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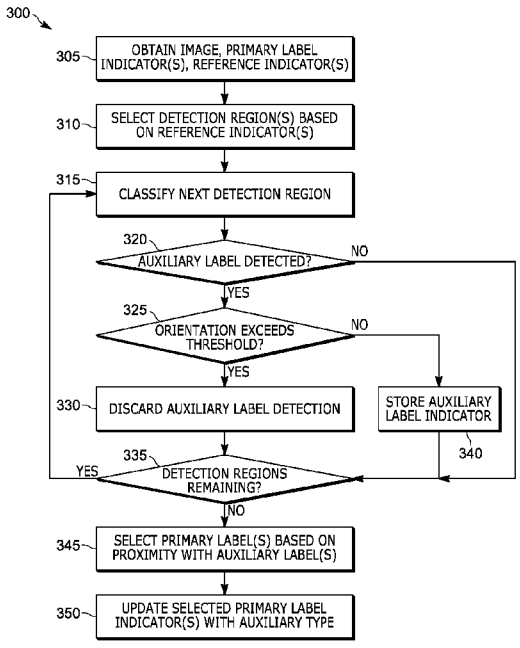


FIG. 3

(57) Abstract: A method of auxiliary label detection includes: at an imaging controller, obtaining (i) an image of a support structure and (ii) a plurality of primary label indicators each defining a position of a primary label within the image; at the imaging controller, selecting a detection region from the image based on a reference indicator; at the imaging controller, detecting an auxiliary label within the detection region based on predefined visual attributes of the auxiliary label; at the imaging controller, selecting one of the primary label indicators based on proximity between the auxiliary label and the selected primary label indicator; updating the selected primary label indicator with an identifier of the auxiliary label; and storing the updated primary label indicator in a memory.

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METHOD, SYSTEM AND APPARATUS FOR AUXILIARY LABEL DETECTION AND ASSOCIATION

BACKGROUND

[0001] Environments in which inventories of objects are managed, such as products for purchase in a retail environment, may be complex and fluid. For example, a given environment may contain a wide variety of objects with different attributes (size, shape, price and the like). Further, the placement and quantity of the objects in the environment may change frequently. Still further, imaging conditions such as lighting may be variable both over time and at different locations in the environment. These factors may reduce the accuracy with which information concerning the objects may be collected within the environment.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0002] The accompanying figures, where like reference numerals refer to identical or functionally similar elements throughout the separate views, together with the detailed description below, are incorporated in and form part of the specification, and serve to further illustrate embodiments of concepts that include the claimed invention, and explain various principles and advantages of those embodiments.

[0003] FIG. 1 is a schematic of a mobile automation system.

[0004] FIG. 2A depicts a mobile automation apparatus in the system of FIG. 1.

[0005] FIG. 2B is a block diagram of certain internal hardware components of the mobile automation apparatus in the system of FIG. 1.

[0006] FIG. 3 is a flowchart of a method for detecting auxiliary labels.

[0007] FIG. 4A is a diagram illustrating an example image obtained at block 305 of the method of FIG. 3.

[0008] FIG. 4B is a diagram illustrating primary label indicators obtained along with the image of FIG. 4A.

[0009] FIG. 5 is a flowchart of a method for selecting detection regions at block 310 of the method of FIG. 3.

[0010] FIGS. 6A-6C are diagrams illustrating the performance of the method of FIG. 5.

[0011] FIG. 7 is a flowchart of another method for selecting detection regions at block 310 of the method of FIG. 3.

[0012] FIG. 7B is a diagram illustrating the performance of the method of FIG. 7.

[0013] FIGS. 8A-8B are diagrams illustrating the performance of block 315 of the method of FIG. 3.

[0014] FIG. 9 is a flowchart of a method for performing blocks 345-350 of the method of FIG. 3.

[0015] FIGS. 10A-10B are diagram illustrating the use of landmarks in the performance of the method of FIG. 9.

[0016] FIG. 11 is a diagram illustrating updated primary label indicators following the performance of the method of FIG. 3.

[0017] Skilled artisans will appreciate that elements in the figures are illustrated for simplicity and clarity and have not necessarily been drawn to scale. For example, the dimensions of some of the elements in the figures may be exaggerated relative to other elements to help to improve understanding of embodiments of the present invention.

[0018] The apparatus and method components have been represented where appropriate by conventional symbols in the drawings, showing only those specific details that are pertinent to understanding the embodiments of the present invention so as not to obscure the disclosure with details that will be readily apparent to those of ordinary skill in the art having the benefit of the description herein.

DETAILED DESCRIPTION

[0019] Examples disclosed herein are directed to a method of auxiliary label detection, comprising: at an imaging controller, obtaining (i) an image of a support structure and (ii) a plurality of primary label indicators each defining a position of a primary label within the image; at the imaging controller, selecting a detection region from the image

based on a reference indicator; at the imaging controller, detecting an auxiliary label within the detection region based on predefined visual attributes of the auxiliary label; at the imaging controller, selecting one of the primary label indicators based on proximity between the auxiliary label and the selected primary label indicator; updating the selected primary label indicator with an identifier of the auxiliary label; and storing the updated primary label indicator in a memory.

