

DESCRIPTION

Title of Invention: CUTTING APPARATUS, AND METHOD FOR MANUFACTURING CUT PRODUCT

5 Technical Field

[0001] The present invention relates to a cutting apparatus and a method for manufacturing a cut product.

Background Art

10 [0002] JP 2010-125488A (Patent Document 1) discloses a cutting apparatus that cuts a workpiece. In this cutting apparatus, a plurality of individual workpieces are manufactured by cutting the workpiece, and visual inspection is performed on each of the individual workpieces (see Patent Document 1).

15 Citation List

Patent Document

[0003] Patent Document 1: JP 2010-125488A

Summary of Invention

20 Technical Problem

[0004] The appearance of cut products (e.g., individual workpieces) manufactured by cutting a substrate is inspected based on, for example, a captured image of the cut products. In this case, inspection areas are set in the captured image of the cut products, and the appearance of the cut products is inspected based on
25 images in the inspection areas. In other words, in order to perform visual inspection on the cut products based on a captured image of the cut products, it is necessary to set inspection areas in the captured image of the cut products. However, the above-

mentioned Patent Document 1 does not disclose a specific method for setting the inspection areas.

[0005] The present invention has been made to solve such problems, and an object of the present invention is to provide a cutting apparatus and a method for manufacturing a cut product that are capable of relatively efficiently automatically setting inspection areas in a captured image of cut products.

Solution to Problem

[0006] A cutting apparatus according to an aspect of the present invention manufactures a plurality of cut products by cutting a substrate. This cutting apparatus includes an image capturing unit, a first processing unit, and a second processing unit. The image capturing unit is configured to generate a captured image by performing image capturing on a portion or all of the plurality of cut products. The first processing unit is configured to set a plurality of inspection areas in the captured image. The second processing unit is configured to perform visual inspection on each of the cut products included in the captured image based on images respectively included in the plurality of inspection areas in the captured image. Each of the inspection areas has a rectangular shape. Each of the cut products has a rectangular shape. The first processing unit executes determination processing to, based on pixel values of a predetermined number of pixels arranged consecutively in a first direction in the captured image, determine whether or not a portion of one edge of one of the plurality of cut products is included in the predetermined number of pixels. The predetermined number is smaller than a total number of pixels in the captured image. The first processing unit sets at least a portion of the plurality of inspection areas by repeatedly shifting positions of the predetermined number of pixels and executing the determination processing.

[0007] A method for manufacturing a cut product according to another aspect of

the present invention manufactures a cut product using the cutting apparatus described above. The cutting apparatus further includes a cutting table and a cutting unit. The substrate is placeable on the cutting table. The cutting unit is configured to cut the substrate placed on the cutting table. The manufacturing method includes
5 placing the substrate on the cutting table, and cutting the substrate placed on the cutting table.

Advantageous Effects of Invention

[0008] According to the present invention, it is possible to provide a cutting
10 apparatus and a method for manufacturing a cut product that can relatively efficiently automatically set inspection areas in a captured image of cut products.

Brief Description of Drawings

[0009] FIG. 1 is a plan view schematically showing a cutting apparatus.
15 FIG. 2 is a diagram schematically showing a state in which an image of electronic components is being captured by a second optical inspection camera.

FIG. 3 is a diagram schematically showing a hardware configuration of a computer.

FIG. 4 is a diagram schematically showing an example of a captured image
20 generated by the second optical inspection camera.

FIG. 5 is a flowchart showing a procedure of visual inspection of electronic components.

FIG. 6 is a flowchart showing a procedure of processing for setting inspection areas.

25 FIG. 7 is a flowchart showing a procedure of processing for setting a first inspection area.

FIG. 8 is a diagram for describing a procedure for specifying a portion of the

left edge of a first electronic component in a captured image.

FIG. 9 is a diagram for describing how positions of a predetermined number of pixels that are targets of left edge determination processing are changed.

FIG. 10 is a diagram for describing generation of an approximation curve in
5 left edge determination processing.

FIG. 11 is a diagram schematically showing a curve showing a result of differentiating an approximation curve.

FIG. 12 is a diagram for describing a procedure for specifying another portion of the left side.

10 FIG. 13 is a diagram for describing a procedure for specifying the left edge based on pixel positions respectively corresponding to maximum values of differential values (maximum value > first predetermined value) obtained through left edge determination processing.

FIG. 14 is a flowchart showing a procedure of processing for specifying the
15 left edge of a first electronic component.

FIG. 15 is a flowchart showing a procedure of processing for specifying the upper end and the lower end of the left edge.

FIG. 16 is a diagram for describing a procedure for specifying the right edge of the first electronic component.

20 FIG. 17 is a flowchart showing a procedure of processing for specifying the right edge of the first electronic component.

FIG. 18 is a diagram for describing a procedure for specifying the top edge and the bottom edge of the first electronic component.

FIG. 19 is a flowchart showing a procedure for specifying the top edge of
25 the first electronic component.

FIG. 20 is a flowchart showing a procedure of processing for specifying the bottom edge of the first electronic component.

FIG. 21 is a diagram for describing a procedure of processing for setting another inspection area at a position shifted from a first inspection area in a row direction or a column direction.

FIG. 22 is a flowchart showing a procedure of processing for setting another inspection area at a position shifted from the first inspection area in the row direction.

FIG. 23 is a flowchart showing a procedure of processing for setting another inspection area at a position shifted from the first inspection area in the column direction.

10 Description of Embodiments

[0010] Embodiments according to aspects of the present invention (hereinafter also referred to as “present embodiment”) will be described in detail below with reference to the drawings. Note that, in the drawings, the same reference signs are given to the same or equivalent parts, and the description thereof will not be repeated.

15 Also, the illustrations in the drawings are schematic illustrations with elements omitted or exaggerated as appropriate to facilitate understanding.

[0011] [1. Configuration]

<1-1. Configuration of cutting apparatus>

FIG. 1 is a plan view schematically showing a cutting apparatus 1 according to the present embodiment. The cutting apparatus 1 is configured to cut a package substrate (an example of a cutting target) to divide the package substrate into a plurality of individual electronic components (an example of a cut product). In the package substrate, substrate or lead frames with semiconductor chips fixed thereto are each sealed with resin. Note that the cutting target does not necessarily need to be a package substrate, and may be, for example, a substrate (or a wafer) that is not sealed with resin.

[0012] Examples of package substrates include a BGA (Ball Grid Array)

package substrate, an LGA (Land Grid Array) package substrate, a CSP (Chip Size Package) package substrate, an LED (Light Emitting Diode) package substrate, and a QFN (Quad Flat No-leaded) package substrate.

[0013] The cutting apparatus 1 is also configured to inspect each of the separated
5 electronic components. In the cutting apparatus 1, images of the electronic components are captured, and the electronic components are inspected based on the captured images. Inspection data is generated through the inspection, and each electronic component is classified as a “good component” or a “defective component”.

[0014] In this example, a package substrate P1 is the cutting target, and the
10 cutting apparatus 1 divides the package substrate P1 into a plurality of individual electronic components S1 (see FIG. 2). Hereinafter, regarding the two main surfaces of the package substrate P1, the resin-sealed surface will be referred to as the mold surface, and the surface opposite to the mold surface will be referred to as the ball/lead surface. Note that in the case where the cutting target is a substrate that
15 is not sealed with resin, the surface that faces upward during cutting (i.e., the cut surface) corresponds to the ball/lead surface in the present embodiment, and the surface opposite to the cut surface corresponds to the mold surface in the present embodiment.

[0015] As shown in FIG. 1, the cutting apparatus 1 includes a cutting module A1
20 and an inspection/storage module B1 as constituent elements. The cutting module A1 is configured to cut the package substrate P1 to produce a plurality of electronic components S1. The inspection/storage module B1 is configured to inspect each of the manufactured electronic components S1, and then store the electronic components S1 in trays. Various constituent elements of the cutting apparatus 1 can
25 be removed from the other constituent elements and replaced.

[0016] The cutting module A1 mainly includes a substrate supply unit 3, a positioning unit 4, cutting tables 5, spindle units 6, and a transport unit 7.

[0017] A magazine M1 stores a plurality of package substrates P1, and the substrate supply unit 3 supplies the package substrates P1 one by one to the positioning unit 4 by pushing out the package substrates P1 one by one from the magazine M1. At this time, the package substrates P1 are each arranged such that the ball/lead surface faces upward.

[0018] The positioning unit 4 positions the package substrate P1, which has been pushed out from the substrate supply unit 3, by arranging the package substrate P1 on the rail portion 4a. Thereafter, the positioning unit 4 transports the positioned package substrate P1 to the cutting table 5.

[0019] The cutting table 5 holds the package substrate P to be cut. Here, the illustrated cutting apparatus 1 has a twin cut table configuration including two cutting tables 5. Each of the cutting tables 5 includes a holding member 5a, a rotating mechanism 5b, and a moving mechanism 5c. The holding member 5a holds the package substrate P1 transported by the positioning unit 4 by suctioning the package substrate P1 from below. The rotating mechanism 5b is capable of rotating the holding member 5a on a horizontal plane in a direction $\theta 1$ shown in the figure. The moving mechanism 5c is capable of moving the holding member 5a along the Y axis shown in the figure.

[0020] The spindle unit 6 divides the package substrate P1 into a plurality of electronic components S1 by cutting the package substrate P1. Here, the illustrated cutting apparatus 1 has a twin spindle configuration including two spindle units 6. The spindle units 6 can be moved along the X axis and the Z axis shown in the figure. Note that the cutting apparatus 1 may have a single spindle configuration including only one spindle unit 6.

[0021] Each of the spindle units 6 includes a rotation shaft 6c. A blade 6a is fixed to the rotation shaft 6c of the spindle unit 6. The blade 6a cuts the package substrate P1 by rotating at high speed, and thus divides the package substrate P1 into

a plurality of electronic components S1. The blade 6a is attached to the rotation shaft 6c so as to be clamped between first and second flanges (not shown). The first and second flanges are fixed to the rotation shaft 6c by fastening members (not shown) such as nuts.

