

IMAGE DETECTION METHOD AND APPARATUS, ELECTRONIC DEVICE, AND STORAGE MEDIUM

[0001] This application claims the priority to Chinese Patent Application No. 202311811816.8, titled "IMAGE DETECTION METHOD AND APPARATUS, ELECTRONIC DEVICE, AND STORAGE MEDIUM", filed on December 27, 2023 with the China National Intellectual Property Administration, which is incorporated herein by reference in its entirety.

FIELD

[0002] The present disclosure relates to the field of technology, and in particular, to an image detection method, an image detection apparatus, an electronic device, and a storage medium.

BACKGROUND

[0003] Conventional surface quality inspection of industrial products is performed manually by quality inspectors. However, manual inspection methods have drawbacks such as low accuracy, low efficiency, and high labor intensity. The use of machine vision technology for automated quality inspection of industrial product surfaces has become a very important means for the manufacturing industry to improve product quality. Machine vision-based quality inspection systems typically offer advantages such as high precision, high efficiency, fast continuous inspection speed, and non-contact measurement.

[0004] In related art, visual inspection algorithms are often used directly to detect whether defects exist on the surface of industrial products. However, when the threshold control of conventional visual inspection algorithms is relatively low, normal industrial products are prone to be determined as defective. Consequently, this affects the accuracy of the inspection results.

SUMMARY

[0005] In view of above issues, the present disclosure is provided. An image detection method, an image detection apparatus, an electronic device, and a storage medium are provided according to the present disclosure.

[0006] According to an aspect of the present disclosure, an image detection method is provided, comprising: obtaining a to-be-detected image; performing defect detection on the to-be-detected image by using a preset defect detection algorithm to determine a first defect detection result, where the first defect detection result comprises position information of a defect region in the to-be-detected image; obtaining a defect-free image from the to-be-detected image based on the first defect detection result; training a defect detection model by using the defect-free image to obtain a trained defect detection model; and performing defect detection on a target image at least by using the trained defect detection model to determine a second defect detection result, where the second defect detection result comprises position information of a defect region in the target image, and the target image is the to-be-detected image or a defective image obtained from the to-be-detected image based on the first defect detection result.

[0007] In the foregoing technical solution, a defect-free image is obtained from the to-be-detected image based on the first defect detection result which is obtained via the preset defect detection algorithm, and defect detection is performed on the target image using the defect detection model trained based on the defect-free image, improving the accuracy and robustness of image detection. In addition, this solution does not require additional collection of images when training the defect detection model, which is beneficial for improving the efficiency of image detection.

[0008] In a possible implementation, the performing defect detection on a target image at least by using the trained defect detection model to determine a second defect detection result comprises: extracting, from the target image, a to-be-detected sub-image in one-to-one correspondence with at least one target image position; performing defect detection on at least a portion of the extracted at least one to-be-detected sub-image by using the trained defect detection model to determine a sub-defect detection result in one-to-one correspondence with all to-be-detected sub-image among the at least a portion of the to-be-detected sub-image , where the sub-defect detection result comprises position information of a sub-defect region and/or an area of the sub-defect region in the corresponding to-be-detected sub-image, and where the second defect detection result comprises the sub-defect detection result in one-to-one correspondence with the at least a portion of the to-be-detected sub-image.

[0009] In the foregoing technical solution, the to-be-detected sub-image is extracted from the target image and the defect detection is performed on at least a portion of the extracted at least

one to-be-detected sub-image by using the trained defect detection model, thereby obtaining the sub-defect detection result in one-to-one correspondence with the at least a portion of the to-be-detected sub-image. In summary, this solution helps determine the defect detection result of the target image more accurately.

5 **[0010]** In a possible implementation, the performing defect detection on at least a portion of the at least one to-be-detected sub-image by using the trained defect detection model comprises: performing defect detection by using the trained defect detection model on a to-be-detected sub-image, among the at least one to-be-detected sub-image, that intersects with the defect region indicated in the first defect detection result.

10 **[0011]** In the solution of this example, it is only required to input the to-be-detected sub-image determined to have a defect based on the first defect detection result into the trained defect detection model for defect detection, thereby reducing computational load and improving defect detection efficiency.

15 **[0012]** In a possible implementation, the performing defect detection on at least a portion of the at least one to-be-detected sub-image by using the trained defect detection model comprises: performing defect detection on a to-be-detected sub-image among the at least one to-be-detected sub-image by using the trained defect detection model, where a pixel value fluctuation degree of the to-be-detected sub-image is greater than a preset fluctuation degree.

20 **[0013]** In the solution of this example, it is only required to input a to-be-detected sub-image with higher image noise into the trained defect detection model for defect detection, thereby reducing computational load and improving defect detection efficiency.

25 **[0014]** In a possible implementation, the performing defect detection on a target image at least by using the trained defect detection model to determine a second defect detection result further comprises: for each to-be-detected sub-image among a remaining to-be-detected sub-image, determining the first defect detection result corresponding to the to-be-detected sub-image as a sub-defect detection result corresponding to the to-be-detected sub-image; or, performing defect detection on the remaining to-be-detected sub-image by using the trained defect detection model to determine a sub-defect detection result in one-to-one correspondence with the remaining to-be-detected sub-image, where the remaining to-be-detected sub-image is
30 other to-be-detected sub-image among the at least one to-be-detected sub-image excluding the at least a portion of the to-be-detected sub-image, and the second defect detection result further

comprises the sub-defect detection result in one-to-one correspondence with the remaining to-be-detected sub-image.

[0015] In the foregoing technical solution, the sub-defect detection results corresponding to the respective remaining to-be-detected sub-images are determined directly based on the first defect detection result, or the sub-defect detection results corresponding to the respective remaining to-be-detected sub-images are determined by using the trained defect detection model. The process of determining the sub-defect detection results corresponding to the respective remaining to-be-detected sub-images based directly on the first defect detection result reduces repeated computation and improves defect detection efficiency. The process of determining the sub-defect detection results corresponding to the respective remaining to-be-detected sub-images by using the trained defect detection model improves the accuracy of the sub-defect detection results.

[0016] In a possible implementation, the preset defect detection algorithm is implemented by performing defect detection based on a difference between each image region of at least one image region in the to-be-detected image and a standard image.

[0017] In the foregoing technical solution, defect detection is directly performed based on the difference between each of the at least one image region in the to-be-detected image and a standard image, thereby obtaining the first defect detection result of the to-be-detected image more accurately and rapidly.

[0018] In a possible implementation, pixels of each image region of the at least one image region correspond to pixels of the standard image in a one-to-one manner, and the preset defect detection algorithm comprises: for each image region among the at least one image region, calculating a pixel value difference between a pixel value of each pixel in the image region and a pixel value of a corresponding pixel in the standard image, where a pixel difference between the image region and the standard image is represented by the pixel value difference; and determining a region in the image region where pixels have pixel value differences greater than a preset difference threshold as the defect region in the to-be-detected image.

[0019] In the foregoing technical solution, defect detection is performed based on the pixel value difference between the pixel value of each pixel in the image region and the pixel value of the corresponding pixel in the standard image. The technical solution features a simple calculation, improving computational efficiency and accuracy.

[0020] In a possible implementation, the to-be-detected image and the standard image are product images of to-be-detected products, each image region of the at least one image region and the standard image respectively comprise one of the to-be-detected products, and the preset defect detection algorithm further comprises: obtaining a plurality of sample images each comprising one to-be-detected product, where the plurality of sample images have consistent width and height; calculating a median or a mean of pixel values of pixels located at a same image coordinate among the obtained plurality of sample images; and determining an image having pixel values equal to the median or the mean of pixel values as the standard image.

[0021] In the foregoing technical solution, an image having pixel values equal to the median or the mean of pixel values is determined as the standard image. Accordingly, the first defect detection result of the to-be-detected image can be determined more accurately based on this standard image.