[0020] Additional examples disclosed herein are directed to a computing device for auxiliary label detection, the computing device comprising: a memory storing (i) an image of a support structure and (ii) a plurality of primary label indicators each defining a position of a primary label within the image; an imaging controller connected to the memory, the imaging controller configured to obtain the image of the support structure and the plurality of primary label indicators; the imaging controller further configured to select a detection region from the image based on a reference indicator; the imaging controller further configured to detect an auxiliary label within the detection region based on predefined visual attributes of the auxiliary label; the imaging controller further configured to select one of the primary label indicators based on proximity between the auxiliary label and the selected primary label indicator; the imaging controller further configured to update the selected primary label indicator with an identifier of the auxiliary label; and the imaging controller further configured to store the updated primary label indicator in the memory.

[0021] Further examples disclosed herein are directed to a non-transitory computer-readable medium storing a plurality of computer-readable instructions executable by an imaging controller, wherein execution of the instructions causes the imaging controller to: obtain (i) an image of a support structure and (ii) a plurality of primary label indicators each defining a position of a primary label within the image; select a detection region from the image based on a reference indicator; detect an auxiliary label within the detection region based on predefined visual attributes of the auxiliary label; select one of the primary label indicators based on proximity between the auxiliary label and the selected primary label indicator; update the selected primary label indicator with an identifier of the auxiliary label; and store the updated primary label indicator in a memory.

[0022] FIG. 1 depicts a mobile automation system 100 in accordance with the teachings of this disclosure. The system 100 is illustrated as being deployed in a retail environment, but in other embodiments can be deployed in a variety of other environments, including warehouses, hospitals, and the like. The system 100 includes a server 101 in communication with at least one mobile automation apparatus 103 (also referred to herein simply as the apparatus 103) and at least one client computing device 105 via communication links 107, illustrated in the present example as including wireless links. In the present example, the links 107 are provided by a wireless local area network (WLAN) deployed within the retail environment by one or more access points (not shown). In other examples, the server 101, the client device 105, or both, are located outside the retail environment, and the links 107 therefore include wide-area networks such as the Internet, mobile networks, and the like. The system 100 also includes a dock 108 for the apparatus 103 in the present example. The dock 108 is in communication with the server 101 via a link 109 that in the present example is a wired link. In other examples, however, the link 109 is a wireless link.

[0023] The client computing device 105 is illustrated in FIG. 1 as a mobile computing device, such as a tablet, smart phone or the like. In other examples, the client device 105 is implemented as another type of computing device, such as a desktop computer, a laptop computer, another server, a kiosk, a monitor, and the like. The system 100 can include a plurality of client devices 105 in communication with the server 101 via respective links 107.

[0024] The system 100 is deployed, in the illustrated example, in a retail environment including a plurality of support structures such as shelf modules 110-1, 110-2, 110-3 and so on (collectively referred to as shelves 110, and generically referred to as a shelf 110 – this nomenclature is also employed for other elements discussed herein). In other examples, additional types of support structures may also be present, such as pegboards. Each shelf module 110 supports a plurality of products 112, as well as labels and related objects, as will be discussed in greater detail below. Each shelf module 110 includes a shelf back 116-1, 116-2, 116-3 and a support surface (e.g. support surface 117-3 as illustrated in FIG. 1) extending from the shelf back 116 to a shelf edge 118-1, 118-2, 118-3.

[0025] The shelf modules 110 are typically arranged in a plurality of aisles, each of which includes a plurality of modules 110 aligned end-to-end. In such arrangements, the shelf edges 118 face into the aisles, through which customers in the retail environment as well as the apparatus 103 may travel. As will be apparent from FIG. 1, the term "shelf edge" 118 as employed herein, which may also be referred to as the edge of a support surface (e.g., the support surfaces 117) refers to a surface bounded by adjacent surfaces having different angles of inclination. In the example illustrated in FIG. 1, the shelf edge 118-3 is at an angle of about ninety degrees relative to each of the support surface 117-3 and the underside (not shown) of the support surface 117-3. In other examples, the angles between the shelf edge 118-3 and the adjacent surfaces, such as the support surface 117-3, is more or less than ninety degrees. The shelf edges 118 define a front of the shelves 110, separated from the shelf backs 116 by a shelf depth. A common frame of reference 102 is illustrated in FIG. 1. In the present example, the shelf depth is defined in the Y dimension of the frame of reference 102, while the shelf backs 116 and shelf edges 118 are shown as being parallel to the XZ plane.

[0026] The apparatus 103 is deployed within the retail environment, and communicates with the server 101 (e.g. via the link 107) to navigate, autonomously or partially autonomously, along a length 119 (illustrated in FIG. 1 as being parallel to the X axis of the frame of reference 102) of at least a portion of the shelves 110. The apparatus 103, autonomously or in conjunction with the server 101, is configured to continuously determine its location within the environment, for example with respect to a map of the environment. The apparatus 103 may also be configured to update the map (e.g. via a simultaneous mapping and localization, or SLAM, process).