5 [0022] The cutting module A1 includes a cutting water nozzle, a cooling water nozzle, a waste removal water nozzle, and the like (not shown). The cutting water nozzle sprays cutting water toward the blade 6a rotating at high speed. The cooling water nozzle sprays cooling water toward the cut region of the package substrate P1. The waste removal water nozzle sprays waste removal water for removing cutting
10 waste and the like.

[0023] While the cutting table 5 suctions the package substrate P1, an image of the package substrate P1 is captured by a first position checking camera 5d, and the position of the package substrate P1 is checked. The checking performed using the first position checking camera 5d is, for example, checking of the positions of
15 alignment marks provided on the package substrate P1. Information on the positions of the alignment marks is used, for example, to determine a cutting line for the package substrate P1.

[0024] After that, the cutting table 5 moves along the Y axis in the figure toward a corresponding one of the spindle units 6. After the cutting table 5 moves to a
20 position below the blade 6a, the package substrate P1 is cut by moving the cutting table 5 and the spindle unit 6 relative to each other. After that, if necessary, an image of the package substrate P1 is captured by a second position checking camera 6b provided in the cutting module A1, and the position or the like of the package substrate P1 is checked. The checking performed using the second position
25 checking camera 6b is, for example, the checking of a cutting position and a cutting width of the package substrate P1.

[0025] After the cutting of the package substrate P1 is complete, the cutting table

5 moves away from the spindle unit 6 along the Y axis in the figure while suctioning the separated electronic components S1. During this moving process, a first cleaner 5e cleans and dries the upper surfaces (ball/lead surfaces) of the electronic components S1. This cleaning may be performed by, for example, directly spraying
5 cleaning water onto the upper surfaces of the electronic components S1, or supplying cleaning water to the upper surfaces of the electronic components S1 via a brush or the like. Note that although the cutting apparatus 1 includes two first cleaners 5e arranged side by side in the X-axis direction in the figure, the number of first cleaners 5e is not limited to this.

10 [0026] The transport unit 7 suctions the electronic components S1 held on the cutting table 5 from above, and transports the electronic components S1 to the inspection table 11 of the inspection/storage module B1. During this transportation process, a second cleaner 7a cleans and dries the lower surfaces (mold surfaces) of the electronic components S1. This cleaning may be performed by, for example,
15 directly spraying cleaning water onto the lower surfaces of the electronic components S1, or supplying cleaning water to the lower surfaces of the electronic components S1 via a brush or the like.

[0027] The inspection/storage module B1 mainly includes the inspection table 11, a first optical inspection camera 12, a second optical inspection camera 13, an
20 arrangement unit 14, and an extraction unit 15. Note that the first optical inspection camera 12 may be provided in the cutting module A1.

[0028] The inspection table 11 holds the electronic components S1 for optical inspection of the electronic components S1. The inspection table 11 can be moved along the X axis in the figure. Furthermore, the inspection table 11 can be vertically
25 inverted. The inspection table 11 includes a holding member 11b (see FIG. 2) that holds an electronic component S1 by suctioning the electronic component S1.

[0029] A first optical inspection camera 12 and a second optical inspection

camera 13 capture images of the mold surfaces and the ball/lead surfaces, respectively, of the electronic components S1. Based on the image data generated by the first optical inspection camera 12 and the second optical inspection camera 13, various types of inspection (visual inspection) regarding the appearance of the electronic components S1 are performed. One example of visual inspection is inspection of the sizes of the electronic components S1, inspection of the sizes of ball portions BA1, and inspection of the distance between adjacent ball portions BA1. The first optical inspection camera 12 and the second optical inspection camera 13 are disposed near the inspection table 11 so as to capture images from above.

10 [0030] The first optical inspection camera 12 captures an image of the mold surfaces of the electronic components S1 that have been transported to the inspection table 11 by the transport unit 7. After that, the transport unit 7 places the electronic components S1 on the holding member 11b of the inspection table 11. After the holding member 11b suctions the electronic components S1, the inspection table 11 is vertically inverted. The inspection table 11 moves to a position above the second optical inspection camera 13, and an image of the ball/lead surfaces of the electronic components S1 is captured by the second optical inspection camera 13.

[0031] FIG. 2 is a diagram schematically showing a state in which an image of the electronic components S1 is being captured by the second optical inspection camera 13. The inspection table 11 includes an inspection table body 11a and a holding member 11b. The holding member 11b is provided below the inspection table body 11a. The surface of the holding member 11b on which the electronic components S1 are held is made of, for example, black rubber. Note that the color of the rubber does not need to be black, and may be, for example, white. The second optical inspection camera 13 captures an image of the electronic components S1 that are suctioned and held by the holding member 11b. Inspection regarding the appearance of the ball/lead surfaces of the electronic components S1 is performed

based on the captured image or image data representing the captured image generated by second optical inspection camera 13 (hereinafter also simply referred to as the “captured image”). A procedure for inspecting the appearance of the ball/lead surfaces of the electronic components S1 will be described in detail later.

5 [0032] Returning to FIG. 1, the inspected electronic components S1 are then disposed on the arrangement unit 14. The arrangement unit 14 can be moved along the Y axis in the figure. The inspection table 11 disposes the inspected electronic components S1 on the arrangement unit 14.

[0033] The electronic components S1 that were disposed on the arrangement unit
10 14 are transferred to a tray by the extraction unit 15. The electronic components S1 are classified as a “good component” or a “defective component” based on the results of the inspections performed using the first optical inspection camera 12 and the second optical inspection camera 13. The extraction unit 15 transfers each of the electronic components S1 to a good component tray 15a or a defective component
15 tray 15b based on the classification results. In other words, good components are stored in the good component tray 15a, and defective components are stored in the defective component tray 15b. When the good component tray 15a or the defective component tray 15b is completely full with electronic components S1, it is replaced with a new tray.

20 [0034] The cutting apparatus 1 further includes a computer 50 and a monitor 20. The monitor 20 is configured to display images. The monitor 20 is constituted by a display device such as a liquid crystal monitor or an organic EL (Electro Luminescence) monitor. The monitor 20 is provided, for example, at the front surface of the cutting apparatus 1.

25 [0035] The computer 50 controls the operations of various units of the cutting module A1 and the inspection/storage module B1, for example. For example, the computer 50 controls the operations of the substrate supply unit 3, the positioning

unit 4, the cutting tables 5, the spindle units 6, the transport unit 7, the inspection table 11, the first optical inspection camera 12, the second optical inspection camera 13, the arrangement unit 14, the extraction unit 15, and the monitor 20.

[0036] Also, the computer 50 performs various types of inspection on the electronic components S1 based on image data generated by the first optical inspection camera 12 and the second optical inspection camera 13, for example. Next, the computer 50 will be described in detail.

[0037] <1-2. Configuration of computer>

FIG. 3 is a diagram schematically showing the hardware configuration of the computer 50. As shown in FIG. 3, the computer 50 includes a control unit 70, an input/output I/F (interface) 90, an acceptance unit 95, and a storage unit 80, and these elements are electrically connected to each other via a bus.

[0038] The control unit 70 includes a CPU (Central Processing Unit) 72, a RAM (Random Access Memory) 74, a ROM (Read Only Memory) 76, and the like. The control unit 70 is configured to control constituent elements of the computer 50 and constituent elements of the cutting apparatus 1 according to information processing.

[0039] The input/output I/F 90 is configured to communicate with various constituent elements included in the cutting apparatus 1 via signal lines. The input/output I/F 90 is used in the transmission of data from the computer 50 to various constituent elements of the cutting apparatus 1 and in the reception of data transmitted from various constituent elements of the cutting apparatus 1 to the computer 50. The acceptance unit 95 is configured to accept instructions from the user. The acceptance unit 95 includes one or more of the following: a touch panel, a keyboard, a mouse, and a microphone, for example.

[0040] The storage unit 80 is an auxiliary storage device such as a hard disk drive or a solid state drive, for example. The storage unit 80 is configured to store a control program 81, for example. Various operations in the cutting apparatus 1 are

realized by execution of the control program 81 by the control unit 70. When the control unit 70 is to execute the control program 81, the control program 81 is loaded to the RAM 74. The control unit 70 then controls various constituent elements by using the CPU 72 to interpret and execute the control program 81 loaded to the RAM
5 74.

[0041] [2. Need for automatic setting of inspection areas]

As described above, in the cutting apparatus 1, visual inspection of the electronic components S1 is performed based on captured images generated by the first optical inspection camera 12 and the second optical inspection camera 13.

10 [0042] FIG. 4 is a diagram schematically showing an example of a captured image IM1 generated by the second optical inspection camera 13. As shown in FIG. 4, a plurality of electronic components S1 (e.g., electronic components S1A, S1B, S1C, and S1D) appear in the captured image IM1. In the captured image IM1, the electronic components S1 are arranged in a grid pattern. Since the captured image
15 IM1 is an image of the ball/lead surfaces of the electronic components S1, a plurality of ball portions BA1 of each of the electronic components S1 appear in the captured image IM1. Furthermore, the holding member 11b of the inspection table 11 can be seen between adjacent electronic components S1.

[0043] The captured image IM1 is a grayscale (256 tones) image. In this
20 example, the color of the electronic components S1 is brighter than the color of the holding member 11b. For example, the electronic components S1 appear in gray, and the holding member 11b appears in black. Note that when an object “appears” in a captured image, this will also be referred to as the object being “included” in the captured image.

25 [0044] The captured image IM1 has a rectangular shape, and each of the electronic components S1 has a rectangular shape. Note that in this specification, the term “rectangular” refers to a quadrangular shape (a quadrangle with four equal

corners) and may also refer to a square shape. A left edge IL1, a right edge IR1, a top edge IT1, and a bottom edge IB1 of the captured image IM1 are respectively parallel with a left edge EL1, a right edge ER1, a top edge ET1, and a bottom edge EB1 of each of the electronic components S1. Here, “parallel” means not only
5 strictly parallel, but also substantially parallel. In other words, even if the angle between two sides is not 0, if the angle between the two sides is within a range of error, the two sides are considered to be parallel.