[0022] In a possible implementation, the to-be-detected image comprises a plurality of identical to-be-detected regions, and the obtaining a defect-free image from the to-be-detected image based on the first defect detection result comprises: extracting a plurality of target product images from the to-be-detected image, where each target product image of the plurality of target product images comprises one of the to-be-detected regions; and determining a target product image, among the plurality of target product images, that does not comprise the defect region indicated in the first defect detection result as the defect-free image.

[0023] In the solution of this example, the to-be-detected image includes multiple identical to-be-detected objects. A region where each to-be-detected product is located corresponds to a target product image. According to the solution, for each target product image, it is determined whether the target product image has a defect (i.e., whether the target product image is a defective image) by using the first defect detection result, so as to obtain defect-free images more accurately, thereby facilitating provision of relatively accurate samples for subsequent training of the defect detection model and improving the detection precision of the defect detection model.

[0024] In a possible implementation, the target image is the defective image, and when performing the process of obtaining a defect-free image from the to-be-detected image based on the first defect detection result, the image detection method further comprises: determining a target product image, among the plurality of target product images, that comprises the defect

region indicated in the first defect detection result as the defective image.

[0025] In the solution of this example, it is directly determined whether a target product image is a defective image based on the first defect detection result. In subsequent steps, a secondary determination may be performed on the defective image using the trained defect detection model, thereby further improving the accuracy of the image detection method.

[0026] In a possible implementation, the to-be-detected image is more than one in number, the plurality of to-be-detected images respectively comprise identical to-be-detected products, and the obtaining a defect-free image from the to-be-detected image based on the first defect detection result comprises: determining a to-be-detected image, among the plurality of to-be-detected images, that does not comprise the defect region indicated in the first defect detection result as the defect-free image.

[0027] In the foregoing technical solution, defect-free images are obtained from the multiple to-be-detected images accurately, thereby facilitating provision of relatively accurate samples for subsequent training of the defect detection model and improving the detection precision of the defect detection model.

[0028] In a possible implementation, the target image is the defective image, and when performing the process of obtaining a defect-free image from the to-be-detected image based on the first defect detection result, the image detection method further comprises: determining a to-be-detected image, among the plurality of to-be-detected images, that comprises the defect region indicated in the first defect detection result as the defective image.

[0029] In the solution of this example, defective images among the multiple to-be-detected images are directly determined. In subsequent steps, a secondary determination may be performed on the defective images using the trained defect detection model, thereby further improving the accuracy of the image detection method.

[0030] In a possible implementation, the training a defect detection model by using the defect-free image comprises: extracting, from the defect-free image, a sample sub-image in one-to-one correspondence with at least one target image position; and for each target image position among the at least one target image position, training the defect detection model by using the sample sub-image corresponding to the target image position to obtain a trained defect detection model corresponding to the target image position.

[0031] In the foregoing technical solution, for each target image position, the defect detection model is trained by using the sample sub-image corresponding to the target image position, thereby obtaining trained defect detection models respectively corresponding to the respective target image positions. This solution helps obtain a defect detection model with high detection precision.

[0032] According to another aspect of the present disclosure, an image detection apparatus is provided, comprising: a first obtaining module, configured to obtain a to-be-detected image; a first detection module, configured to perform defect detection on the to-be-detected image by using a preset defect detection algorithm to determine a first defect detection result, where the first defect detection result comprises position information of a defect region in the to-be-detected image; a second obtaining module, configured to obtain a defect-free image from the to-be-detected image based on the first defect detection result; a training module, configured to train a defect detection model by using the defect-free image to obtain a trained defect detection model; and a second detection module, configured to perform defect detection on a target image at least by using the trained defect detection model to determine a second defect detection result, where the second defect detection result comprises position information of a defect region in the target image, and the target image is the to-be-detected image or a defective image obtained from the to-be-detected image based on the first defect detection result.

[0033] In the foregoing technical solution, a defect-free image is obtained from the to-be-detected image based on the first defect detection result which is obtained via the preset defect detection algorithm, and defect detection is performed on the target image using the defect detection model trained based on the defect-free image, improving the accuracy and robustness of image detection. In addition, this solution does not require additional collection of images when training the defect detection model, which is beneficial for improving the efficiency of image detection.

[0034] According to another aspect of the present disclosure, an electronic device is provided, comprising a processor and a memory, where the memory stores computer program instructions, and the computer program instructions, when run by the processor, are configured to execute the image detection method described above.

[0035] In the foregoing technical solution, a defect-free image is obtained from the to-be-detected image based on the first defect detection result which is obtained via the preset defect

detection algorithm, and defect detection is performed on the target image using the defect detection model trained based on the defect-free image, improving the accuracy and robustness of image detection. In addition, this solution does not require additional collection of images when training the defect detection model, which is beneficial for improving the efficiency of image detection.

[0036] According to another aspect of the present disclosure, a storage medium storing program instructions is provided. The program instructions, when run, being configured to execute the image detection method described above.

[0037] In the foregoing technical solution, a defect-free image is obtained from the to-be-detected image based on the first defect detection result which is obtained via the preset defect detection algorithm, and defect detection is performed on the target image using the defect detection model trained based on the defect-free image, improving the accuracy and robustness of image detection. In addition, this solution does not require additional collection of images when training the defect detection model, which is beneficial for improving the efficiency of image detection.

BRIEF DESCRIPTION OF THE DRAWINGS

[0038] The above and other objectives, features, and advantages of the present disclosure will become more apparent by describing the embodiments of the present disclosure in more detail with reference to the accompanying drawings. The drawings are intended to provide further understanding of the embodiments of the present disclosure and constitute a part of the specification. They are used together with the embodiments of the present disclosure to explain the present disclosure and do not constitute a limitation to the present disclosure. In the drawings, the same reference numerals generally represent the same components or steps.

[0039] FIG. 1 shows a schematic flowchart of an image detection method according to an embodiment of the present disclosure;

[0040] FIG. 2 shows a schematic diagram of an image detection method according to an embodiment of the present disclosure;

[0041] FIG. 3 shows a schematic diagram of an image detection method according to another embodiment of the present disclosure;

[0042] FIG. 4 shows a schematic diagram of a to-be-detected image according to an embodiment of the present disclosure;

[0043] FIG. 5 shows a schematic block diagram of an image detection apparatus according to an embodiment of the present disclosure; and

5 [0044] FIG. 6 shows a schematic block diagram of an electronic device according to an embodiment of the present disclosure.

DETAILED DESCRIPTION

[0045] In order to make the objectives, technical solutions, and advantages of the present disclosure more apparent, exemplary embodiments according to the present disclosure will be described in detail below with reference to the accompanying drawings. Apparently, the described embodiments are only part of the embodiments of the present disclosure, not all of them. It should be understood that the present disclosure is not limited by the exemplary embodiments described herein. Based on the embodiments of the present disclosure described herein, all other embodiments obtained by those skilled in the art without creative effort shall fall within the protection scope of the present disclosure.

[0046] Conventional surface quality inspection of industrial products is performed manually by quality inspectors. Taking a wafer as an example, at least four optical inspections are required in the semiconductor packaging process. Personnel use microscopes at different magnifications to perform sampling inspection or full inspection, which suffers from low efficiency, visual fatigue of personnel, missed detection of defects, and other phenomena. To improve inspection efficiency, machine vision technology is currently often used to perform quality inspection across the entire semiconductor packaging process.

[0047] In related art, visual inspection (MV) algorithms are often used directly to detect whether defects exist on the surface of industrial products. In some embodiments of related art, a standard template is pre-established by using an MV algorithm for the to-be-detected product based on sample images. Then, a difference operation is performed between the to-be-detected image containing the to-be-detected product and the standard template image, and when the difference is greater than a preset threshold, it is determined that a defect exists in the to-be-detected image.