[0027] The apparatus 103 is equipped with a plurality of navigation and data capture sensors 104, such as image sensors (e.g. one or more digital cameras) and depth sensors (e.g. one or more Light Detection and Ranging (LIDAR) sensors, one or more depth cameras employing structured light patterns, such as infrared light, or the like). The apparatus 103 can be configured to employ the sensors 104 to both navigate among the shelves 110 (e.g. according to the paths mentioned above) and to capture shelf data, such as point cloud and/or image data, during such navigation.

[0028] The server 101 includes a special purpose imaging controller, such as a processor 120, specifically designed to obtain data captured by the apparatus 103 via a communications interface 124 for storage in a repository 132, and to perform subsequent processing of the captured data. Such processing includes, as will be discussed herein, the detection of labels and auxiliary labels disposed on the shelves 110. Other examples of processing performed by the processor 120 include the detection of objects such as shelved products in the captured data as well as status information corresponding to the objects. The processor 120 can also be configured to control and/or assist the mobile automation apparatus 103 to navigate the environment and to capture the above-mentioned data.

[0029] The server 101 may also be configured to transmit status notifications (e.g. notifications indicating that products are out-of-stock, low stock or misplaced) to the client device 105 responsive to the determination of product status data. The client device 105 includes one or more controllers (e.g. central processing units (CPUs) and/or field-programmable gate arrays (FPGAs) and the like) configured to process (e.g. to display) notifications received from the server 101.

[0030] The processor 120 is interconnected with a non-transitory computer readable storage medium, such as a memory 122 containing the above-mentioned repository 132, having stored thereon computer readable instructions for performing various functionality, including control of the apparatus 103 to capture shelf data, post-processing of the shelf data, and generating and providing certain navigational data to the apparatus 103, such as target locations at which to capture shelf data. The memory 122 includes a combination of volatile (e.g. Random Access Memory or RAM) and non-volatile memory (e.g. read only memory or ROM, Electrically Erasable Programmable Read Only Memory or EEPROM, flash memory). The processor 120 and the memory 122 each comprise one or more integrated circuits. In some embodiments, the processor 120 is implemented as one or more central processing units (CPUs) and/or graphics processing units (GPUs).

[0031] The server 101 also includes the above-mentioned communications interface 124 interconnected with the processor 120. The communications interface 124 includes suitable hardware (e.g. transmitters, receivers, network interface controllers and the

like) allowing the server 101 to communicate with other computing devices – particularly the apparatus 103, the client device 105 and the dock 108 – via the links 107 and 109. The links 107 and 109 may be direct links, or links that traverse one or more networks, including both local and wide-area networks. The specific components of the communications interface 124 are selected based on the type of network or other links that the server 101 is required to communicate over. In the present example, as noted earlier, a wireless local-area network is implemented within the retail environment via the deployment of one or more wireless access points. The links 107 therefore include either or both wireless links between the apparatus 103 and the mobile device 105 and the above-mentioned access points, and a wired link (e.g. an Ethernet-based link) between the server 101 and the access point.

[0032] The memory 122 stores a plurality of applications, each including a plurality of computer readable instructions executable by the processor 120. The execution of the above-mentioned instructions by the processor 120 configures the server 101 to perform various actions discussed herein. The applications stored in the memory 122 include an auxiliary label detection application 128, which may also be implemented as a suite of logically distinct applications. In general, via execution of the application 128 or subcomponents thereof and in conjunction with the other components of the server 101, the processor 120 is configured to implement various functionality related to obtaining captured data depicting the shelves 110 and performing various post-processing operations on the captured data to detect label objects therein.

[0033] The processor 120, as configured via the execution of the application 128, is also referred to herein as the above-mentioned imaging controller 120. As will now be apparent, some or all of the functionality implemented by the imaging controller 120 described below may also be performed by preconfigured special purpose hardware controllers (e.g. one or more logic circuit arrangements specifically configured to optimize the speed of image processing, for example via FPGAs and/or Application-Specific Integrated Circuits (ASICs) configured for this purpose) rather than by execution of the control application 128 by the processor 120.

[0034] Turning now to FIGS. 2A and 2B, the mobile automation apparatus 103 is shown in greater detail. The apparatus 103 includes a chassis 201 containing a

locomotive mechanism 203 (e.g. one or more electrical motors driving wheels, tracks or the like). The apparatus 103 further includes a sensor mast 205 supported on the chassis 201 and, in the present example, extending upwards (e.g., substantially vertically) from the chassis 201. The mast 205 supports the sensors 104 mentioned earlier. In particular, the sensors 104 include at least one imaging sensor 207, such as a digital camera, as well as at least one depth sensor 209, such as a 3D digital camera. The apparatus 103 also includes additional depth sensors, such as LIDAR sensors 211. In other examples, the apparatus 103 includes additional sensors, such as one or more RFID readers, temperature sensors, and the like.