[0045] When visual inspection of the electronic components S1 is to be performed based on the captured image IM1, first, a plurality of inspection areas T1
10 are set in the captured image IM1. Each inspection area T1 corresponds to one of the electronic components S1 included in the captured image IM1. For example, inspection areas T1A, T1B, T1C, and T1D correspond to the electronic components S1A, S1B, S1C, and S1D, respectively. In the cutting apparatus 1, the appearance of each of the electronic components S1 included in the captured image IM1 is
15 inspected based on the image included in the corresponding inspection area T1 in the captured image IM1.

[0046] One conceivable method for setting the inspection areas T1 is, for example, a method in which a worker manually sets the areas. However, when a worker manually sets the inspection areas T1, problems may arise, such as the fact
20 that it takes a relatively long time to set the inspection areas T1, the accuracy of setting the inspection areas T1 varies from worker to worker, and the frequency of errors in setting the inspection areas T1 is relatively high.

[0047] In the cutting apparatus 1 according to the present embodiment, the inspection areas T1 are set automatically. Therefore, the cutting apparatus 1 can
25 prevent the occurrence of problems that may occur when the inspection areas T1 are manually set by a worker. Also, although details will be described later, in the cutting apparatus 1, an innovation has been made regarding the algorithm for

automatically setting the inspection areas T1. Therefore, with the cutting apparatus 1, automatic setting of the inspection areas T1 can be performed relatively efficiently.

[0048] [3. Procedure of visual inspection of electronic component (cut product)]

FIG. 5 is a flowchart showing a procedure of visual inspection of the electronic components S1. In the cutting apparatus 1 according to the present embodiment, the second optical inspection camera 13 captures an image of only a portion of the electronic components S1 among all of the electronic components S1 arranged on the inspection table 11 at one time, and visual inspection of the electronic components S1 is performed on one captured image at a time. Visual inspection is performed on all of the electronic components S1 arranged on the inspection table 11 by repeatedly adjusting the positional relationship between the second optical inspection camera 13 and the inspection table 11 and capturing an image with the second optical inspection camera 13.

[0049] The processing shown in the flowchart in FIG. 5 is executed by the control unit 70 of the computer 50 when, for example, image capturing is performed the first time for visual inspection of all of the electronic components S1 arranged on the inspection table 11.

[0050] As shown in FIG. 5, the control unit 70 controls the second optical inspection camera 13 to capture an image of the electronic components S1 arranged on the inspection table 11 (step S100). The control unit 70 executes processing for setting the inspection areas T1 in the captured image IM1 generated by the second optical inspection camera 13 (step S110). The processing in step S110 will be described in detail later.

[0051] The control unit 70 executes various types of visual inspection processing on the electronic components S1 included in the captured image IM1 based on the images included in the inspection areas T1 (step S120). When visual inspection is performed based on the second or subsequent time image capturing is performed for

visual inspection of all of the electronic components S1 arranged on the inspection table 11, for example, the inspection areas T1 set for visual inspection performed based on the first image capturing is used, and the processing in step S110 is omitted.

[0052] FIG. 6 is a flowchart showing a procedure of processing for setting the inspection areas (step S110 in FIG. 5). The processing shown in this flowchart is executed by the control unit 70 of the computer 50.

[0053] As shown in FIG. 6, the control unit 70 executes processing for setting an inspection area T1 (e.g., an inspection area T1A in FIG. 4) corresponding to a first electronic component S1 among the electronic components S1 included in the captured image IM1 (step S200). The processing in step S200 will be described in detail later.

[0054] Based on the inspection area T1 set in step S200, the control unit 70 executes processing for setting an inspection area T1 (e.g., an inspection area T1B in FIG. 4) corresponding to the electronic component S1 located at a position shifted in the row direction (step S210). The processing in step S210 will be described in detail later.

[0055] Based on the inspection area T1 set in step S200, the control unit 70 executes processing for setting an inspection area T1 (e.g., an inspection area T1C in FIG. 4) corresponding to the electronic component S1 located at a position shifted in the column direction (step S220). The processing in step S220 will be described in detail later.

[0056] The control unit 70 determines the number of inspection areas T1 in the row direction and the number of inspection areas T1 in the column direction based on the inspection areas T1 set through the processing in steps S200, S210, and S220, and sets another inspection area T1 (e.g., an inspection area T1D in FIG. 4) based on the result (step S230). In the example shown in FIG. 4, through the processing in steps S200, S210, and S220, the number of inspection areas T1 in the row direction

is determined to be “2”, and the number of inspection areas T1 in the column direction is determined to be “2”. Then, another inspection area T1 is set such that the inspection areas T1 are arranged in a 2-row, 2-column grid.

[0057] FIG. 7 is a flowchart showing a procedure of processing for setting the first inspection area T1 (step S200 in FIG. 6). The processing shown in this flowchart is executed by the control unit 70 of the computer 50.

[0058] As shown in FIG. 7, the control unit 70 executes processing to specify the left edge EL1 of the first electronic component S1 among the electronic components S1 included in the captured image IM1 (hereinafter also simply referred to as the “first electronic component”) (step S300). The processing in step S300 will be described in detail later. The control unit 70 executes processing for specifying the right edge ER1 of the first electronic component S1 based on the specified left edge EL1 (step S310). The processing in step S310 will be described in detail later.

[0059] The control unit 70 executes processing for specifying the top edge ET1 of the first electronic component S1 based on the left edge EL1 and the right edge ER1 that were specified (step S320). The processing in step S320 will be described in detail later. The control unit 70 executes processing for specifying the bottom edge EB1 of the first electronic component S1 based on the left edge EL1 and the right edge ER1 that were specified (step S330). The processing in step S330 will be described in detail later. The control unit 70 sets the inspection area T1 corresponding to the first electronic component S1 based on the left edge EL1, the right edge ER1, the top edge ET1, and the bottom edge EB1 that were specified (step S340).

[0060] FIG. 8 is a diagram for describing a procedure for specifying a portion of the left edge EL1 of the first electronic component S1 in the captured image IM1. As shown in FIG. 8, left edge determination processing is executed in the cutting apparatus 1. The left edge determination processing is processing for, based on the

pixel values of a predetermined number of pixels arranged consecutively in the row direction (hereinafter simply referred to as “the predetermined number of pixels”), determining whether or not a portion of the left edge EL1 is included in the predetermined number of pixels. In the left edge determination processing, the
5 boundary between the holding member 11b and the electronic component S1 is specified based on the pixel value of each of the predetermined number of pixels. For example, from left to right in the figure, a portion is specified in which a pixel with a small pixel value (a pixel corresponding to the holding member 11b (dark pixel)) and a pixel with a large pixel value (a pixel corresponding to the electronic
10 component S1 (bright pixel)) are arranged adjacent to each other in that order.

[0061] If it is determined through the left edge determination processing that a portion of the left edge EL1 is not included in the predetermined number of pixels, the positions of the predetermined number of pixels subjected to determination are changed, for example, obliquely downward to the right, and the left edge
15 determination processing is executed on the predetermined number of pixels at the changed positions. By repeatedly performing a process of changing the positions of the predetermined number of pixels subjected to determination and executing the left edge determination processing, the position of a portion of the left edge EL1 is specified.

20 [0062] FIG. 9 is a diagram for describing how the positions of the predetermined number of pixels subjected to left edge determination processing are changed. In the captured image IM1 shown in this figure, the electronic component S1 and the like are not shown in order to simplify the description.

[0063] As shown in FIG. 9, the captured image IM1 is made up of a plurality of
25 pixels PX1. In the cutting apparatus 1, first, five pixels (an example of the predetermined number of pixels) are selected from an upper left pixel PX1 toward the right in the row direction, and the left edge determination processing is executed

for the five selected pixels. If it is determined that a portion of the left edge EL1 is not included in the five selected pixels, the positions of the five pixels are shifted by one pixel to the right in the row direction and one pixel downward in the column direction. Then, the left edge determination processing is executed for the five
5 pixels at the changed positions. The process of changing the positions of the five pixels and executing the left edge determination processing is repeated until a portion of the left edge EL1 is specified.

[0064] FIG. 10 is a diagram for describing generation of an approximation curve L1 in the left edge determination processing. As shown in FIG. 10, the horizontal
10 axis indicates the positions of the predetermined number of pixels, and the vertical axis indicates the pixel value. In the left edge determination processing, an approximation curve L1, which indicates how the pixel values of the predetermined number of pixels change from the left to the right in the captured image IM1, is generated. The approximation curve L1 may be generated using, for example,
15 various known techniques.

[0065] FIG. 11 is a diagram schematically showing a curve L2 showing a result of differentiating the approximation curve L1. As shown in FIG. 11, the horizontal axis indicates the positions of the predetermined number of pixels, and the vertical axis indicates the differential value. In the left edge determination processing, the
20 generated approximation curve L1 is differentiated. In the left edge determination processing, if the maximum value of the differential values exceeds a threshold value (first predetermined value), it is determined that a portion of the left edge EL1 is present in the predetermined number of pixels. If it is determined that a portion of the left edge EL1 is present in the predetermined number of pixels, another portion
25 of the left edge EL1 is specified based on the specified portion of the left edge EL1.

[0066] FIG. 12 is a diagram for describing a procedure for specifying another portion of the left edge EL1. As shown in FIG. 12, a pixel PX1A is an example of

a pixel PX1 corresponding to the maximum value of the differential values (maximum value > first predetermined value) obtained through the left edge determination processing. In the process of specifying the other portion of the left edge EL1, processing for specifying the upper end of the left edge EL1 is first executed, and then processing for specifying the lower end of the left edge EL1 is executed.