[0048] However, the preset threshold is generally set by users. In a case that the preset threshold is relatively small, normal industrial products are prone to be determined as defective; and in a case that the preset threshold is relatively large, defective industrial products are prone to be determined as normal. Consequently, this affects the accuracy of the detection results.

5 **[0049]** To at least partially address the issues mentioned above, an image detection method is provided according to an embodiment of the present disclosure. FIG. 1 shows a schematic flowchart of an image detection method according to an embodiment of the present disclosure. As shown in FIG. 1, an image detection method 100 includes following steps S110, S120, S130, S140, and S150.

10 **[0050]** In step S110, a to-be-detected image is obtained.

[0051] The to-be-detected image according to an embodiment of the present disclosure may be an image of any object to be subjected to defect detection. In other words, the to-be-detected image includes a target object to be subjected to defect detection. The target object may be any suitable object, including but not limited to metals, glass, paper, electronic components, etc.,
15 which have strict appearance requirements and clear criteria. The present disclosure does not impose limitations thereon.

[0052] In a possible implementation, the to-be-detected image may be a black-and-white image or a color image. In a possible implementation, the to-be-detected image may be an image of any size or resolution. In another possible implementation, the to-be-detected image
20 may also be an image meeting preset resolution requirements. In one example, the to-be-detected image may be a black-and-white image with a size of 512*512 pixels. Requirements for the to-be-detected image may be set based on practical detection needs, hardware conditions of the image acquisition apparatus, and requirements of the defect detection algorithm (e.g., the preset defect detection algorithm mentioned below) for input images. The present disclosure
25 does not impose limitations thereon.

[0053] In a possible implementation, the to-be-detected image may be a raw image captured by an image acquisition apparatus. According to an embodiment of the present disclosure, any existing or future image acquisition method may be adopted to obtain the to-be-detected image. In a possible implementation, an image acquisition apparatus in a machine vision inspection
30 system may be used to obtain the to-be-detected image, such as using a lighting device, lens, high-speed camera, and image acquisition card that match the inspection environment and the

to-be-detected object to obtain the to-be-detected image.

[0054] In another example, the to-be-detected image may be an image obtained after performing a preprocessing operation on a raw image.

[0055] In a possible implementation, the preprocessing operation may be any preprocessing operation that can meet the needs of subsequent image detection steps, and the preprocessing operation may include all operations that facilitate image detection on the to-be-detected image, such as improving the visual effect of the image, enhancing image clarity, or highlighting certain features in the image. In a possible implementation, the preprocessing operation may include denoising operations such as filtering, and may further include adjustments of image parameters, such as image enhancement, and adjustments of grayscale, contrast, and brightness. In another possible implementation, the preprocessing operation may include normalization processing performed on pixels of the to-be-detected image. For example, each pixel of the to-be-detected image may be divided by 255 so that pixels of the preprocessed to-be-detected image are in the range of 0 to 1, which improves the efficiency of subsequent image detection.

[0056] In a possible implementation, the preprocessing operation may further include operations such as cropping an image or deleting an image. For example, a raw image may be cropped to a size required by the defect detection algorithm, or a raw image that does not meet image quality requirements may be deleted to obtain to-be-detected images that meet image quality requirements, etc.

[0057] In a possible implementation, the number of to-be-detected images may be one or multiple. In a possible implementation, the number of to-be-detected image is one, for example, only one to-be-detected image is obtained each time. In another possible implementation, the number of to-be-detected images may be multiple, for example, 10 or 500, and multiple to-be-detected images may be obtained at one time, and then defect detection is performed on the multiple to-be-detected images by using a preset defect detection algorithm described below.

[0058] In step S120, defect detection is performed on the to-be-detected image by using a preset defect detection algorithm to determine a first defect detection result, where the first defect detection result includes position information of a defect region in the to-be-detected image.

[0059] In a possible implementation, the defect region is a region where the target object in

the to-be-detected image has a defect, and the defect region may be a partial region of the to-be-detected image. It can be understood that a normal region and a defect region of the target object in the to-be-detected image may have different forms. The defect region may be detected based on these different forms, such as grayscale, texture, etc. For example, the to-be-detected image is an image of a metal object, and the defect region may be a region showing a scratch on the metal object. For example, the to-be-detected image is an image of a glass, and the defect region may be a region showing bubbles, impurities, cracks, etc., in the glass.

[0060] In a possible implementation, the preset defect detection algorithm may be any existing or future-developed defect detection algorithm. For example, the algorithm may be implemented by determining whether a defect exists in the to-be-detected image based on a comparison result between the to-be-detected image and a standard template image. In some embodiments, an image of the target object may be pre-obtained as a standard template image. Then, feature vectors may be extracted from the to-be-detected image and the standard template image respectively to obtain a feature vector of the to-be-detected image and a feature vector of the standard template image. A similarity calculation is performed between the two feature vectors to obtain the first defect detection result. In other embodiments, template matching may be performed based on the to-be-detected image and the standard template image to obtain the first defect detection result. In other embodiments, a subtraction operation may be performed between the to-be-detected image and the standard template image to obtain pixel differences corresponding to respective pixel positions in the image. By comparing each pixel difference with a pixel difference threshold, the first defect detection result is obtained.

[0061] In a possible implementation, the position information of the defect region in the to-be-detected image may be a relative position of the defect region in the to-be-detected image. In another possible implementation, the position information of the defect region in the to-be-detected image may further be coordinates of the defect region in the to-be-detected image, such as coordinates of four corner points of a bounding box where the defect region is located.

[0062] In step S130, a defect-free image is obtained from the to-be-detected image based on the first defect detection result.

[0063] In a possible implementation, the defect-free image may include a partial region of the to-be-detected image. In some embodiments, the to-be-detected image may be a wafer image, and each wafer image includes multiple die units. The partial region may be an image

region corresponding to any die unit in the wafer image. In this embodiment, step S120 may be performed for each wafer image to determine whether a defect exists in the die units on the wafer image. In a case that a die unit has a defect, the image region where the die unit is located is determined as a defective image. In a case that an image region where a die unit is located has no defect, then the image region where the die unit is located is determined to be a defect-free image. The above division manner is merely an example, and other division manners may further be adopted to divide the to-be-detected image into partial regions. For example, a region including a preset number of die units may be taken as one to-be-processed unit, and a single wafer may be pre-divided into regions of the same size. When all die units in a region have no defect, the region is determined to be a defect-free image for the purpose of training the defect detection model.

[0064] In a possible implementation, there may be multiple to-be-detected images. The multiple to-be-detected images may include the same number of target objects (e.g., wafers). After performing step S120 on the to-be-detected images, first defect detection results respectively corresponding to the multiple to-be-detected images are obtained. Then, based on the first defect detection results respectively corresponding to the multiple to-be-detected images, to-be-detected images having no defects are determined to be defect-free images. In some embodiments, all defect-free images among the to-be-detected images may be obtained. In other embodiments, only a portion of the defect-free images among the to-be-detected images may be obtained.

[0065] After the defect-free image is obtained, step S140 may be performed based on the obtained defect-free image.

[0066] In step S140, a defect detection model is trained by using the defect-free image to obtain a trained defect detection model.

[0067] In a possible implementation, the defect-free image may be divided into multiple sample sub-images to train a same one or different defect detection models. In an embodiment, one defect detection model may be trained based on multiple sample sub-images located at different positions of the defect-free image. In another embodiment, multiple defect detection models may be trained based on sample sub-images at respective positions of the defect-free image to obtain trained defect detection models in one-to-one correspondence with the respective positions of the defect-free image.