[0035] In the present example, the mast 205 supports seven digital cameras 207-1 through 207-7, and two LIDAR sensors 211-1 and 211-2. The mast 205 also supports a plurality of illumination assemblies 213, configured to illuminate the fields of view of the respective cameras 207. That is, the illumination assembly 213-1 illuminates the field of view of the camera 207-1, and so on. The sensors 207 and 211 are oriented on the mast 205 such that the fields of view of each sensor face a shelf 110 along the length 119 of which the apparatus 103 is travelling. The apparatus 103 is configured to track a location of the apparatus 103 (e.g. a location of the center of the chassis 201) in the common frame of reference 102 previously established in the retail facility, permitting data captured by the mobile automation apparatus 103 to be registered to the common frame of reference.

[0036] The mobile automation apparatus 103 includes a special-purpose controller, such as a processor 220, as shown in FIG. 2B, interconnected with a non-transitory computer readable storage medium, such as a memory 222. The memory 222 includes a combination of volatile (e.g. Random Access Memory or RAM) and non-volatile memory (e.g. read only memory or ROM, Electrically Erasable Programmable Read Only Memory or EEPROM, flash memory). The processor 220 and the memory 222 each comprise one or more integrated circuits. The memory 222 stores computer readable instructions for execution by the processor 220. In particular, the memory 222 stores a control application 228 which, when executed by the processor 220, configures the processor 220 to perform various functions related to the navigation of the apparatus 103 and capture of data for subsequent processing, e.g. by the server 101. In some embodiments, such subsequent processing can be performed by the apparatus 103 itself

via execution of the application 228. The application 228 may also be implemented as a suite of distinct applications in other examples.

[0037] The processor 220, when so configured by the execution of the application 228, may also be referred to as an imaging controller 220. Those skilled in the art will appreciate that the functionality implemented by the processor 220 via the execution of the application 228 may also be implemented by one or more specially designed hardware and firmware components, including logic circuit configurations optimized for image and/or depth sensor data processing, such as via specifically configured FPGAs, ASICs and the like in other embodiments.

[0038] The memory 222 may also store a repository 232 containing, for example, one or more maps representing the environment in which the apparatus 103 operates, for use during the execution of the application 228. The apparatus 103 may communicate with the server 101, for example to receive instructions to navigate to specified locations and initiate data capture operations, via a communications interface 224 over the link 107 shown in FIG. 1. The communications interface 224 also enables the apparatus 103 to communicate with the server 101 via the dock 108 and the link 109.

[0039] As will be apparent in the discussion below, other examples, some or all of the processing performed by the server 101 may be performed by the apparatus 103, and some or all of the processing performed by the apparatus 103 may be performed by the server 101. That is, although in the illustrated example the application 128 resides in the server 101, in other embodiments some or all of the actions described below to determine the shelf depth of the shelves 110 from captured data may be performed by the processor 220 of the apparatus 103, either in conjunction with or independently from the processor 120 of the server 101. As those of skill in the art will realize, distribution of such computations between the server 101 and the mobile automation apparatus 103 may depend upon respective processing speeds of the processors 120 and 220, the quality and bandwidth of the link 107, as well as criticality level of the underlying instruction(s).

[0040] The functionality of the application 128 will now be described in greater detail. In particular, the support structure depth determination mentioned above will be described as performed by the server 101. Turning to FIG. 3, a method 300 of detecting

auxiliary labels is shown. The method 300 will be described in conjunction with its performance by the server 101, with reference to the components illustrated in FIG. 1.

[0041] At block 305, the server 101 is configured to obtain an image of a support structure, such as one or more shelf modules 110 as illustrated in FIG. 1. The image obtained at block 305 may be obtained by retrieval from the repository 132. For example, the image may have been previously provided to the server 101 for storage in the repository 132 by the apparatus 103.

[0042] The server 101 is also configured, at block 305, to obtain a plurality of primary label indicators and a plurality of reference indicators. As will be understood by those skilled in the art, retail environments such as that depicted in FIG. 1 typically include a plurality of labels disposed on the shelves 110 (e.g. on the shelf edges 118). Each label may contain, for example, a barcode or other machine-readable indicium encoding an identifier of a product 112. Each label may also contain other information, such as a price of the corresponding product 112, a name of the corresponding product 112, or the like. Primary label indicators obtained at block 305 indicate at least a position of a corresponding primary label within the image. The position can take the form, for example, of a bounding box defined by image coordinates for the corners of the bounding box.

[0043] The primary label indicators can also include data extracted from the image, such as data decoded from a barcode of the primary label, a price string extracted (e.g. via optical character recognition, OCR) from the image of the label, and the like. The primary label indicators can also include, in some examples, bounding boxes for components of the primary label. For example, a primary label indicator can include a first bounding box for the label, as well as a second bounding box within the first bounding box and indicating a position of a barcode on the label.