[0067] Specifically, five pixels including the pixel PX1A, two pixels to the left of the pixel PX1A, and two pixels to the right of the pixel PX1A are selected as the pixels to be subjected to determination. The process of shifting the positions of the five pixels subjected to determination by one pixel upward in the column direction and executing the left edge determination processing is repeatedly performed until it is determined that a portion of the left edge EL1 is not included in the five selected pixels. If each of the five selected pixels corresponds to the holding member 11b (see FIG. 4), the process of shifting the positions of the five pixels to be subjected to determination one pixel upward in the column direction stops, and the upper end of the left edge EL1 is specified. It should be noted that the pixels to be subjected to determination do not necessarily need to be five pixels including the pixel PX1A, two pixels to the left of the pixel PX1A, and two pixels to the right of the pixel PX1A. For example, the pixels to be subjected to determination may be three pixels including the pixel PX1A, one pixel to the left of the pixel PX1A, and one pixel to the right of the pixel PX1A, or four pixels including the pixel PX1A, two pixels to the left of the pixel PX1A, and one pixel to the right of the pixel PX1A, or four pixels including the pixel PX1A, one pixel to the left of the pixel PX1A, and two pixels to the right of the pixel PX1A.

[0068] When the upper end of the left edge EL1 has been specified, the process of shifting the positions of the five pixels to be subjected to determination by one pixel downward in the column direction and executing the left edge determination

processing is repeatedly performed until it is determined that a portion of the left edge EL1 is not included in the five pixels including the pixel PX1A, two pixels to the left of the pixel PX1A, and two pixels to the right of the pixel PX1A. If each of the five selected pixels corresponds to the holding member 11b (see FIG. 4), the process of
5 shifting the positions of the five pixels to be subjected to determination one pixel downward in the column direction stops, and the lower end of the left edge EL1 is specified.

[0069] FIG. 13 is a diagram for describing a procedure for specifying the left edge EL1 based on the pixel positions corresponding to the maximum values of the
10 differential values (maximum value > first predetermined value) obtained through the left edge determination processing. In this example, a group of pixels PX1 each including a pixel position (differential maximum position PO1) corresponding to the maximum value of the differential values (maximum value > first predetermined value), are arranged side by side in the column direction. In this case, for example,
15 the left edge EL1 is specified by applying a predetermined algorithm to differential maximum positions PO1. One example of the predetermined algorithm is RANSAC (Random Sample Consensus). Accordingly, the left edge of the first electronic component S1 is specified.

[0070] FIG. 14 is a flowchart showing a procedure of processing for specifying
20 the left edge EL1 of the first electronic component S1 (step S300 in FIG. 7). The processing shown in this flowchart is executed by the control unit 70 of the computer 50.

[0071] As shown in FIG. 14, the control unit 70 determines the positions of the predetermined number of the pixels that are to be subjected to the left edge
25 determination processing (step S400). For example, the control unit 70 determines five pixels from the pixel PX1 at the top left corner of the captured image IM1 to the right as targets for the left edge determination processing.

[0072] The control unit 70 generates an approximation curve based on the pixel values of the five determined pixels (step S410). The control unit 70 differentiates the generated approximation curve (step S420). The control unit 70 determines whether or not the maximum value of the differential values is greater than the first predetermined value (step S430). If it is determined that the maximum value of the differential values is less than or equal to the first predetermined value (NO in step S430), the control unit 70 shifts the positions of the five pixels to be subjected to left edge determination processing obliquely downward to the right (step S440), and executes steps S410, S420, and S430 (left edge determination processing) again.

10 [0073] On the other hand, if it is determined that the maximum value of the differential values is greater than the first predetermined value (YES in step S430), the control unit 70 executes processing for specifying the upper end and the lower end of the left edge EL1 (step S450). Processing for specifying the upper end and the lower end of the left edge EL1 will be described in detail later.

15 [0074] When the upper end and the lower end of the left edge EL1 have been specified, the control unit 70 determines whether or not the difference between a first predetermined length and the vertical length from the upper end to the lower end is less than a second predetermined value (step S460). The first predetermined length is, for example, a length corresponding to a specification value of the length from the upper end to the lower end of the electronic component S1. The second predetermined value may be, for example, a length corresponding to 0.5% to 5% of the specification value of the length from the upper end to the lower end of the electronic component S1.

20 [0075] If it is determined that the difference between the first predetermined length and the length from the upper end to the lower end is greater than or equal to the second predetermined value (NO in step S460), the control unit 70 executes the processing in step S440 based on the five pixels for which it was last determined in

step S430 that the maximum value of the differential values is greater than the first predetermined value. For example, this may occur when a ball portion BA1 (see FIG. 4) is included in the predetermined number of the pixels that are subjected to the left edge determination processing.

5 [0076] On the other hand, if it is determined that the difference between the first predetermined length and the length from the upper end to the lower end is less than the second predetermined value (YES in step S460), the control unit 70 specifies the left edge EL1 based on the pixel positions corresponding to the maximum values of the differential values (maximum value > first predetermined value) obtained through
10 the left edge determination processing (step S470).

[0077] FIG. 15 is a flowchart showing a procedure of processing for specifying the upper end and the lower end of the left edge EL1 (step S450 in FIG. 14). The processing shown in this flowchart is executed by the control unit 70 of the computer 50.

15 [0078] As shown in FIG. 15, based on the positions of the predetermined number of pixels (5 pixels) including the pixel PX1 corresponding to the maximum value of the differential values (maximum value > first predetermined value) calculated in step S420 of FIG. 14, the control unit 70 shifts the positions of the predetermined number of pixels (5 pixels) to be subjected to the left edge determination processing one pixel
20 upward in the column direction (step S500).

[0079] The control unit 70 generates an approximation curve based on the pixel values of the five pixels at the changed positions (step S510). The control unit 70 differentiates the generated approximation curve (step S520). The control unit 70 determines whether or not the maximum value of the differential values is greater
25 than the first predetermined value (step S530). If it is determined that the maximum value of the differential values is greater than the first predetermined value (YES in step S530), the control unit 70 executes the processing in step S500 again. On the

other hand, if it is determined that the maximum value of the differential values is less than or equal to the first predetermined value (NO in step S530), the control unit 70 specifies the upper end of the left edge EL1 (step S540).

[0080] Based on the positions of the predetermined number of pixels (5 pixels) including the pixel PX1 corresponding to the maximum value of the differential values (maximum value > first predetermined value) calculated in step S420 of FIG. 14, the control unit 70 shifts the positions of the predetermined number of pixels (5 pixels) to be subjected to the left edge determination processing one pixel downward in the column direction (step S550).

[0081] The control unit 70 generates an approximation curve based on the pixel values of the five pixels at the changed positions (step S560). The control unit 70 differentiates the generated approximation curve (step S570). The control unit 70 determines whether or not the maximum value of the differential values is greater than the first predetermined value (step S580). If it is determined that the maximum value of the differential values is greater than the first predetermined value (YES in step S580), the control unit 70 executes the processing in step S550 again. On the other hand, if it is determined that the maximum value of the differential values is less than or equal to the first predetermined value (NO in step S580), the control unit 70 specifies the lower end of the left edge EL1 (step S590). Accordingly, the upper end and the lower end of the left edge EL1 are specified in this way.

[0082] In this manner, in the cutting apparatus 1 according to the present embodiment, the process of shifting the positions of the predetermined number of pixels and executing the left edge determination processing is repeatedly performed, thereby setting at least a portion of the inspection areas T1. Therefore, according to the cutting apparatus 1, the inspection areas T1 can be automatically set more efficiently than when, for example, the inspection areas T1 are set based on the pixel values of the pixels PX1 in the entire captured image IM1.

[0083] Furthermore, according to the cutting apparatus 1, the positions of the predetermined number of pixels are gradually shifted in an oblique direction, and since a portion of one of the sides (e.g., the left edge EL1) of the electronic components S1 intersects with the predetermined number of pixels at a relatively early stage, it is possible to specify a portion of one side of one of the electronic components S1 relatively efficiently.

[0084] Furthermore, according to the cutting apparatus 1, another part of the left edge EL1 is specified based on the specified portion of the left edge EL1, and therefore the entire left edge EL1 can be specified relatively efficiently.

10 [0085] FIG. 16 is a diagram for describing a procedure for specifying the right edge ER1 of the first electronic component S1. As shown in FIG. 16, after the left edge EL1 is specified, the right edge ER1 of the first electronic component S1 is specified based on the left edge EL1.

[0086] For each of the pixels included in the left edge EL1, a predetermined number of pixels (5 pixels) are selected rightward in the row direction beginning from a pixel shifted a plurality of pixels rightward in the row direction from the position of the pixel in the left edge, and a group of the five pixels is generated. Right edge determination processing is executed for each of the five pixels included in the group of five pixels. The position of the leftmost pixel among the five pixels initially selected to specify the right edge ER1 is a position shifted a plurality of pixels rightward in the row direction from the position of the left edge EL1. The number of pixels shifted from the position of the left edge EL1 is determined in advance based on, for example, the specification value of the length of the electronic component S1 in the left-right direction.

25 [0087] The right edge determination processing is processing for determining whether or not a portion of the right edge ER1 is included in a predetermined number of pixels, based on the pixel values of the predetermined number of pixels. In the

right edge determination processing, the boundary between the holding member 11b and the electronic component S1 is specified based on the pixel values of the predetermined number of pixels. For example, from left to right in the figure, a portion is specified in which a pixel with a small pixel value (a pixel corresponding to the holding member 11b (dark pixel)) and a pixel with a large pixel value (a pixel corresponding to the electronic component S1 (bright pixel)) are arranged adjacent to each other in that order.