[0068] In a possible implementation, the defect detection model may be any existing or future-developed defect detection model that is applicable to defect detection. The present disclosure does not impose limitations on the specific type of model. In a possible implementation, the defect detection model may be a neural network model used for defect detection. For example, the defect detection model is a target detection model or a semantic segmentation model based on deep learning. In a possible implementation, the defect detection model may further be obtained through training based on any open-source anomaly detection algorithm. For example, the open-source anomaly detection algorithm may be algorithms such as Patchcore, CFA, PyramidFlow, etc.

[0069] In step S150, defect detection is performed on a target image at least by using the trained defect detection model to determine a second defect detection result. The second defect detection result includes position information of a defect region in the target image, and the target image is the to-be-detected image or a defective image obtained from the to-be-detected image based on the first defect detection result.

[0070] In brief, the detected defect region in step S130 may be caused by over-detection. Based on this, in an embodiment of the present disclosure, step S150 including a secondary detection is performed on the first detection result. That is, a secondary defect detection is performed on the defect region detected in step S130 by using the trained defect detection model to determine the second defect detection result.

[0071] Similar to the defect-free image, the defective image may be a partial region of the to-be-detected image, or may be the entire to-be-detected image. For example, when there are multiple to-be-detected images, if it is determined that a defect exists in a to-be-detected image based on the first defect detection result, then the to-be-detected image is determined to be a defective image.

[0072] FIG. 2 shows a schematic diagram of an image detection method according to an embodiment of the present disclosure. As shown in FIG. 2, first, defect detection is performed on a to-be-detected image by using a preset defect detection algorithm to determine a first defect detection result. Then, a target image from the to-be-detected image is input into the trained defect detection model to obtain a second defect detection result, thereby obtaining the position and area of a defect region in the to-be-detected image. In this embodiment, the target image is a defective image obtained from the to-be-detected image based on the first defect detection

result.

[0073] In the foregoing technical solution, a defect-free image is obtained from the to-be-detected image based on the first defect detection result which is obtained via the preset defect detection algorithm, and defect detection is performed on the target image using the defect detection model trained based on the defect-free image, improving the accuracy and robustness of image detection. In addition, this solution does not require additional collection of images when training the defect detection model, which is beneficial for improving the efficiency of image detection.

[0074] In a possible implementation, step S150, performing defect detection on the target image at least by using the trained defect detection model to determine the second defect detection result may include: extracting, from the target image, a to-be-detected sub-image in one-to-one correspondence with at least one target image position; performing defect detection on at least a portion of the extracted at least one to-be-detected sub-image by using the trained defect detection model to determine a sub-defect detection result in one-to-one correspondence with all to-be-detected sub-image among the at least a portion of the to-be-detected sub-image, where the sub-defect detection result includes position information of a sub-defect region and/or an area of the sub-defect region in the corresponding to-be-detected sub-image, and the second defect detection result includes the sub-defect detection result in one-to-one correspondence with the at least a portion of the to-be-detected sub-image.

[0075] In a possible implementation, the target image may include at least one region, and each region among the at least one region corresponds to a target image position. For example, the target image may be divided into multiple image regions based on a preset division rule, and each image region corresponds to a target image position. In this embodiment, each image region may be taken as a to-be-detected sub-image, and then at least a portion of multiple to-be-detected sub-images is input into the trained defect detection model to obtain sub-defect detection results in one-to-one correspondence with the at least a portion of the to-be-detected sub-images. In an embodiment, the region sizes of the multiple image regions are the same. For example, for each pixel in the target image, a region where the pixel is located may be taken as an image region.

[0076] In a possible implementation, the at least a portion of the to-be-detected sub-images may be all the to-be-detected sub-images in the target image. In another possible

implementation, the at least a portion of the to-be-detected sub-images may be a specified portion of the to-be-detected sub-images in the target image. For example, they may be to-be-detected sub-images that include a defect region as determined based on the first defect detection result. For another example, they may be to-be-detected sub-images that do not include a defect region as determined based on the first defect detection result. In an embodiment, when the threshold corresponding to the preset defect detection algorithm is set low, the at least a portion of the to-be-detected sub-images may be to-be-detected sub-images that include a defect region as determined based on the first defect detection result. Thereby, over-detection is facilitated to be avoided.

[0077] In the foregoing technical solution, the to-be-detected sub-image is extracted from the target image and the defect detection is performed on at least a portion of the extracted at least one to-be-detected sub-image by using the trained defect detection model, thereby obtaining the sub-defect detection result in one-to-one correspondence with the at least a portion of the to-be-detected sub-image. In summary, this solution helps determine the defect detection result of the target image more accurately.

[0078] In a possible implementation, the performing defect detection on at least a portion of the at least one to-be-detected sub-image by using the trained defect detection model may include: performing defect detection by using the trained defect detection model on a to-be-detected sub-image, among the at least one to-be-detected sub-image, that intersects with the defect region indicated in the first defect detection result.

[0079] In this example, at least a portion of the to-be-detected sub-image in the target image intersects with the defect region indicated in the first defect detection result. In other words, at least a portion of the to-be-detected sub-image has a defect. In the solution of this example, it is only required to input the to-be-detected sub-image determined to have a defect based on the first defect detection result into the trained defect detection model for defect detection, thereby reducing computational load and improving defect detection efficiency.

[0080] In a possible implementation, the performing defect detection on at least a portion of the at least one to-be-detected sub-image by using the trained defect detection model may include: performing defect detection on a to-be-detected sub-image among the at least one to-be-detected sub-image by using the trained defect detection model, where a pixel value fluctuation degree of the to-be-detected sub-image is greater than a preset fluctuation degree.

[0081] In a possible implementation, the pixel value fluctuation degree may be a difference between the maximum pixel value and the minimum pixel value in the to-be-detected sub-image. In another possible implementation, a mean of respective pixel values in the to-be-detected sub-image may first be calculated, and then differences between respective pixel values in the to-be-detected sub-image and the mean may be calculated. The pixel value fluctuation degree may be represented by the mean of differences corresponding to the respective pixel values.

[0082] In a possible implementation, the preset fluctuation degree may be set as required.

[0083] It can be understood that for a to-be-detected sub-image, a higher pixel value fluctuation degree in the to-be-detected sub-image indicates a higher noise of the to-be-detected sub-image and a worse image quality of the to-be-detected sub-image. The accuracy of the first defect detection result obtained based on this to-be-detected sub-image may be lower. In the solution of this example, the at least a portion of the to-be-detected sub-image is a to-be-detected sub-image with higher image noise. In other words, according to this solution, it is only required to input a to-be-detected sub-image with higher image noise into the trained defect detection model for defect detection, thereby reducing computational load and improving defect detection efficiency.

[0084] In a possible implementation, step S150, performing defect detection on the target image at least by using the trained defect detection model to determine the second defect detection result may further include: for each to-be-detected sub-image among a remaining to-be-detected sub-image, determining the first defect detection result corresponding to the to-be-detected sub-image as a sub-defect detection result corresponding to the to-be-detected sub-image; or, performing defect detection on the remaining to-be-detected sub-image by using the trained defect detection model to determine a sub-defect detection result in one-to-one correspondence with the remaining to-be-detected sub-image, where the remaining to-be-detected sub-image is other to-be-detected sub-image among the at least one to-be-detected sub-image excluding the at least a portion of the to-be-detected sub-image, and the second defect detection result further includes the sub-defect detection result in one-to-one correspondence with the remaining to-be-detected sub-image.

[0085] In a possible implementation, step S150, performing defect detection on the target image at least by using the trained defect detection model to determine the second defect

detection result may further include: for each to-be-detected sub-image among a remaining to-be-detected sub-image, determining the first defect detection result corresponding to the to-be-detected sub-image as a sub-defect detection result corresponding to the to-be-detected sub-image. In the embodiment, the sub-defect detection results corresponding to respective remaining to-be-detected sub-images may be directly determined based on the first defect detection result. In other words, defect detection may be performed on the remaining to-be-detected sub-images based only on the preset defect detection algorithm. Thus, repeated computation is avoided, and defect detection efficiency is improved.