[0044] Turning to FIG. 4A, an example image 400 of a portion of a shelf module 110 is shown. The image 400 depicts a shelf edge 118 of a shelf supporting products 112-1 and 112-2. Additional products, including a third product 112-3, are also partially depicted in the image 400. The shelf edge 118 also supports a plurality of primary labels 404-1, 404-2 and 404-3. As seen in FIG. 4A, each primary label 404 contains a barcode

(e.g. encoding a universal product code (UPC), or other product identifier) as well as a price string.

[0045] Also shown in the image 400 are auxiliary labels 408-1 and 408-2. As will be apparent from FIG. 4A, the auxiliary labels do not contain product-specific information. Instead, the auxiliary labels contain promotion or other identifiers that can be applied to any product 112. That is, the primary labels correspond to specific products 112, while the auxiliary labels 408 do not correspond to any particular product 112, but instead are associated with certain products 112 by physical placement adjacent to primary labels 404. As shown in FIG. 4A, the auxiliary labels 408 can take various physical forms. The auxiliary label 408-1, for instance, is displayed on a common piece of label media with the label 404-1, while the auxiliary label 408-2 includes a separate piece of label media affixed to the shelf edge 118 adjacent to the label 404-3. Further, as illustrated in FIG. 4A, the placement of the auxiliary label 408-2 is such that it obstructs the price presented on the label 404-3.

[0046] FIG. 4B is a graphical presentation of the above-mentioned primary label indicators. In particular, three primary label indicators 412-1, 412-2 and 412-3 are illustrated, corresponding to the primary labels 404-1, 404-2 and 404-3 respectively. The primary label indicators 412 include both definitions of the bounding boxes shown in FIG. 4B, as well as data extracted from the image 400, such as the decoded UPC from barcodes and the price strings mentioned earlier. It will be understood that the primary label indicators need not be stored or obtained at block 305 in graphical form. For example, rather than storing bounding boxes in graphical form as shown in FIG. 4B, the primary label indicators can include corner coordinates of the bounding boxes.

[0047] Also illustrated in FIG. 4B is a reference indicator obtained at block 305. The reference indicator, as will be discussed herein, is employed by the server 101 to selection detection regions of the image 400 in which to search for auxiliary labels. The reference indicator, in the present example, is a shelf edge indicator 416 defining a bounding box corresponding to the location in the image 400 of the shelf edge 118. Detection of primary labels 404 and shelf edges 118 is performed prior to the performance of the method 300, for example by the server 101 or another suitable computing device. In other examples, as will be discussed below in greater detail, the

reference indicator(s) obtained at block 305 is the primary label indicators 412 themselves (i.e. a separate reference indicator need not be obtained at block 305). In further examples, both the primary label indicators 412 and the shelf edge indicator 416 can be employed as reference indicators.

[0048] Returning to FIG. 3, at block 310 the server 101 is configured to select one or more detection regions of the image 400 based on the reference indicator obtained at block 305. The detection regions selected at block 310 are portions of the image 400, in which the server 101 is configured to subsequently search for auxiliary labels based on known visual attributes of the auxiliary labels. The detection regions are selected at block 310 according to previously established spatial relationships between the auxiliary labels 408 and the reference indicator 416. In the present example, as seen in FIG. 4A, the auxiliary labels 408 are disposed on or below the shelf edge 118. The server 101 is therefore configured, at block 310, to identify regions of the image 400 in which to search for auxiliary labels 408 according to the position of the shelf edge 118 (as defined by the shelf edge indicator 416). Turning to FIG. 5, a method 500 of performing block 310 of the method 300 is illustrated, employing as reference indicator the shelf edge indicator 416.

[0049] At block 505, the server 101 is configured to extract an initial region of the image 400 based on the shelf edge indicator 416. FIG. 6A illustrates an initial region 600 of the image extracted at block 505, based on the knowledge that the auxiliary labels 408 are placed on or below the shelf edge 118. Returning to FIG. 5, at block 510 the server 101 is configured to convert the extracted initial region to a binary image (i.e. black and white) via a suitable thresholding operation, such as Otsu thresholding. The server 101 is further configured to apply one or more morphological operations, such as a closing operation (consisting of a dilation operation followed by an erosion operation). As seen in FIG. 6B, following the performance of block 510, an updated extracted region 604 is generated, in which the labels 404, auxiliary labels 408 and products 112 are represented by foreground blocks 608-1, 608-2, 608-3 and 608-4, while the remainder of the extracted initial region 600 is background.

[0050] At block 515, the server 101 is configured to perform a blob extraction operation, also referred to as a connected components analysis, to identify the

boundaries of the blocks 608. The blob extraction may be based on, for example, identifying edges in the updated extracted region 604. At block 520, the server 101 is configured to select detection regions corresponding to each blob (i.e. component) identified at block 515. The detection regions can correspond directly to the boundaries of the blobs. In other examples, as shown in FIG. 6C, the detection regions are selected as rectangular regions 612-1, 612-2, 612-3 and 612-4 encompassing the blobs detected at block 515.