[0088] In the above-described left edge determination processing, regarding the five pixels to be subjected to left edge determination processing, it is determined whether or not a portion of the left edge EL1 is included in the predetermined number of pixels based on how the pixel values change from left to right in the figure. On the other hand, in the right edge determination processing, regarding the five pixels to be subjected to the right edge determination processing, it is determined whether or not a portion of the right edge ER1 is included in the predetermined number of pixels based on how the pixel values change from right to left in the figure. This is because the pixel values of five pixels that include the left edge EL1 increase (become brighter) from left to right, whereas the pixel values of five pixels that include the right edge ER1 increase from right to left. In other respects, the content of the right edge determination processing is similar to the content of the left edge determination processing.

[0089] If it is determined through the right edge determination processing that a predetermined number of pixels that do not include a portion of the right edge ER1 is present in the group of the predetermined number of pixels (the five selected pixels), the position of the group of the predetermined number of pixels is shifted one pixel to the right in the row direction. Then, the right edge determination processing is executed for the group of the predetermined number of pixels at the changed positions. The position of the right edge ER1 is specified by repeatedly performing the process

of changing the position of the group of the predetermined number of pixels and executing the right edge determination processing.

[0090] FIG. 17 is a flowchart showing a procedure of processing for specifying the right edge ER1 of the first electronic component S1 (step S310 in FIG. 7). The processing shown in this flowchart is executed by the control unit 70 of the computer 50.

[0091] As shown in FIG. 17, the control unit 70 determines the position of a group of the predetermined number of pixels that are to be subjected to the right edge determination processing (step S600). For example, for each of the pixels PX1 included in the left edge EL1, the control unit 70 determines, as the position of the group to be subjected to the right edge determination processing, a predetermined number of pixels (5 pixels) rightward in the row direction beginning from a pixel PX1 shifted a plurality of pixels rightward in the row direction from the position of the pixel in the left edge.

[0092] The control unit 70 generates approximation curves based on the pixel values of the determined groups of five pixels (step S610). The control unit 70 differentiates each of the generated approximation curves (step S620). The control unit 70 determines whether or not each of the maximum values of the differential values is greater than the first predetermined value (step S630). If it is determined that one or more of the maximum values of the differential values is less than or equal to the first predetermined value (NO in step S630), the control unit 70 shifts the position of the group of five pixels to be subjected to the right edge determination processing by one pixel to the right (step S640).

[0093] The control unit 70 determines whether or not an error has occurred based on the position of the group of five pixels to be subjected to the right edge determination processing at the changed positions (step S650). For example, if the length from the position of the left edge EL1 to the position of the leftmost pixel in

the changed group of five pixels to be subjected the right edge determination processing is longer than the specification value of the length of the electronic component S1 in the left-right direction, and the value of the difference therebetween is greater than or equal to a predetermined length, it is determined that an error has occurred.

[0094] If it is determined that an error has occurred (YES in step S650), the control unit 70 again executes the processing in step S440 based on the five pixels for which it was last determined in step S430 of FIG. 14 that the maximum value of the differential values is greater than the first predetermined value. On the other hand, if it is determined that an error has not occurred (NO in step S650), the control unit 70 executes steps S610, S620, and S630 (right edge determination processing) again.

[0095] On the other hand, if it is determined that the maximum values of the differential values are greater than the first predetermined value (YES in step S630), the control unit 70 specifies the right edge ER1 based on the pixel positions corresponding to the maximum values of the differential values (maximum value > first predetermined value) obtained through the right edge determination processing (step S650).

[0096] FIG. 18 is a diagram for describing a procedure for specifying the top edge ET1 and the bottom edge EB1 of the first electronic component S1. As shown in FIG. 18, after the left edge EL1 and the right edge ER1 of the first electronic component S1 are specified, the top edge ET1 and the bottom edge EB1 are specified based on the left edge EL1 and the right edge ER1.

[0097] Specifically, selection is performed to select a predetermined number of pixels located at the left end in groups of the predetermined number of pixels (five pixels) that are arranged side by side in the column direction and orthogonally intersect a straight line connecting the upper end pixels of the left edge EL1 and the

right edge ER1, and top edge determination processing is executed on the five selected pixels. The top edge determination processing is processing for determining whether or not a portion of the top edge ET1 is included in the predetermined number of pixels based on the pixel values of the predetermined number of pixels. In the top edge determination processing, the boundary between the holding member 11b and the electronic component S1 is specified based on the pixel values of the predetermined number of pixels. For example, from top to bottom in the figure, a portion is specified in which a pixel with a small pixel value (a pixel corresponding to the holding member 11b (dark pixel)) and a pixel with a large pixel value (a pixel corresponding to the electronic component S1 (bright pixel)) are arranged adjacent to each other in that order.

[0098] In the above-described left edge determination processing, regarding the five pixels to be subjected to left edge determination processing, it is determined whether or not a portion of the left edge EL1 is included in the predetermined number of pixels based on how the pixel values change from left to right in the figure. On the other hand, in the top edge determination processing, regarding the five pixels to be subjected to the top edge determination processing, it is determined whether or not a portion of the top edge ET1 is included in the predetermined number of pixels based on how the pixel values change from top to bottom in the figure. This is because the pixel values of the five pixels that include the left edge EL1 increase (become brighter) from left to right, whereas the pixel values of five pixels that include the top edge ET1 increase from top to bottom. In other respects, the content of the top edge determination processing is similar to the content of the left edge determination processing.

[0099] Until it is determined through the top edge determination processing that a portion of the top edge ET1 is not included in the predetermined number of pixels, the process of changing the positions of the predetermined number of pixels to be

subjected to determination to the right in the row direction and executing the top edge determination processing is repeatedly performed. When it is determined through the top edge determination processing that a portion of the top edge ET1 is not included in the predetermined number of pixels, the left end and the right end of the top edge ET1 are specified, and the top edge ET1 is specified.

[0100] Also, selection is performed to select a predetermined number of pixels located at the left end of groups of the predetermined number of pixels (5 pixels) that are arranged side by side in the column direction and orthogonally intersect a straight line connecting the lower end pixels of the left edge EL1 and the right edge ER1, and bottom edge determination processing is executed on the five selected pixels. The bottom edge determination processing is processing for determining whether or not a portion of the bottom edge EB1 is included in the predetermined number of pixels based on the pixel values of the predetermined number of pixels. In the bottom edge determination processing, the boundary between the holding member 11b and the electronic component S1 is specified based on the pixel value of each of the predetermined number of pixels. For example, from bottom to top in the figure, a portion is specified in which a pixel with a small pixel value (a pixel corresponding to the holding member 11b (dark pixel)) and a pixel with a large pixel value (a pixel corresponding to the electronic component S1 (bright pixel)) are arranged adjacent to each other in that order.

[0101] In the above-described left edge determination processing, regarding the five pixels to be subjected to left edge determination processing, it is determined whether or not a portion of the left edge EL1 is included in the predetermined number of pixels based on how the pixel values change from left to right in the figure. On the other hand, in the bottom edge determination processing, regarding the five pixels to be subjected to the bottom edge determination processing, it is determined whether or not a portion of the bottom edge EB1 is included in the predetermined number of

pixels based on how the pixel values change from bottom to top in the figure. This is because the pixel values of the five pixels that include the left edge EL1 increase (become brighter) from left to right, whereas the pixel values of five pixels that include the bottom edge EB1 increase from bottom to top. In other respects, the content of the bottom edge determination processing is similar to the content of the left edge determination processing.

[0102] Until it is determined through the bottom edge determination processing that a portion of the bottom edge EB1 is not included in the predetermined number of pixels, the process of changing the positions of the predetermined number of pixels to be subjected to determination to the right in the row direction and executing the bottom edge determination processing is repeatedly performed. When it is determined through the bottom edge determination processing that a portion of the bottom edge EB1 is not included in the predetermined number of pixels, the left end and the right end of the bottom edge EB1 are specified, and the bottom edge EB1 is specified.

[0103] FIG. 19 is a flowchart showing a procedure of processing for specifying the top edge ET1 of the first electronic component S1 (step S320 in FIG. 7). The processing shown in this flowchart is executed by the control unit 70 of the computer 50.

[0104] As shown in FIG. 19, the control unit 70 determines the positions of the predetermined number of pixels that are to be subjected to the top edge determination processing (step S700). For example, the control unit 70 determines, as targets for the top edge determination processing, a predetermined number of pixels located at the left end of groups of the predetermined number of pixels (five pixels) that are arranged side by side in the column direction and orthogonally intersect a straight line connecting the upper end pixels of the left edge EL1 and the right edge ER1.

[0105] The control unit 70 generates an approximation curve based on the pixel

values of the five determined pixels (step S710). The control unit 70 differentiates the generated approximation curve (step S720). The control unit 70 determines whether or not the maximum value of the differential values is greater than the first predetermined value (step S730). If it is determined that the maximum value of the differential values is greater than the first predetermined value (YES in step S730), the control unit 70 shifts the positions of the five pixels to be subjected to the top edge determination processing by one pixel to the right in the row direction (step S740) and executes steps S710, S720, and S730 (top edge determination processing) again.

10 [0106] On the other hand, if it is determined that the maximum value of the differential values is less than or equal to the first predetermined value (NO in step S730), the control unit 70 obtains the difference between a second predetermined length and the length (horizontal length) between the position of the upper end of the left edge EL1 and the position of the predetermined number of pixels for which it was

15 determined that the maximum value of the differential values is less than or equal to the first predetermined value, and determines whether or not the obtained difference is less than a third predetermined value (step S750). The second predetermined length is, for example, a length corresponding to a specification value of the length of the electronic component S1 in the left-right direction. The third predetermined

20 value may be, for example, a length corresponding to 0.5% to 5% of the specification value of the length of the electronic component S1 in the left-right direction.

[0107] If it is determined that the difference between the horizontal length and the second predetermined length is greater than or equal to the third predetermined value (NO in step S750), the control unit 70 again executes the processing in step

25 S440 based on the five pixels for which it was last determined in step S430 of FIG. 14 that the maximum value of the differential values is greater than the first predetermined value.