[0086] In a possible implementation, step S150, performing defect detection on the target image at least by using the trained defect detection model to determine the second defect detection result may further include: performing defect detection on the remaining to-be-detected sub-image by using the trained defect detection model to determine a sub-defect detection result in one-to-one correspondence with the remaining to-be-detected sub-image. In the embodiment, the sub-defect detection results corresponding to the respective remaining to-be-detected sub-images are determined by the trained defect detection model, thereby improving the accuracy of defect detection.

[0087] In the foregoing technical solution, the sub-defect detection results corresponding to the respective remaining to-be-detected sub-images are determined directly based on the first defect detection result, or the sub-defect detection results corresponding to the respective remaining to-be-detected sub-images are determined by using the trained defect detection model. The process of determining the sub-defect detection results corresponding to the respective remaining to-be-detected sub-images based directly on the first defect detection result reduces repeated computation and improves defect detection efficiency. The process of determining the sub-defect detection results corresponding to the respective remaining to-be-detected sub-images by using the trained defect detection model improves the accuracy of the sub-defect detection results.

[0088] In a possible implementation, step S140, training a defect detection model by using the defect-free image, may include: extracting, from the defect-free image, a sample sub-image in one-to-one correspondence with at least one target image position; and for each target image position among the at least one target image position, training the defect detection model by using the sample sub-image corresponding to the target image position to obtain a trained defect

detection model corresponding to the target image position.

[0089] In a possible implementation, the defect-free image may include at least one region, each region of the at least one region corresponds to a target image position. For example, taking a wafer image as an example, the wafer image includes multiple die units. When it is determined that a region has no defect, for example, the upper left corner region of the wafer image has no defect, each die unit within that region may be taken as a defect-free image.

[0090] In a possible implementation, each defect-free image may be divided into multiple image regions, and each image region of the image regions corresponds to a target image position. In this case, each image region may be determined as a sample sub-image, and then the defect detection model is trained by using the sample sub-image at the corresponding target image position to obtain a trained defect detection model corresponding to the target image position.

[0091] FIG. 3 shows a schematic diagram of an image detection method according to another embodiment of the present disclosure. As shown in FIG. 3, first, defect detection is performed on a to-be-detected image by using a preset defect detection algorithm, so as to obtain a defect-free image from the to-be-detected image according to the obtained first defect detection result (in this embodiment, the to-be-detected image is a wafer image, and the defect-free image is an image region corresponding to a die unit on the wafer image). Then, multiple sample sub-images of the same size as the at least one target image may be extracted from the defect-free image by using a sliding window with a preset step size. Next, for each target image position, the defect detection model may be trained by using the sample sub-image corresponding to the target image position to obtain a trained defect detection model corresponding to the target image position. Thus, the training of the defect detection model is completed.

[0092] As shown in FIG. 3, after the training of the defect detection model is completed, defect detection may be performed on the target image by using the trained defect detection model. In this embodiment, first, the target image may be divided into to-be-detected sub-images in one-to-one correspondence with at least one target image position by using a sliding window with a preset step size. Then, for each of the to-be-detected sub-images in one-to-one correspondence with at least one target image position, the defect detection is performed on the to-be-detected sub-image by using the trained defect detection model corresponding to the target image position, thereby obtaining the second defect detection result and further

determining the defect region in the target image.

[0093] In the foregoing technical solution, for each target image position, the defect detection model is trained by using the sample sub-image corresponding to the target image position, thereby obtaining trained defect detection models respectively corresponding to the respective target image positions. This solution helps obtain a defect detection model with high detection precision.

[0094] In a possible implementation, the to-be-detected image includes multiple to-be-detected regions, and the multiple to-be-detected regions correspond one-to-one with multiple target image positions. The performing defect detection on the target image at least by using the trained defect detection model to determine the second defect detection result includes: extracting, from the to-be-detected image, to-be-detected sub-images in one-to-one correspondence with the multiple target image positions; for each to-be-detected sub-image among the multiple to-be-detected sub-images, performing defect detection on the to-be-detected sub-image by using the trained defect detection model corresponding to the target image position where the to-be-detected sub-image is located, to obtain a second sub-defect detection result corresponding to the to-be-detected sub-image, where, for any two identical to-be-detected sub-images among the multiple to-be-detected sub-images, the trained defect detection models used for defect detection are the same.

[0095] It can be understood that in the solution of this example, the to-be-detected image may include multiple target image positions, and the target image positions each corresponds to a to-be-detected region in the to-be-detected image. The multiple to-be-detected regions may include identical to-be-detected regions, and for identical to-be-detected regions, a same trained defect detection model may be used to perform defect detection.

[0096] In a possible implementation, methods such as Normalized Cross Correlation (NCC) matching may be used to determine identical to-be-detected regions in the to-be-detected image.

[0097] FIG. 4 shows a schematic diagram of a to-be-detected image according to an embodiment of the present disclosure. As shown in FIG. 4, the to-be-detected image includes multiple to-be-detected regions that are identical to each other (i.e., the circular holes in the figure). Therefore, each region where one circular hole is located may be extracted as a to-be-detected sub-image, and then defect detection is performed on the to-be-detected sub-images by using the same trained defect detection model.

[0098] In this example, identical to-be-detected sub-images may be subjected to the same defect detection model, avoiding repeated model training and thereby improving image detection efficiency.

[0099] In a possible implementation, defect detection is performed based on the difference between each of the at least one image region in the to-be-detected image and a standard image by using the preset defect detection algorithm.

[0100] In a possible implementation, the difference may be a pixel value difference between each of the at least one image region in the to-be-detected image and the standard image, or may be a feature vector difference between each of the at least one image region in the to-be-detected image and the standard image. For example, feature vectors may be extracted from the to-be-detected image and the standard template image respectively to obtain a feature vector of the to-be-detected image and a feature vector of the standard template image, and then a similarity calculation may be performed between the two feature vectors to determine the feature vector difference between each of the at least one image region in the to-be-detected image and the standard image.

[0101] In the foregoing technical solution, defect detection is directly performed based on the difference between each of the at least one image region in the to-be-detected image and a standard image, thereby obtaining the first defect detection result of the to-be-detected image more accurately and rapidly.

[0102] In a possible implementation, pixels of each image region of the at least one image region correspond one-to-one with pixels of the standard image, and the preset defect detection algorithm includes the following operations: for each image region among the at least one image region, calculating a pixel value difference between a pixel value of each pixel in the image region and a pixel value of a corresponding pixel in the standard image, where a pixel difference between the image region and the standard image is represented by the pixel value difference; and determining a region in the image region where pixels have pixel value differences greater than a preset difference threshold to be the defect region in the to-be-detected image.

[0103] In a possible implementation, the preset difference threshold may be set as required. It can be understood that when the preset difference threshold is excessively high, missed detection may occur. When the preset difference threshold is excessively low, over-detection may occur. Therefore, users may set the preset difference threshold according to practical

requirements. In an embodiment, the preset difference threshold may be set to a low value. It can be understood that in subsequent step S150, defect detection may be performed only on the defective image obtained from the to-be-detected image based on the first defect detection result. In other words, even if over-detection occurs due to a low preset difference threshold, in subsequent steps, a secondary determination is performed through the trained defect detection model to exclude over-detection cases and improve detection accuracy.

[0104] In the foregoing technical solution, defect detection is performed based on the pixel value difference between the pixel value of each pixel in the image region and the pixel value of the corresponding pixel in the standard image. The technical solution features a simple calculation, improving computational efficiency and accuracy.

