as the defocus amount in laser-based focusing.

6. The defocus amount determining method according to claim 1, wherein the defocus amount of each of the first region images or the first target region images is calculated according to the following steps:

calculating a centroid of each sub-region image and a centroid of a second region image corresponding to the sub-region image by using an image centroid calculation method, wherein the sub-region image comprises the first region image or the first target region image, the second region image is a region image that is obtained by dividing a reference image according to the division rule, and the reference image is a laser image that is of a second target object and that is obtained under an ideal focusing condition; and

calculating a difference between the centroid of each sub-region image and the centroid of the second region image corresponding to the sub-region image, to obtain a defocus amount of the sub-region image.

7. The defocus amount determining method according to claim 1, further comprising:

before selecting the first region image with the confidence not less than the first threshold according to the confidence of each of the first region images, calculating the confidence of each of the first region images, wherein the confidence of each of the first region images is a mean squared error of pixel gray values of each of the first region images or a laser line width of the first region image.

8. A defocus amount determining apparatus, wherein the defocus amount determining apparatus comprises:

a capturing module, configured to obtain a target laser image, wherein the target laser image is a laser image that is of a target object and that is obtained under an actual focusing condition; and

a processing module, configured to: divide the target laser image based on a division rule to obtain a plurality of first region images, wherein the division rule refers to dividing a to-be-divided image in a direction perpendicular to a laser line of the to-be-divided image;

select a first region image with a confidence not less than a first threshold according to a confidence of each of the first region images, to obtain a first target region image, wherein the confidence of each of the first region images refers to a laser line width of each of the first region images;

calculate a defocus amount mean value of all of the first target region images according to a defocus amount of each of the first target region images, to obtain a first defocus amount mean value; and

determine a defocus amount in laser-based focusing according to the first defocus amount mean value.

9. A computer device, comprising a memory, a processor, and a computer program stored in the memory and executable on the processor, wherein the processor executes the computer program to implement the steps of the defocus amount determining method according to any one of claims 1 to 7.

10. A computer-readable storage medium, wherein the computer-readable storage medium stores a computer program, and the computer program is executed by a processor to implement the steps of the defocus amount determining method according to any one of claims 1 to 7.