[0108] On the other hand, if it is determined that the difference between the horizontal length and the second predetermined length is less than the third predetermined value (YES in step S750), the control unit 70 specifies the top edge ET1 based on the pixel positions corresponding to the maximum values of the differential values (maximum value > first predetermined value) obtained through the top edge determination processing (step S760).

[0109] FIG. 20 is a flowchart showing a procedure of processing for specifying the bottom edge EB1 of the first electronic component S1 (step S330 in FIG. 7). The processing shown in this flowchart is executed by the control unit 70 of the computer 50.

[0110] As shown in FIG. 20, the control unit 70 determines the positions of the predetermined number of pixels that are to be subjected to the bottom edge determination processing (step S800). For example, the control unit 70 determines, as targets for the bottom edge determination processing, a predetermined number of pixels located at the left end of a group of the predetermined number of pixels (five pixels) that are arranged side by side in the column direction and orthogonally intersect a straight line connecting the lower end pixels of the left edge EL1 and the right edge ER1.

[0111] The control unit 70 generates an approximation curve based on the determined pixel values of the five pixels (step S810). The control unit 70 differentiates the generated approximation curve (step S820). The control unit 70 determines whether or not the maximum value of the differential values is greater than the first predetermined value (step S830). If it is determined that the maximum value of the differential values is greater than the first predetermined value (YES in step S830), the control unit 70 shifts the positions of the five pixels to be subjected to bottom edge determination processing by one pixel to the right in the row direction (step S840) and executes steps S810, S820, and S830 (bottom edge determination

processing) again.

[0112] On the other hand, if it is determined that the maximum value of the differential values is less than or equal to the first predetermined value (NO in step S830), the control unit 70 obtains the difference between the second predetermined length and the length (horizontal length) between the position of the lower end of the left edge EL1 and the position of the predetermined number of pixels for which it was determined that the maximum value of the differential values is less than or equal to the first predetermined value, and determines whether or not the obtained difference is less than the third predetermined value (step S850).

10 [0113] If it is determined that the difference between the horizontal length and the second predetermined length is greater than or equal to the third predetermined value (NO in step S850), the control unit 70 again executes the processing in step S440 based on the five pixels for which it was last determined in step S430 of FIG. 14 that the maximum value of the differential values is greater than the first predetermined value.

15 [0114] On the other hand, if it is determined that the difference between the horizontal length and the second predetermined length is less than the third predetermined value (YES in step S850), the control unit 70 specifies the bottom edge EB1 based on the pixel positions corresponding to the maximum values of the differential values (maximum value > first predetermined value) obtained through the bottom edge determination processing (step S860). Then, the inspection area T1 is set based on the left edge EL1, the right edge ER1, the top edge ET1, and the bottom edge EB1 that were specified.

20 [0115] In this way, according to the cutting apparatus 1 of the present embodiment, the other three edges of the electronic component S1 that includes the left edge EL1 are specified based on the specified left edge EL1, and therefore the inspection area T1 can be set relatively efficiently.

[0116] Furthermore, according to the cutting apparatus 1, when searching for the right edge ER1 opposite to the left edge EL1, the left edge EL1 has been specified, and the rough positions of the two ends (upper end and lower end) of the right edge ER1 are known, and therefore the right edge ER1 can be specified relatively efficiently. Furthermore, according to the cutting apparatus 1, when searching for the two edges other than the left edge EL1 and the right edge ER1 (i.e., when searching for the top edge ET1 and the bottom edge EB1), the left edge EL1 and the right edge ER1 have been specified, and the rough positions of the two ends of each of the two edges other than the left edge EL1 and the right edge ER1 are known, and therefore the two edges other than the left edge EL1 and the right edge ER1 can be specified relatively efficiently.

[0117] FIG. 21 is a diagram for describing a procedure of processing for setting another inspection area T1 at a position shifted in the row direction or the column direction from the first inspection area T1. As shown in FIG. 21, for example, the inspection area T1B, which is shifted in the row direction with respect to the inspection area T1A, and the inspection area T1C, which is shifted in the column direction with respect to the inspection area T1A, are each set based on the inspection area T1A.

[0118] In order to set the inspection area T1 at a position shifted in the row direction with respect to the inspection area T1A, for example, a provisional inspection area T1B1 having the same shape as the inspection area T1A is selected. The shape of the provisional inspection area T1B1 is the same as the shape of the inspection area T1A. In other words, the lengths of the left edge, the right edge, the top edge, and the bottom edge of the provisional inspection area T1B1 are the same as the lengths of the left edge, the right edge, the top edge, and the bottom edge of the inspection area T1A, respectively.

[0119] The position of the provisional inspection area T1B1 is shifted by a

plurality of pixels in the row direction from the position of the inspection area T1A. The number of pixels shifted from the position of the inspection area T1A is determined in advance based on, for example, the specification value of the length of the electronic component S1 in the left-right direction.

5 [0120] When a provisional inspection area T1 (e.g., the provisional inspection area T1B1) is selected, determination processing (hereinafter also referred to as “edge-related determination processing”) is executed to determine whether or not the left edge, the right edge, the top edge, and the bottom edge of the provisional inspection area T1 (e.g., the provisional inspection area T1B1) correspond to the left
10 edge, the right edge, the top edge, and the bottom edge of the electronic component S1 (e.g., the electronic component S1B), respectively. In the edge-related determination processing, the left edge determination processing is repeatedly executed along the left edge of the provisional inspection area T1, and the right edge determination processing is repeatedly executed along the right edge of the provisional inspection area T1. Moreover, the top edge determination processing is
15 repeatedly executed along the top edge of the provisional inspection area T1, and the bottom edge determination processing is repeatedly executed along the bottom edge of the provisional inspection area T1. Accordingly, it is possible to determine whether or not the edges of the provisional inspection area T1 correspond to the edges
20 of the electronic component S1.

[0121] If it is determined that any edge of the provisional inspection area T1 does not correspond to an edge of the electronic component S1, a new provisional inspection area T1 (e.g., the provisional inspection area T1B2) is selected at a position shifted by one pixel in the row direction. Then, the edge-related determination
25 processing is executed for the newly selected provisional inspection area T1. The process of shifting the position of the provisional inspection area T1 in the row direction and executing the edge-related determination processing is repeatedly

performed until it is determined that each edge of the provisional inspection area T1 corresponds to an edge of the electronic component S1. As a result, another inspection area T1 is set at a position shifted in the row direction from the first inspection area T1. By repeating this procedure, it is possible to set an inspection area T1 for each electronic component S1 that exists at a position shifted in the row direction from the first set the inspection area T1.

[0122] In order to set the inspection area T1 at a position shifted in the column direction with respect to the inspection area T1A, for example, a provisional inspection area T1C1 having the same shape as the inspection area T1A is selected. The shape of the provisional inspection area T1C1 is the same as the shape of the inspection area T1A. In other words, the lengths of the left edge, the right edge, the top edge, and the bottom edge of the provisional inspection area T1C1 are the same as the lengths of the left edge, the right edge, the top edge, and the bottom edge of the inspection area T1A, respectively.

[0123] The position of the provisional inspection area T1C1 is shifted by a plurality of pixels in the column direction from the position of the inspection area T1A. The number of pixels shifted from the position of the inspection area T1A is determined in advance based on, for example, the specification value of the length of the electronic component S1 in the up-down direction.

[0124] When a provisional inspection area T1 (e.g., the provisional inspection area T1C1) is selected, edge-related determination processing is executed. If it is determined that any edge of the provisional inspection area T1 does not correspond to an edge of the electronic component S1, a new provisional inspection area T1 (e.g., the provisional inspection area T1C2) is selected at a position shifted by one pixel in the column direction. Then, the edge-related determination processing is executed for the newly selected provisional inspection area T1. The process of shifting the position of the provisional inspection area T1 in the column direction and executing

the edge-related determination processing is repeated until it is determined that each edge of the provisional inspection area T1 corresponds to an edge of the electronic component S1. As a result, another inspection area T1 is set at a position shifted in the column direction from the first inspection area T1. By repeating this procedure,
5 it is possible to set an inspection area T1 for each electronic component S1 that exists at a position shifted in the column direction from the first set the inspection area T1.

[0125] FIG. 22 is a flowchart showing a procedure of processing for setting another inspection area T1 at a position shifted in the row direction from the first inspection area T1 (step S210 in FIG. 6). The processing shown in this flowchart is
10 executed by the control unit 70 of the computer 50.

[0126] As shown in FIG. 22, based on set the inspection area T1, the control unit 70 selects a provisional inspection area T1 at a position shifted by a plurality of pixels in the row direction from the set inspection area T1 (step S900). The control unit 70 executes edge-related determination processing on the selected provisional
15 inspection area T1 (step S910). The control unit 70 determines whether or not the edges of the provisional inspection area T1 correspond to the edges of the electronic component S1 (step S920).

[0127] If it is determined that any edge of the provisional inspection area T1 does not correspond to an edge of the electronic component S1 (NO in step S920), the
20 control unit 70 changes the position of the provisional inspection area T1 by shifting the position of the provisional inspection area T1 by one pixel in the row direction (step S930). Thereafter, the control unit 70 executes the processing in steps S910 and S920 again.

[0128] On the other hand, if it is determined that each edge of the provisional
25 inspection area T1 corresponds to an edge of the electronic component S1 (YES in step S920), the control unit 70 sets the currently selected provisional inspection area T1 as the inspection area T1 (step S940). Thereafter, the control unit 70 determines

whether or not inspection areas T1 have been set for all of the electronic components S1 present in the row direction (step S950). If it is determined that the setting of inspection areas T1 for all of the electronic components S1 present in the row direction has not been completed (NO in step S950), the control unit 70 executes the processing in step S900 again. On the other hand, if it is determined that the inspection areas T1 have been set for all of the electronic components S1 present in the row direction (YES in step S950), the processing shown in this flowchart ends.