[0105] In a possible implementation, the to-be-detected image and the standard image are product images of to-be-detected products, each image region of the at least one image region and the standard image respectively include one of the to-be-detected products, and the preset defect detection algorithm further includes: obtaining multiple sample images each including one to-be-detected product, where the multiple sample images have consistent width and height; calculating a median or a mean of pixel values of pixels located at a same image coordinate among the obtained multiple sample images; and determining an image having pixel values equal to the median or the mean of pixel values as the standard image.

[0106] In this embodiment, multiple sample images of the same size, each including a single to-be-detected product, may be obtained. A median or a mean of pixel values of pixels located at the same image coordinate among the obtained multiple sample images may be calculated. This median or mean may be referred to as a standard pixel value at the corresponding image coordinate. A standard image may be generated based on the standard pixel values corresponding to respective image coordinates.

[0107] In the foregoing technical solution, an image having pixel values equal to the median or the mean of pixel values is determined as the standard image. Accordingly, the first defect detection result of the to-be-detected image can be determined more accurately based on this standard image.

[0108] In a possible implementation, the to-be-detected image includes multiple identical to-be-detected regions, and step S130, obtaining a defect-free image from the to-be-detected image based on the first defect detection result, may include: extracting multiple target product images

from the to-be-detected image, where each target product image includes one of the to-be-detected regions; and determining a target product image, among the multiple target product images, that does not include the defect region indicated in the first defect detection result as the defect-free image.

5 **[0109]** In the solution of this example, the to-be-detected image includes multiple identical to-be-detected regions. A region where each to-be-detected product is located corresponds to a target product image. Taking a wafer image as an example, the wafer image includes multiple identical die units, and an image region where each die unit is located is a to-be-detected region. According to the solution, for each target product image, it is determined whether the target
10 product image has a defect (i.e., whether the target product image is a defective image) by using the first defect detection result, so as to obtain defect-free images more accurately, thereby facilitating provision of relatively accurate samples for subsequent training of the defect detection model and improving the detection precision of the defect detection model.

[0110] In a possible implementation, the target image is a defective image, and when
15 performing the process of obtaining a defect-free image from the to-be-detected image based on the first defect detection result, the method 100 may further include: determining a target product image, among the multiple target product images, that includes the defect region indicated in the first defect detection result as the defective image. In the solution of this example, it is directly determined whether a target product image is a defective image based on
20 the first defect detection result. In subsequent steps (e.g., step S150), a secondary determination may be performed on the defective image using the trained defect detection model, thereby further improving the accuracy of the image detection method.

[0111] In a possible implementation, there are multiple to-be-detected images, the multiple to-be-detected images respectively include identical to-be-detected products, and the obtaining
25 a defect-free image from the to-be-detected image based on the first defect detection result may include: determining a to-be-detected image, among the multiple to-be-detected images, that does not include the defect region indicated in the first defect detection result as the defect-free image.

[0112] In the solution of this example, there are multiple to-be-detected images. After
30 performing step S120 on each of the multiple to-be-detected images, first defect detection results respectively corresponding to the multiple to-be-detected images are obtained. Based on

the first defect detection results respectively corresponding to the multiple to-be-detected images, the to-be-detected image having no defect is determined as the defect-free image.

[0113] In the foregoing technical solution, defect-free images are obtained from the multiple to-be-detected images accurately, thereby facilitating provision of relatively accurate samples for subsequent training of the defect detection model and improving the detection precision of the defect detection model.

[0114] In a possible implementation, the target image is a defective image, and when performing the process of obtaining a defect-free image from the to-be-detected image based on the first defect detection result, method 100 may further include: determining a to-be-detected image, among the multiple to-be-detected images, that includes the defect region indicated in the first defect detection result as the defective image.

[0115] In the solution of this example, defective images among the multiple to-be-detected images are directly determined. In subsequent steps (e.g., step S150), a secondary determination may be performed on the defective images using the trained defect detection model, thereby further improving the accuracy of the image detection method.

[0116] According to another aspect of the present disclosure, an image detection apparatus is provided. FIG. 5 shows a schematic block diagram of an image detection apparatus according to an embodiment of the present disclosure. As shown in FIG. 5, an image detection apparatus 500 includes a first obtaining module 510, a first detection module 520, a second obtaining module 530, a training module 540, and a second detection module 550.

[0117] The first obtaining module 510 is configured to obtain a to-be-detected image.

[0118] The first detection module 520 is configured to perform defect detection on the to-be-detected image by using a preset defect detection algorithm to determine a first defect detection result, where the first defect detection result includes position information of a defect region in the to-be-detected image.

[0119] The second obtaining module 530 is configured to obtain a defect-free image from the to-be-detected image based on the first defect detection result.

[0120] The training module 540 is configured to train a defect detection model by using the defect-free image to obtain a trained defect detection model.

[0121] The second detection module 550 is configured to perform defect detection on a target

image at least by using the trained defect detection model to determine a second defect detection result, where the second defect detection result includes position information of a defect region in the target image, and the target image is the to-be-detected image or a defective image obtained from the to-be-detected image based on the first defect detection result.

5 **[0122]** According to another aspect of the present disclosure, an electronic device is provided. FIG. 6 shows a schematic block diagram of an electronic device according to an embodiment of the present disclosure. As shown in FIG. 6, a control apparatus 600 includes a processor 610 and a memory 620. The memory 620 stores a computer program. The processor 610 is configured to execute the computer program to implement the image detection method 100.

10 **[0123]** In a possible implementation, the processor may include any suitable processing component with data processing capability and/or instruction execution capability. For example, the processor may be implemented using one or a combination of several of: a Programmable Logic Controller (PLC), a Digital Signal Processor (DSP), a Field Programmable Gate Array (FPGA), a Programmable Logic Array (PLA), a Central Processing Unit (CPU), an
15 Application-Specific Integrated Circuit (ASIC), a Microcontroller Unit (MCU), and other forms of processing units.

[0124] According to another aspect of an embodiment of the present disclosure, a storage medium is further provided. The storage medium stores computer program/instructions. When the computer program/instructions are executed by a processor, the image detection method
20 100 described above is implemented. The storage medium may, for example, include a Read-Only Memory (ROM), an Erasable Programmable Read-Only Memory (EPROM), a portable Compact Disc Read-Only Memory (CD-ROM), a USB memory, or any combination of the above storage media. The computer-readable storage medium may be any combination of one or more computer-readable storage media.

25 **[0125]** Those of ordinary skill in the art, by reading the relevant descriptions above regarding the image detection method 100, can understand the specific implementation solutions of the above image detection apparatus, electronic device, and storage medium. For conciseness, details are not repeated here.

[0126] Embodiment 1

30 An image detection method is provided, and the image detection method comprises:

obtaining a to-be-detected image;

performing defect detection on the to-be-detected image by using a preset defect detection algorithm to determine a first defect detection result, where the first defect detection result comprises position information of a defect region in the to-be-detected image;

5 obtaining a defect-free image from the to-be-detected image based on the first defect detection result;

training a defect detection model by using the defect-free image to obtain a trained defect detection model; and

performing defect detection on a target image at least by using the trained defect detection
10 model to determine a second defect detection result, where the second defect detection result comprises position information of a defect region in the target image, and the target image is the to-be-detected image or a defective image obtained from the to-be-detected image based on the first defect detection result.

[0127] Embodiment 2

15 The image detection method described in embodiment 1 is provided, where the performing defect detection on a target image at least by using the trained defect detection model to determine a second defect detection result comprises:

extracting, from the target image, a to-be-detected sub-image in one-to-one correspondence with at least one target image position;

20 performing defect detection on at least a portion of the extracted at least one to-be-detected sub-image by using the trained defect detection model to determine a sub-defect detection result in one-to-one correspondence with all to-be-detected sub-image among the at least a portion of the to-be-detected sub-image, where the sub-defect detection result comprises position information of a sub-defect region and/or an area of the sub-defect region in the corresponding
25 to-be-detected sub-image, and

where the second defect detection result comprises the sub-defect detection result in one-to-one correspondence with the at least a portion of the to-be-detected sub-image.

