What is claimed is:

1. A method for recognizing an empty tray, comprising:

receiving an image of a to-be-recognized tray from an image collection module;

determining, for the image, whether a valid empty tray reference image for the image is present in a recognition module;

determining, by using a first method, whether the to-be-recognized tray corresponding to the image is an empty tray based on the image, or based on the image and the valid empty tray reference image for the image, in response to a presence of the valid empty tray reference image for the image; and

determining, by using a second method different from the first method, whether the to-be-recognized tray corresponding to the image is an empty tray based on the image alone, in response to an absence of the valid empty tray reference image for the image, wherein

in a case that the tray is determined to be an empty tray, an image corresponding to the empty tray is determined to be a new valid empty tray reference image; and

the method further comprises:

measuring, by using a distance measurement unit, a distance from the distance measurement unit to a bottom surface of the to-be-recognized tray or to a highest point of an upper surface of an item in the to-be-recognized tray in a vertical direction;

determining the to-be-recognized tray not to be an empty tray in response to the distance being less than a second predetermined threshold; and

determining the to-be-recognized tray to be an empty tray in response to the distance being equal to the second predetermined threshold.

2. The method for recognizing an empty tray according claim 1, wherein the valid empty tray reference image for the image is an empty tray image within a

time period from a time instant, an interval between which and a receiving time of the image is a first predetermined threshold, to the receiving time of the image.

3. The method for recognizing an empty tray according claim 1, further comprising:

initiating an operation of determining whether a valid empty tray reference image for the image is present in the recognition module, when the to-be-recognized tray is determined to be an empty tray in response to the distance being equal to the second predetermined threshold.

4. The method for recognizing an empty tray according claim 1, wherein the determining, by using a first method, whether the to-be-recognized tray corresponding to the image is an empty tray based on the image, or based on the image and the valid empty tray reference image for the image comprises:

calculating a difference value between each pixel in the image and a corresponding pixel in the valid empty tray reference image for the image, and calculating a sum of absolute values of respective difference values or a sum of squares of the respective difference values;

determining the to-be-recognized tray corresponding to the image not to be an empty tray in response to the sum being greater than or equal to a third predetermined threshold; and

determining the to-be-recognized tray corresponding to the image to be an empty tray in response to the sum being less than the third predetermined threshold.

5. The method for recognizing an empty tray according claim 1, wherein the determining, by using a first method, whether the to-be-recognized tray corresponding to the image is an empty tray based on the image, or based on the image and the valid empty tray reference image for the image comprises:

combining a large number of empty tray images obtained at different time instants in pairs, and combining a large number of empty tray images obtained at different time instants and a large number of non-empty tray images obtained at different time instants in pairs, so as to obtain a first sample set and a second sample set;

performing a deep learning method based on the first sample set and the second sample set, so as to obtain a first recognition model; and

determining whether the to-be-recognized tray corresponding to the image is an empty tray using the first recognition model.

6. The method for recognizing an empty tray according claim 1, wherein the determining, by using a second method different from the first method, whether the to-be-recognized tray corresponding to the image is an empty tray based on the image alone comprises:

binarizing the image to obtain a binarized image;

calculating a pixel sum of pixels in the binarized image;

determining the to-be-recognized tray corresponding to the image to be an empty tray in response to the pixel sum being less than a fourth predetermined threshold; and

determining the to-be-recognized tray corresponding to the image not to be an empty tray in response to the pixel sum being greater than or equal to the fourth predetermined threshold.

7. The method for recognizing an empty tray according claim 1, wherein the determining, by using a second method different from the first method, whether the to-be-recognized tray corresponding to the image is an empty tray based on the image alone comprises:

taking a large number of empty tray images obtained at different time instants and a large number of non-empty tray images obtained at different time

instants as a third sample set and a fourth sample set;

performing a deep learning method based on the third sample set and the fourth sample set, so as to obtain a second recognition model; and

determining whether the to-be-recognized tray corresponding to the image is an empty tray using the second recognition model.

8. The method for recognizing an empty tray according claim 1, further comprising:

obtaining a region of interest ROI in the image using a third method; and

determining, by using the first method or the second method, whether the to-be-recognized tray corresponding to the image is an empty tray based on the ROI, or based on both the ROI and the valid empty tray reference image for the image.

9. The method for recognizing an empty tray according claim 8, wherein the third method comprises:

edge detection, adaptive threshold binarization, template matching, image gradient operation, and deep learning.

10. An apparatus for recognizing an empty tray, comprising:

an image collection module configured to collect an image of a to-be-recognized tray; and

a recognition module configured to perform following operations:

receiving the image of the to-be-recognized tray from the image collection module;

determining, for the image, whether a valid empty tray reference image for the image is present in the recognition module;

determining, by using a first method, whether the

to-be-recognized tray corresponding to the image is an empty tray based on the image, or based on the image and the valid empty tray reference image for the image, in response to a presence of the valid empty tray reference image for the image; and

determining, by using a second method different from the first method, whether the to-be-recognized tray corresponding to the image is an empty tray based on the image alone, in response to an absence of the valid empty tray reference image for the image, wherein

in a case that the tray is determined to be an empty tray, an image corresponding to the empty tray is determined to be a new valid empty tray reference image,

wherein the apparatus further comprises a distance measurement unit configured to measure a distance from the distance measurement unit to a bottom surface of the to-be-recognized tray or to a highest point of an upper surface of an item in the to-be-recognized tray in a vertical direction; and

the recognition module is configured to:

determine the to-be-recognized tray not to be an empty tray in response to the distance being less than a second predetermined threshold; and

determine the to-be-recognized tray to be an empty tray in response to the distance being equal to the second predetermined threshold.

11. An electronic device, comprising:

one or more processors; and

a memory configured to store one or more programs, wherein

the one or more programs, when executed by the one or more processors, cause the one or more processors to implement the method according to claim 1.

12. A computer-readable storage medium having executable instructions stored thereon, wherein the instructions, when executed by a processor, cause the processor to implement the method according to claim 1.