[0051] Turning to FIG. 7A, in another embodiment the reference indicators obtained at block 305 are the primary label indicators 412 themselves. The performance of block 310 is therefore implemented as a method including a single step 700, at which the server 101 is configured to select detection regions based on each primary label indicator 412 and predefined spatial relationships between the primary label indicators 412 and the auxiliary labels. In the present example, as shown in FIG. 7B, a detection region 704 is selected for each primary label indicator 412, containing a region of the image 400 encompassing the primary label indicator 412 itself as well as a predefined region below the primary label indicator 412. Thus, three detection regions 704-1, 704-2 and 704-3 are selected via performance of the method 700.

[0052] Returning to FIG. 3, following the selection of detection regions at block 310, a classification operation is applied to each detection region to detect any auxiliary labels in the detection region. Specifically, at block 315 the server 101 is configured to select one of the detection regions and apply the above-mentioned classification operation to the detection region. Any of a variety of suitable classification operations can be employed by the server 101 at block 315. In the present example, the classification operation is based on the bag of visual words (BOVW) model. In particular, the server 101 is configured to identify a plurality of features in each of a set of training images, and to generate feature descriptors for each image. For example, the server 101 may be configured to apply the Oriented FAST and Rotated BRIEF (ORB) feature descriptor algorithm. The ORB algorithm includes the identification, in each of a plurality of training images of auxiliary labels, feature points such as corners. The algorithm further includes the generation of a binary feature vector corresponding to each feature point. Thus, each training image is described by a descriptor containing the binary feature vectors of each feature point. The server 101 is then configured to

generate classification parameters according to a suitable machine learning algorithm, such as k-means clustering, based on the image descriptors.

[0053] Turning to FIG. 8A, example training images 800 and 804 of certain features of the auxiliary labels 412 are shown, from which the above-mentioned classification parameters are generated (typically, multiple training images for each type of auxiliary label are employed). In an example performance of block 315, the server 101 is configured to apply the above-mentioned classification parameters to the detection region 612-2. FIG. 8A illustrates the detection regions overlaid on the extracted portion 600 of the image 400. At block 320, the server 101 is configured to determine whether any auxiliary labels were detected in the current detection region.

[0054] As seen in FIG. 8B, classification of the detection region 612-2 results in a detection of an auxiliary label indicator 808-2. The classification generated at block 315 specifies the type of the auxiliary label (i.e. "Clearance" or "New", although any of a variety of other type names may be applied to the auxiliary labels), as well as a transformation matrix (also referred to as a homography matrix) indicating the position of the detected auxiliary label relative to a reference auxiliary label (e.g. the images 800 and 804 shown in FIG. 8A). As seen in FIG. 8B, the auxiliary label indicator 808-2 is oriented at an angle of 90 degrees relative to the reference image 800.

[0055] Returning to FIG. 3, the determination at block 320 is therefore affirmative and the server 101 is configured to determine, at block 325, whether the orientation of the detected auxiliary label exceeds a predefined threshold. The threshold is set based on expected physical orientations of the auxiliary labels 412 on the shelves 110, and may permit the server 101 to discard false positive classifications arising from block 315. For example, the threshold may be set at about 30 degrees, indicating that any detected auxiliary label having an orientation of more than 30 degrees relative to the reference image 800 or 804 is likely to be a false positive detection rather than an actual auxiliary label 412. Thus, in the present example (in which the auxiliary label indicator 808-2 is at an orientation of ninety degrees) the determination at block 325 is affirmative, and the auxiliary label indicator 808-2 is discarded at block 330. In other embodiments, at block 325 the server 101 is configured to validate the detected auxiliary label by determining whether the detected auxiliary label indicates the presence of a primary

label satisfying one or more structural conditions. That is, the server 101 is configured to determine the expected position and orientation of a primary label in the captured image based on a known spatial relationship between auxiliary labels and primary labels. When the expected position and orientation of the primary label does not satisfy the above-mentioned conditions, the detection at block 320 may have been erroneous, and can be discarded.

[0056] In such embodiments, the server 101 is configured to determine, based on the detected auxiliary label, the position and orientation of a corresponding primary label. For example, the server 101 can be configured to identify a plurality of predefined landmark points in the detected auxiliary label. The server 101 stores predefined spatial relationships between the landmarks and a reference image of a primary label (e.g. a distance and direction from each landmark to the corners of the reference primary label). Thus, by detecting the landmarks, the server 101 can be configured to determine a transformation between the reference primary label and the primary label as depicted in the image (i.e. a homography between the reference primary label and the captured image). The detection of landmarks and determination of expected position of the primary label is discussed in further detail in connection with FIG. 9.

[0057] Having determined an expected position and orientation of the primary label from the detected auxiliary label, the server 101 is configured to determine whether the expected position and orientation of the primary label satisfies one or more structural conditions. For example, when the reference primary label is a rectangle, the server 101 can be configured to identify each corner of the expected primary label position, and to determine the internal angles of the corners. If any of the internal angles are below a threshold (e.g. 70 degrees), the server 101 determines at block 325 that the detected auxiliary label is a false positive detection, and proceeds to block 330. Other examples of structural conditions evaluated at block 325 in such embodiments include an aspect ratio condition, in which the server 101 determines the aspect ratio of dimensions of the expected primary label, and determines whether the aspect ratio is within a predefined range of a reference aspect ratio for the primary label.