[0128] Embodiment 3

The image detection method described in any one of embodiments 1 to 2 is provided,

where the performing defect detection on at least a portion of the at least one to-be-detected sub-image by using the trained defect detection model comprises:

performing defect detection by using the trained defect detection model on a to-be-detected sub-image, among the at least one to-be-detected sub-image, that intersects with the defect region indicated in the first defect detection result.

[0129] Embodiment 4

The image detection method described in any one of embodiments 1 to 3 is provided, where the performing defect detection on at least a portion of the at least one to-be-detected sub-image by using the trained defect detection model comprises:

performing defect detection on a to-be-detected sub-image among the at least one to-be-detected sub-image by using the trained defect detection model, where a pixel value fluctuation degree of the to-be-detected sub-image is greater than a preset fluctuation degree.

[0130] Embodiment 5

The image detection method described in any one of embodiments 1 to 4 is provided, where the performing defect detection on a target image at least by using the trained defect detection model to determine a second defect detection result further comprises:

for each to-be-detected sub-image among a remaining to-be-detected sub-image, determining the first defect detection result corresponding to the to-be-detected sub-image as a sub-defect detection result corresponding to the to-be-detected sub-image; or,

performing defect detection on the remaining to-be-detected sub-image by using the trained defect detection model to determine a sub-defect detection result in one-to-one correspondence with the remaining to-be-detected sub-image,

where the remaining to-be-detected sub-image is other to-be-detected sub-image among the at least one to-be-detected sub-image excluding the at least a portion of the to-be-detected sub-image, and the second defect detection result further comprises the sub-defect detection result in one-to-one correspondence with the remaining to-be-detected sub-image.

[0131] Embodiment 6

The image detection method described in any one of embodiments 1 to 5 is provided, where the preset defect detection algorithm is implemented by performing defect detection

based on a difference between each image region of at least one image region in the to-be-detected image and a standard image.

[0132] Embodiment 7

The image detection method described in any one of embodiments 1 to 6 is provided, where pixels of each image region of the at least one image region correspond to pixels of the standard image in a one-to-one manner, and the preset defect detection algorithm comprises:

for each image region among the at least one image region,

calculating a pixel value difference between a pixel value of each pixel in the image region and a pixel value of a corresponding pixel in the standard image, where a pixel difference between the image region and the standard image is represented by the pixel value difference; and

determining a region in the image region where pixels have pixel value differences greater than a preset difference threshold as the defect region in the to-be-detected image.

[0133] Embodiment 8

The image detection method described in any one of embodiments 1 to 7 is provided, where the to-be-detected image and the standard image are product images of to-be-detected products, each image region of the at least one image region and the standard image respectively comprise one of the to-be-detected products, and the preset defect detection algorithm further comprises:

obtaining a plurality of sample images each comprising one to-be-detected product, where the plurality of sample images have consistent width and height;

calculating a median or a mean of pixel values of pixels located at a same image coordinate among the obtained plurality of sample images; and

determining an image having pixel values equal to the median or the mean of pixel values as the standard image.

[0134] Embodiment 9

The image detection method described in any one of embodiments 1 to 8 is provided, where the to-be-detected image comprises a plurality of identical to-be-detected regions, and the obtaining a defect-free image from the to-be-detected image based on the first defect

detection result comprises:

extracting a plurality of target product images from the to-be-detected image, where each target product image of the plurality of target product images comprises one of the to-be-detected regions; and

- 5 determining a target product image, among the plurality of target product images, that does not comprise the defect region indicated in the first defect detection result as the defect-free image.

[0135] Embodiment 10

- 10 The image detection method described in any one of embodiments 1 to 9 is provided, where the target image is the defective image, and when performing the process of obtaining a defect-free image from the to-be-detected image based on the first defect detection result, the image detection method further comprises:

determining a target product image, among the plurality of target product images, that comprises the defect region indicated in the first defect detection result as the defective image.

- 15 **[0136]** Embodiment 11

The image detection method described in any one of embodiments 1 to 10 is provided, where the to-be-detected image is more than one in number, the plurality of to-be-detected images respectively comprise identical to-be-detected products, and the obtaining a defect-free image from the to-be-detected image based on the first defect detection result comprises:

- 20 determining a to-be-detected image, among the plurality of to-be-detected images, that does not comprise the defect region indicated in the first defect detection result as the defect-free image.

[0137] Embodiment 12

- 25 The image detection method described in any one of embodiments 1 to 11 is provided, where the target image is the defective image, and when performing the process of obtaining a defect-free image from the to-be-detected image based on the first defect detection result, the image detection method further comprises:

determining a to-be-detected image, among the plurality of to-be-detected images, that comprises the defect region indicated in the first defect detection result as the defective image.

[0138] Embodiment 13

The image detection method described in any one of embodiments 1 to 12 is provided, where the training a defect detection model by using the defect-free image comprises:

extracting, from the defect-free image, a sample sub-image in one-to-one correspondence with at least one target image position; and

for each target image position among the at least one target image position, training the defect detection model by using the sample sub-image corresponding to the target image position to obtain a trained defect detection model corresponding to the target image position.

[0139] Embodiment 14

An image detection apparatus is provided, and the image detection apparatus comprises:

a first obtaining module, configured to obtain a to-be-detected image;

a first detection module, configured to perform defect detection on the to-be-detected image by using a preset defect detection algorithm to determine a first defect detection result, where the first defect detection result comprises position information of a defect region in the to-be-detected image;

a second obtaining module, configured to obtain a defect-free image from the to-be-detected image based on the first defect detection result;

a training module, configured to train a defect detection model by using the defect-free image to obtain a trained defect detection model; and

a second detection module, configured to perform defect detection on a target image at least by using the trained defect detection model to determine a second defect detection result, where the second defect detection result comprises position information of a defect region in the target image, and the target image is the to-be-detected image or a defective image obtained from the to-be-detected image based on the first defect detection result.

[0140] Embodiment 15

An electronic device is provided, and the electronic device comprises a processor and a memory. The memory stores computer program instructions, and the computer program instructions, when run by the processor, are configured to execute the image detection method described in any one of embodiments 1 to 13.

[0141] Embodiment 16

A storage medium, storing program instructions, is provided. The program instructions, when run, are configured to execute the image detection method described in any one of embodiments 1 to 13.

5 **[0142]** Although the embodiments have been described herein with reference to the drawings, it should be understood that the above embodiments are merely exemplary and are not intended to limit the scope of the present disclosure. Various changes and modifications may be made by those skilled in the art without departing from the scope and spirit of the present disclosure. All such changes and modifications are deemed to fall into the scope claimed by the claims of the
10 present disclosure.

[0143] Those skilled in the art may realize that the units and algorithm steps of each example described in conjunction with the embodiments herein may be implemented by electronic hardware, or a combination of computer software and electronic hardware. Whether these functions are performed in hardware or software depends on the specific application and design
15 constraints of the technical solution. Those skilled in the art may use different methods to implement the described functions for each specific application, but such implementation should not be regarded as exceeding the scope of the present disclosure.

[0144] It should be noted that the above embodiments illustrate rather than limit the present disclosure, and alternative embodiments may be designed by those skilled in the art without
20 departing from the scope of the claims. In the claims, any reference symbol between parentheses shall not be construed as a limitation of the claims. The word "comprising (including)" does not exclude the presence of elements or steps not listed in the claims. The word "a" or "an" preceding an element does not exclude the presence of multiple of such elements. The present disclosure may be implemented by means of hardware including several different elements and
25 by means of a suitably programmed computer. In a unit claim enumerating several apparatuses, several of these apparatuses may be embodied by a same hardware item. The use of the words "first", "second", "third" and the like does not indicate any order. These words may be interpreted as names.