[0129] FIG. 23 is a flowchart showing a procedure of processing for setting another inspection area T1 at a position shifted in the column direction from the first inspection area T1 (step S220 in FIG. 6). The processing shown in this flowchart is executed by the control unit 70 of the computer 50.

[0130] As shown in FIG. 23, based on set the inspection area T1, the control unit 70 selects a provisional inspection area T1 at a position shifted by a plurality of pixels in the column direction from the set inspection area T1 (step S1000). The control unit 70 executes edge-related determination processing on the selected provisional inspection area T1 (step S1010). The control unit 70 determines whether or not the edges of the provisional inspection area T1 correspond to the edges of the electronic component S1 (step S1020).

[0131] If it is determined that any edge of the provisional inspection area T1 does not correspond to an edge of the electronic component S1 (NO in step S1020), the control unit 70 changes the position of the provisional inspection area T1 by shifting the position of the provisional inspection area T1 by one pixel in the column direction (step S1030). Thereafter, the control unit 70 executes the processing in steps S1010 and S1020 again.

[0132] On the other hand, if it is determined that each edge of the provisional inspection area T1 corresponds to an edge of the electronic component S1 (YES in step S1020), the control unit 70 sets the currently selected provisional inspection area

T1 as the inspection area T1 (step S1040). Thereafter, the control unit 70 determines whether or not inspection areas T1 have been set for all of the electronic components S1 present in the column direction (step S1050). If it is determined that the setting of inspection areas T1 for all of the electronic components S1 present in the column direction has not been completed (NO in step S1050), the control unit 70 executes the processing in step S1000 again. On the other hand, if it is determined that the inspection areas T1 have been set for all of the electronic components S1 present in the column direction (YES in step S1050), the processing shown in this flowchart ends.

[0133] In this manner, according to the cutting apparatus 1 of the present embodiment, other inspection areas T1 are specified based on the inspection area T1 that is specified first, and therefore a plurality of inspection areas T1 can be specified relatively efficiently.

[0134] [4. Features]

As described above, in the cutting apparatus 1 according to the present embodiment, at least a portion of the inspection areas T1 are set by repeatedly shifting the positions of the predetermined number of pixels PX1 and executing determination processing (e.g., the left edge determination processing). Therefore, according to the cutting apparatus 1, the inspection areas T1 can be automatically set more efficiently than when, for example, the inspection areas T1 are set based on the pixel values of the pixels PX1 in the entire captured image IM1.

[0135] Note that the cutting apparatus 1 is an example of a “cutting apparatus” according to the present invention. The electronic component S1 is an example of a “cut product” according to the present invention. The first optical inspection camera 12 and the second optical inspection camera 13 are each an example of an “image capturing unit” according to the present invention. The control unit 70 is an example of a “first processing unit” and an example of a “second processing unit”

according to the present invention. The captured image IM1 is an example of a “captured image” according to the present invention.

[0136] [5. Other embodiments]

5 The idea of the above embodiment is not limited to the embodiment described above. For example, at least a portion of the configurations of any one of the embodiments may be combined with at least a portion of the configurations of any other one of the embodiments. Examples of other embodiments to which the idea of the above embodiment can be applied will be described below.

[0137] <5-1>

10 In the above embodiment, the cutting apparatus 1 is controlled by the computer 50. However, the cutting apparatus 1 does not need to be controlled by one computer 50, and may be controlled by a plurality of computers.

[0138] <5-2>

15 In the above embodiment, the color of the holding member 11b of the inspection table 11 is black. However, as mentioned above, the color of the holding member 11b may be white. When the color of the holding member 11b is white, the pixel value decreases from left to right at the left edge of the electronic component S1, and the pixel value decreases from right to left at the right edge. Moreover, the pixel values decrease from top to bottom at the top edge of the electronic component S1, and the pixel values decrease from bottom to top at the bottom edge. Therefore, in the left edge determination processing, it may be determined that a portion of the left edge is included in the predetermined number of pixels when the minimum value of the differential values of the approximation curve showing the change in pixel values from left to right is less than a threshold value. Also, in the left edge
20 determination processing, it may be determined that a portion of the left edge is included in the predetermined number of pixels when the maximum value of the differential value of the approximation curve showing the change in pixel values from
25

right to left is greater than a threshold value. This can similarly apply to the right edge determination processing, the top edge determination processing, and the bottom edge determination processing.

[0139] <5-3>

5 In the above embodiment, the left edge EL1 is specified first in order to set the initial inspection area T1. However, the first specified edge is not limited to being the left edge EL1. The right edge ER1 may be specified first, the top edge ET1 may be specified first, or the bottom edge EB1 may be specified first.

[0140] <5-4>

10 Furthermore, in the processing for specifying the left edge EL1, the right edge ER1, the top edge ET1, and the bottom edge EB1, the number of pixels used when shifting the predetermined number of pixels does not need to be one pixel. The positions of the predetermined number of pixels may be shifted by a unit of multiple pixels. Also, the predetermined number of pixels does not need to be five
15 pixels. The predetermined number of pixels may be two or more pixels. Furthermore, in the processing for setting the second and subsequent inspection areas T1, the number of pixels used when shifting the provisional inspection area T1 does not need to be one pixel. The position of the provisional inspection area T1 may be shifted by a unit of multiple pixels.

20 [0141] <5-5>

Furthermore, in the above embodiment, each of the edges of the electronic component S1 in the captured image IM1 is specified based on the differential value of the approximation curve generated based on the pixel values of the predetermined number of pixels. However, such differential values do not necessarily need to be
25 used to specify the edges of the electronic component S1 in the captured image IM1.

[0142] <5-6>

Furthermore, in the above embodiment, an image of only a portion of the

electronic components S1 arranged on the inspection table 11 is captured by the second optical inspection camera 13 at one time. However, the image capturing area of the second optical inspection camera 13 is not limited to this, and an image of all of the electronic components S1 arranged on the inspection table 11 may be captured
5 by the second optical inspection camera 13 at one time.

[0143] <5-7>

Furthermore, in the above embodiment, some of the inspection areas T1 (e.g., the inspection area T1D in FIG. 4) among the second and subsequent inspection areas T1 are set without undergoing the edge-related determination processing. However,
10 the method of setting the second and subsequent inspection areas T1 is not limited to this, and for example, all of the inspection areas T1 set in the captured image IM1 from the second inspection area onward may be set through edge-related determination processing.

[0144] <5-8>

15 In the above embodiment, after the first inspection area T1 is set, another inspection area T1 is set at a position shifted in the row direction, and then another inspection area T1 is set at a position shifted in the column direction. However, the order of setting of the inspection areas T1 is not limited to this. For example, after the first inspection area T1 is set, an inspection area T1 may be set at a position shifted
20 in the column direction, and then an inspection area T1 may be set at a position shifted in the row direction.

[0145] <5-9>

In the above embodiment, the left edge EL1, the right edge ER1, the top edge ET1, and the bottom edge EB1 are specified in this order in order to set the first
25 inspection area T1. However, the order in which the edges are specified is not limited to this.

[0146] <5-10>

Also, in the above embodiment, the setting of the inspection areas T1 in the captured image IM1 captured by the second optical inspection camera 13 has been mainly described, but similar processing may also be performed in setting the inspection areas in the captured image captured by the first optical inspection camera

5 12.

[0147] <5-11>

Furthermore, in the above embodiment, in the case where one portion of the left edge EL1 is specified and then another portion of the left edge EL1 is specified, the upper end of the left edge EL1 is specified first, and then the lower end of the left

10 edge EL1 is specified. However, the order in which the upper end and the lower end are specified is not limited to this. For example, in the case where one portion of the left edge EL1 is specified and then another portion of the left edge EL1 is specified, the lower end of the left edge EL1 may be specified first, and then the upper end of the left edge EL1 may be specified.

15 [0148] The embodiments of the present invention described above are illustrative. In other words, the detailed description and accompanying drawings have been disclosed for the purpose of illustration. Therefore, some of the components described in the detailed description and the attached drawings may not be essential for solving the problem. Accordingly, simply because non-essential components

20 are described in the detailed description and accompanying drawings, such non-essential components are not intended to be immediately identified as essential.

[0149] Furthermore, the above embodiments are merely illustrative of the present invention in all respects. Various improvements and changes can be made to the above embodiments within the scope of the present invention. In other words,

25 when implementing the present invention, specific configurations can be adopted as appropriate depending on the embodiment.

[0150] [6. Supplementary notes]

<Technology 1>

(Configuration)

A cutting apparatus that manufactures a plurality of cut products by cutting a substrate, the cutting apparatus including:

5 an image capturing unit configured to generate a captured image by performing image capturing on a portion or all of the plurality of cut products;

 a first processing unit configured to set a plurality of inspection areas in the captured image; and

 a second processing unit configured to perform visual inspection on each of
10 the cut products included in the captured image based on images respectively included in the plurality of inspection areas in the captured image,

 wherein each of the inspection areas has a rectangular shape,

 each of the cut products has a rectangular shape,

 the first processing unit executes determination processing to, based on pixel
15 values of a predetermined number of pixels arranged consecutively in a first direction in the captured image, determine whether or not a portion of one edge of one of the plurality of cut products is included in the predetermined number of pixels,

 the predetermined number is smaller than a total number of pixels in the captured image, and

20 the first processing unit sets at least a portion of the plurality of inspection areas by repeatedly shifting positions of the predetermined number of pixels and executing the determination processing.

(Effects, etc.)

 In this cutting apparatus, at least a portion of the inspection areas are set by
25 repeatedly shifting the positions of the predetermined number of pixels and executing the determination processing. Therefore, according to this cutting apparatus, the inspection areas can be automatically set more efficiently than when, for example,

the inspection areas are set based on the pixel values of the pixels in the entire captured image.

[0151] <Technology 2>

(Configuration)

5 In the cutting apparatus according to Technology 1, a left edge, a right edge, a top edge, and a bottom edge of the captured image are parallel with a left edge, a right edge, a top edge, and a bottom edge of each of the cut products, respectively.