[0058] Following block 330, the server 101 is configured to determine, at block 335, whether any detection regions remain to be processed. In the present example, the

determination at block 335 is affirmative, and therefore at block 315 the next detection region (e.g. the region 612-4) is selected. As will be apparent from FIG. 8A, the detection region 612-4 does not contain any auxiliary labels, and the determination at block 320 is therefore negative. A further performance of block 315, for the detection region 612-1, leads to the detection of the auxiliary label 408-1 (more specifically, the auxiliary label indicator 808-1 shown in FIG. 8B). The orientation of the auxiliary label indicator 808-1 is equal to that of the reference image 800, and the determination at block 325 is therefore negative. At block 340, therefore, the auxiliary label indicator 808-1 is stored in the memory 122 for further processing. A final performance of blocks 315, 320, 325 and 340 leads to the detection and storage of an auxiliary label indicator 808-3, shown in FIG. 8B. Following a negative determination at block 335, performance of the method 300 proceeds to block 345.

[0059] At block 345, the server 101 is configured to select, for each auxiliary label indicator 808 stored at block 340, one of the primary label indicators 412 to associate with the auxiliary label indicator 808. The selection at block 345 is based on proximity between the current auxiliary label indicator 808 and the primary label indicators 412. For example, the server 101 can be configured to determine the center of each auxiliary label indicator 808, and select the primary label indicator 412 having the closest center to that of the auxiliary label indicator 808. At block 350, the server 101 is configured to update the selected primary label indicator 412 to include the type (i.e. class) of the associated auxiliary label indicator. The above process is repeated for each auxiliary label indicator stored at block 340. The updated primary label indicators 412 are stored in the memory 122 (e.g. in the repository 132), for example for transmission to another computing device (e.g. to the client device 105 for display), use in further processing of the data captured by the apparatus 103, or the like.

[0060] In some examples, the server 101 is configured to perform blocks 345 and 350 by using additional data stored in conjunction with the reference images 800 and 804 employed to identify the auxiliary label indicators 808. Turning to FIG. 9, a method 900 of associating primary and auxiliary label indicators and updating the primary label indicators accordingly is shown (i.e. a method of performing blocks 345 and 350).

[0061] At block 905, the server 101 is configured to retrieve, from the memory 122, landmarks associated with each auxiliary label indicator 808. The landmarks are predefined points within the reference images 800 and 804. Turning to FIG. 10A, example landmarks 1000-1, 1000-2, 1000-3 and 1000-4 are shown in association with the reference image 800. The landmarks 1000 are defined in the memory 122 by their coordinates within the reference image 800, relative to a frame of reference 1004. The memory 122 also stores relative positions 1008 (e.g. in the form of distances according to the frame of reference 1004) of each landmark 1000 to a corner of an expected primary label indicator position 1012. The expected position 1012, in the illustrated embodiment, is the expected position of a barcode of a primary label 404 relative to the auxiliary label 408. In other examples, the expected position 1012 can be the position of the entire label 404, or of another component of the label 404 (e.g. a price string).

[0062] Returning to FIG. 9, at block 910 the server 101 is configured to determine the equivalent positions of the landmarks 1000 in the image 400, based on the transformation matrix obtained at block 315. In other words, the positions of the landmarks 1000 in an image frame of reference 1016, as shown in FIG. 10B are determined at block 910.

[0063] At block 915, the server 101 is configured to determine, based on the landmarks as positioned in the image 400 and on the expected positions 1008, an expected position for a primary label indicator 412. At block 920, the server 101 is configured to determine whether a primary label indicator 412 is located at the expected position. The server 101 may be configured to apply a predefined tolerance to the determination at block 920, permitting a degree of flexibility in the placement of primary labels 404 relative to auxiliary labels 408. In the present example, as shown in FIG. 10B, an expected position 1020 for the auxiliary label indicator 808-1 matches the location of the barcode of the primary label 404-1. The determination at block 920 is therefore affirmative. The expected position 1024 for the auxiliary label indicator 808-2, however, does not match the position of the barcode on the primary label 404-3. It is assumed, in the present example, that the difference in position between the expected position 1024 and the actual barcode position is within the above-noted tolerance, and the determination at block 920 is therefore also affirmative.