[0145] Described above are only specific embodiments of the present disclosure or
30 explanation for the specific embodiments of the present disclosure, and the protection scope of the present disclosure is not limited thereto. Any changes or alternations that can be easily

envisaged by those familiar with the art within the technical scope disclosed in the present disclosure shall fall within the protection scope of the present disclosure. Therefore, the protection scope of the present disclosure shall be in accordance with the protection scope of the claims.

CLAIMS

1. An image detection method, characterized by comprising:

obtaining a to-be-detected image;

5 performing defect detection on the to-be-detected image by using a preset defect detection algorithm to determine a first defect detection result, wherein the first defect detection result comprises position information of a defect region in the to-be-detected image;

obtaining a defect-free image from the to-be-detected image based on the first defect detection result;

10 training a defect detection model by using the defect-free image to obtain a trained defect detection model; and

performing defect detection on a target image at least by using the trained defect detection model to determine a second defect detection result, wherein the second defect detection result comprises position information of a defect region in the target image, and the target image is
15 the to-be-detected image or a defective image obtained from the to-be-detected image based on the first defect detection result.

2. The image detection method according to claim 1, characterized in that the performing defect detection on a target image at least by using the trained defect detection model to determine a second defect detection result comprises:

20 extracting, from the target image, a to-be-detected sub-image in one-to-one correspondence with at least one target image position;

performing defect detection on at least a portion of the extracted at least one to-be-detected sub-image by using the trained defect detection model to determine a sub-defect detection result in one-to-one correspondence with all to-be-detected sub-image among the at least a portion of
25 the to-be-detected sub-image, wherein the sub-defect detection result comprises position information of a sub-defect region and/or an area of the sub-defect region in the corresponding to-be-detected sub-image, and

wherein the second defect detection result comprises the sub-defect detection result in one-to-one correspondence with the at least a portion of the to-be-detected sub-image.

3. The image detection method according to claim 2, characterized in that the performing defect detection on at least a portion of the at least one to-be-detected sub-image by using the trained defect detection model comprises:

performing defect detection by using the trained defect detection model on a to-be-detected sub-image, among the at least one to-be-detected sub-image, that intersects with the defect region indicated in the first defect detection result.

4. The image detection method according to claim 2 or 3, characterized in that the performing defect detection on at least a portion of the at least one to-be-detected sub-image by using the trained defect detection model comprises:

performing defect detection on a to-be-detected sub-image among the at least one to-be-detected sub-image by using the trained defect detection model, wherein a pixel value fluctuation degree of the to-be-detected sub-image is greater than a preset fluctuation degree.

5. The image detection method according to claim 2 or 3, characterized in that the performing defect detection on a target image at least by using the trained defect detection model to determine a second defect detection result further comprises:

for each to-be-detected sub-image among a remaining to-be-detected sub-image, determining the first defect detection result corresponding to the to-be-detected sub-image as a sub-defect detection result corresponding to the to-be-detected sub-image; or,

performing defect detection on the remaining to-be-detected sub-image by using the trained defect detection model to determine a sub-defect detection result in one-to-one correspondence with the remaining to-be-detected sub-image,

wherein the remaining to-be-detected sub-image is other to-be-detected sub-image among the at least one to-be-detected sub-image excluding the at least a portion of the to-be-detected sub-image, and the second defect detection result further comprises the sub-defect detection result in one-to-one correspondence with the remaining to-be-detected sub-image.

6. The image detection method according to any one of claims 1 to 3, characterized in that the preset defect detection algorithm is implemented by performing defect detection based on a difference between each image region of at least one image region in the to-be-detected image and a standard image.

7. The image detection method according to claim 6, characterized in that pixels of each

image region of the at least one image region correspond to pixels of the standard image in a one-to-one manner, and the preset defect detection algorithm comprises:

for each image region among the at least one image region,

calculating a pixel value difference between a pixel value of each pixel in the image region and a pixel value of a corresponding pixel in the standard image, wherein a pixel difference between the image region and the standard image is represented by the pixel value difference; and

determining a region in the image region where pixels have pixel value differences greater than a preset difference threshold as the defect region in the to-be-detected image.

8. The image detection method according to claim 6, characterized in that the to-be-detected image and the standard image are product images of to-be-detected products, each image region of the at least one image region and the standard image respectively comprise one of the to-be-detected products, and the preset defect detection algorithm further comprises:

obtaining a plurality of sample images each comprising one to-be-detected product, wherein the plurality of sample images have consistent width and height;

calculating a median or a mean of pixel values of pixels located at a same image coordinate among the obtained plurality of sample images; and

determining an image having pixel values equal to the median or the mean of pixel values as the standard image.

9. The image detection method according to any one of claims 1 to 3, characterized in that the to-be-detected image comprises a plurality of identical to-be-detected regions, and the obtaining a defect-free image from the to-be-detected image based on the first defect detection result comprises:

extracting a plurality of target product images from the to-be-detected image, wherein each target product image of the plurality of target product images comprises one of the to-be-detected regions; and

determining a target product image, among the plurality of target product images, that does not comprise the defect region indicated in the first defect detection result as the defect-free image.

10. The image detection method according to claim 9, characterized in that the target image is the defective image, and when performing the process of obtaining a defect-free image from the to-be-detected image based on the first defect detection result, the image detection method further comprises:

5 determining a target product image, among the plurality of target product images, that comprises the defect region indicated in the first defect detection result as the defective image.

11. The image detection method according to any one of claims 1 to 3, characterized in that the to-be-detected image is more than one in number, the plurality of to-be-detected images respectively comprise identical to-be-detected products, and the obtaining a defect-free image
10 from the to-be-detected image based on the first defect detection result comprises:

 determining a to-be-detected image, among the plurality of to-be-detected images, that does not comprise the defect region indicated in the first defect detection result as the defect-free image.

12. The image detection method according to claim 11, characterized in that the target
15 image is the defective image, and when performing the process of obtaining a defect-free image from the to-be-detected image based on the first defect detection result, the image detection method further comprises:

 determining a to-be-detected image, among the plurality of to-be-detected images, that comprises the defect region indicated in the first defect detection result as the defective image.

20 13. The image detection method according to any one of claims 1 to 3, characterized in that the training a defect detection model by using the defect-free image comprises:

 extracting, from the defect-free image, a sample sub-image in one-to-one correspondence with at least one target image position; and

 for each target image position among the at least one target image position, training the
25 defect detection model by using the sample sub-image corresponding to the target image position to obtain a trained defect detection model corresponding to the target image position.

14. An image detection apparatus, characterized by comprising:

 a first obtaining module, configured to obtain a to-be-detected image;

 a first detection module, configured to perform defect detection on the to-be-detected

image by using a preset defect detection algorithm to determine a first defect detection result, wherein the first defect detection result comprises position information of a defect region in the to-be-detected image;

5 a second obtaining module, configured to obtain a defect-free image from the to-be-detected image based on the first defect detection result;

a training module, configured to train a defect detection model by using the defect-free image to obtain a trained defect detection model; and

10 a second detection module, configured to perform defect detection on a target image at least by using the trained defect detection model to determine a second defect detection result, wherein the second defect detection result comprises position information of a defect region in the target image, and the target image is the to-be-detected image or a defective image obtained from the to-be-detected image based on the first defect detection result.

15 15. An electronic device, comprising a processor and a memory, characterized in that the memory stores computer program instructions, and the computer program instructions, when run by the processor, are configured to execute the image detection method according to any one of claims 1 to 13.

16. A storage medium, storing program instructions, characterized in that the program instructions, when run, are configured to execute the image detection method according to any one of claims 1 to 13.