[0152] <Technology 3>

(Configuration)

10 In the cutting apparatus according to Technology 1 or 2, the first processing unit sets at least a portion of the plurality of inspection areas by repeatedly shifting positions of the predetermined number of pixels in a second direction and executing the determination processing, and

the second direction is an oblique direction oblique to the first direction.

15 (Effects, etc.)

According to this cutting apparatus, the positions of the predetermined number of pixels are gradually shifted in an oblique direction, and since a portion of one side of one of the cut products intersects with the predetermined number of pixels at a relatively early stage, it is possible to specify a portion of one side of one of the cut products relatively efficiently.

20

[0153] <Technology 4>

(Configuration)

In the cutting apparatus according to any one of Technology 1 to 3, the first direction is a row direction or a column direction.

25 [0154] <Technology 5>

(Configuration)

In the cutting apparatus according to Technology 3 or 4, the first processing

unit shifts positions of the predetermined number of pixels in the second direction by both shifting a position of each of the predetermined number of pixels by one pixel or a plurality of pixels in a row direction and shifting a position of each of the predetermined number of pixels by one pixel or a plurality of pixels in a column direction.

(Effects, etc.)

According to this cutting apparatus, the positions of the predetermined number of pixels are gradually shifted by one pixel or a plurality of pixels in the row direction and by one pixel or a plurality of pixels in the column direction, and since a portion of one side of one of the cut products intersects with the predetermined number of pixels at a relatively early stage, it is possible to specify a portion of one side of one of the cut products relatively efficiently.

[0155] <Technology 6>

(Configuration)

In the cutting apparatus according to any one of Technology 1 to 5, in a case where the first processing unit determined through the determination processing that one portion of a first edge, which is one edge of one of the plurality of cut products, is included in the predetermined number of pixels, the first processing unit specifies the first edge by specifying another portion of the first edge based on at least a portion of the predetermined number of pixels for which the first processing unit determined that the one portion of the first edge is included.

(Effects, etc.)

According to this cutting apparatus, another portion of the specified first edge is specified based on the one portion of the first edge, and therefore the entire first edge can be specified relatively efficiently.

[0156] <Technology 7>

(Configuration)

In the cutting apparatus according to Technology 6, the first processing unit specifies, based on the first edge that was specified, another three edges of the cut product that includes the first edge, and sets one of the plurality of inspection areas based on the four edges that were specified.

5 (Effects, etc.)

According to this cutting apparatus, the other three edges of the cut product that includes the first edge are specified based on the specified first edge, and therefore the inspection area can be set relatively efficiently.

[0157] <Technology 8>

10 (Configuration)

In the cutting apparatus according to Technology 7, the first processing unit specifies, based on the first edge that was specified, a second edge opposite to the first edge among the other three edges, and then specifies the two edges other than the first edge and the second edge.

15 (Effects, etc.)

According to this cutting apparatus, when searching for the second edge opposite to the first edge, the first edge has been specified, and the rough positions of the two ends of the second edge are known, and therefore the second edge can be specified relatively efficiently. Furthermore, with this cutting apparatus, when
20 searching for the two edges other than the first edge and the second edge, the first edge and the second edge have been specified, and the rough positions of the two ends of each of the two edges other than the first edge and the second edge are known, and therefore the two edges other than the first edge and the second edge can be specified relatively efficiently.

25 [0158] <Technology 9>

(Configuration)

In the cutting apparatus according to any one of Technology 1 to 8, based on

an inspection area set first among the plurality of inspection areas, the first processing unit sets another inspection area among the plurality of inspection areas.

(Effects, etc.)

According to this cutting apparatus, other inspection areas are specified
5 based on the inspection area that was specified first, and therefore it is possible to specify a plurality of inspection areas relatively efficiently.

[0159] <Technology 10>

(Configuration)

A method for manufacturing a cut product using the cutting apparatus
10 according to any one of Technology 1 to 9,

the cutting apparatus further including:

a cutting table on which the substrate is placeable; and

a cutting unit configured to cut the substrate placed on the cutting table, and
the method including:

15 placing the substrate on the cutting table;

manufacturing the plurality of cut products by cutting the substrate placed
on the cutting table;

generating the captured image by performing image capturing on a portion
or all of the plurality of cut products;

20 setting the plurality of inspection areas in the captured image; and

performing visual inspection on each of the cut products included in the
captured image based on images respectively included in the plurality of inspection
areas in the captured image.

(Effects, etc.)

25 In this method for manufacturing a cut product, at least a portion of the inspection areas are set by repeatedly shifting the positions of the predetermined number of pixels and executing the determination processing. Therefore, according

to this method for manufacturing a cut product, the inspection areas can be automatically set more efficiently than when, for example, the inspection areas are set based on the pixel values of the pixels in the entire captured image.

5 List of Reference Numerals

	[0160]	1	Cutting apparatus
		3	Substrate supply unit
		4	Positioning unit
		4a	Rail portion
10		5	Cutting table
		5a	Holding member
		5b	Rotating mechanism
		5c	Moving mechanism
		5d	First position checking camera
15		5e	First cleaner
		6	Spindle unit
		6a	Blade
		6b	Second position checking camera
		6c	Rotation shaft
20		7	Transport unit
		7a	Second cleaner
		11	Inspection table
		11a	Inspection table body
		11b	Holding member
25		12	First optical inspection camera
		13	Second optical inspection camera
		14	Arrangement unit

	15	Extraction unit
	15a	Good component tray
	15b	Defective component tray
	20	Monitor
5	50	Computer
	70	Control unit
	72	CPU
	74	RAM
	76	ROM
10	80	Storage unit
	81	Control program
	90	Input/output I/F
	95	Acceptance unit
	A1	Cutting module
15	B1	Inspection/storage module
	BA1	Ball portion
	EB1, IB1	Bottom edge
	EL1, IL1	Left edge
	ER1, IR1	Right edge
20	ET1, IT1	Top edge
	IM1	Captured image
	L1	Approximation curve
	L2	Curve
	M1	Magazine
25	P1	Package substrate
	PO1	Differential maximum position
	PX1	Pixel

S1 Electronic component

T1 Inspection area

T1B1, T1B2, T1B3, T1C1, T1C2, T1C3 Provisional inspection area

CLAIMS

[Claim 1] A cutting apparatus that manufactures a plurality of cut products by cutting a substrate, the cutting apparatus comprising:

5 an image capturing unit configured to generate a captured image by performing image capturing on a portion or all of the plurality of cut products;

a first processing unit configured to set a plurality of inspection areas in the captured image; and

a second processing unit configured to perform visual inspection on each of
10 the cut products included in the captured image based on images respectively included in the plurality of inspection areas in the captured image,

wherein each of the inspection areas has a rectangular shape,

each of the cut products has a rectangular shape,

the first processing unit executes determination processing to, based on pixel
15 values of a predetermined number of pixels arranged consecutively in a first direction in the captured image, determine whether or not a portion of one edge of one of the plurality of cut products is included in the predetermined number of pixels,

the predetermined number is smaller than a total number of pixels in the captured image, and

20 the first processing unit sets at least a portion of the plurality of inspection areas by repeatedly shifting positions of the predetermined number of pixels and executing the determination processing.

[Claim 2] The cutting apparatus according to claim 1,

25 wherein a left edge, a right edge, a top edge, and a bottom edge of the captured image are parallel with a left edge, a right edge, a top edge, and a bottom edge of each of the cut products, respectively.

[Claim 3] The cutting apparatus according to claim 1 or 2,
 wherein the first processing unit sets at least a portion of the plurality of
inspection areas by repeatedly shifting positions of the predetermined number of
5 pixels in a second direction and executing the determination processing, and
 the second direction is an oblique direction oblique to the first direction.

[Claim 4] The cutting apparatus according to any one of claims 1 to 3,
 wherein the first direction is a row direction or a column direction.

10

[Claim 5] The cutting apparatus according to claim 3 or 4,
 wherein the first processing unit shifts positions of the predetermined
number of pixels in the second direction by both shifting a position of each of the
predetermined number of pixels by one pixel or a plurality of pixels in a row direction
15 and shifting a position of each of the predetermined number of pixels by one pixel or
a plurality of pixels in a column direction.

[Claim 6] The cutting apparatus according to any one of claims 1 to 5,
 wherein in a case where the first processing unit determined through the
20 determination processing that one portion of a first edge, which is one edge of one of
the plurality of cut products, is included in the predetermined number of pixels, the
first processing unit specifies the first edge by specifying another portion of the first
edge based on at least a portion of the predetermined number of pixels for which the
first processing unit determined that the one portion of the first edge is included.

25

[Claim 7] The cutting apparatus according to claim 6,
 wherein the first processing unit specifies, based on the first edge that was

specified, another three edges of the cut product that includes the first edge, and sets one of the plurality of inspection areas based on the four edges that were specified.

[Claim 8] The cutting apparatus according to claim 7,

5 wherein the first processing unit specifies, based on the first edge that was specified, a second edge opposite to the first edge among the other three edges, and then specifies the two edges other than the first edge and the second edge.

[Claim 9] The cutting apparatus according to any one of claims 1 to 8,

10 wherein, based on an inspection area set first among the plurality of inspection areas, the first processing unit sets another inspection area among the plurality of inspection areas.

[Claim 10] A method for manufacturing a cut product using the cutting
15 apparatus according to any one of claims 1 to 9,

 the cutting apparatus further comprising:

 a cutting table on which the substrate is placeable; and

 a cutting unit configured to cut the substrate placed on the cutting table, and
 the method comprising:

20 placing the substrate on the cutting table;

 manufacturing the plurality of cut products by cutting the substrate placed
on the cutting table;

 generating the captured image by performing image capturing on a portion
or all of the plurality of cut products;

25 setting the plurality of inspection areas in the captured image; and

 performing visual inspection on each of the cut products included in the
captured image based on images respectively included in the plurality of inspection

areas in the captured image.