[0064] Referring again to FIG. 9, following an affirmative determination at block 920, at block 925 the server 101 is configured to select the primary label identified at block 920. Thus, for the auxiliary label indicator 808-1 the primary label indicator 412-1 is selected, and for the auxiliary label indicator 808-2 the primary label indicator 412-3 is selected. At block 930, the server 101 is configured to determine, for each selected primary label indicator 412, whether the selected primary label indicator 412 is complete. Specifically, the server 101 is configured to determine whether each of a predefined set of expected attributes of the primary label indicator 412 is present for the primary label indicator 412. Referring to FIG. 4B, for example, the price attribute for the primary label indicator 412-3 is null, as the server 101 was unable to detect a price string for the primary label 404-1. The determination at block 930 is therefore negative, and at block 935 the server 101 is configured to update the primary label indicator 412-3 with the type of the auxiliary label indicator 808-2 (e.g. "New"), as well as an obstruction status indicator. The obstruction status indicator indicates that the primary label 404-3 is present but may be obstructed (in the illustrated case, by the auxiliary label 408-2 itself).

[0065] For the primary label indicator 412-1, on the other hand, the determination at block 930 is affirmative, and at block 935 the server 101 is configured to update the primary label indicator 412-1 with the type of the auxiliary label indicator 808-1 (e.g. "Clearance") at block 940. FIG. 11 illustrates the updated primary label indicators 412. In particular, the primary label indicators 412-1 and 412-3 appear as updated indicators 412-1' and 412-3', and each contain an auxiliary label type or class, as well as an obstruction indicator (in the case of the primary label indicator 412-3').

[0066] Returning to FIG. 9, when the determination at block 920 is negative (i.e. when no primary label indicator is at the expected position defined by the relative positions 1008), the server 101 can be configured at block 945 to generate a new primary label indicator, indicating the presence of a missing primary label at the expected location. The newly generated primary label indicator can also include the type of the associated auxiliary label indicator 808.

[0067] In the foregoing specification, specific embodiments have been described. However, one of ordinary skill in the art appreciates that various modifications and

changes can be made without departing from the scope of the invention as set forth in the claims below. Accordingly, the specification and figures are to be regarded in an illustrative rather than a restrictive sense, and all such modifications are intended to be included within the scope of present teachings.

[0068] The benefits, advantages, solutions to problems, and any element(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential features or elements of any or all the claims. The invention is defined solely by the appended claims including any amendments made during the pendency of this application and all equivalents of those claims as issued.

[0069] Moreover in this document, relational terms such as first and second, top and bottom, and the like may be used solely to distinguish one entity or action from another entity or action without necessarily requiring or implying any actual such relationship or order between such entities or actions. The terms "comprises," "comprising," “has”, “having,” “includes”, “including,” “contains”, “containing” or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that comprises, has, includes, contains a list of elements does not include only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus. An element proceeded by “comprises …a”, “has …a”, “includes …a”, “contains …a” does not, without more constraints, preclude the existence of additional identical elements in the process, method, article, or apparatus that comprises, has, includes, contains the element. The terms “a” and “an” are defined as one or more unless explicitly stated otherwise herein. The terms “substantially”, “essentially”, “approximately”, “about” or any other version thereof, are defined as being close to as understood by one of ordinary skill in the art, and in one non-limiting embodiment the term is defined to be within 10%, in another embodiment within 5%, in another embodiment within 1% and in another embodiment within 0.5%. The term “coupled” as used herein is defined as connected, although not necessarily directly and not necessarily mechanically. A device or structure that is “configured” in a certain way is configured in at least that way, but may also be configured in ways that are not listed.

[0070] It will be appreciated that some embodiments may be comprised of one or more specialized processors (or "processing devices") such as microprocessors, digital signal processors, customized processors and field programmable gate arrays (FPGAs) and unique stored program instructions (including both software and firmware) that control the one or more processors to implement, in conjunction with certain non-processor circuits, some, most, or all of the functions of the method and/or apparatus described herein. Alternatively, some or all functions could be implemented by a state machine that has no stored program instructions, or in one or more application specific integrated circuits (ASICs), in which each function or some combinations of certain of the functions are implemented as custom logic. Of course, a combination of the two approaches could be used.

[0071] Moreover, an embodiment can be implemented as a computer-readable storage medium having computer readable code stored thereon for programming a computer (e.g., comprising a processor) to perform a method as described and claimed herein. Examples of such computer-readable storage mediums include, but are not limited to, a hard disk, a CD-ROM, an optical storage device, a magnetic storage device, a ROM (Read Only Memory), a PROM (Programmable Read Only Memory), an EPROM (Erasable Programmable Read Only Memory), an EEPROM (Electrically Erasable Programmable Read Only Memory) and a Flash memory. Further, it is expected that one of ordinary skill, notwithstanding possibly significant effort and many design choices motivated by, for example, available time, current technology, and economic considerations, when guided by the concepts and principles disclosed herein will be readily capable of generating such software instructions and programs and ICs with minimal experimentation.

[0072] The Abstract of the Disclosure is provided to allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, it can be seen that various features are grouped together in various embodiments for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed embodiments require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than

all features of a single disclosed embodiment. Thus the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separately claimed subject matter.

Claims

1. A method of auxiliary label detection, comprising:

at an imaging controller, obtaining (i) an image of a support structure and (ii) a plurality of primary label indicators each defining a position of a primary label within the image;

at the imaging controller, selecting a detection region from the image based on a reference indicator;

at the imaging controller, detecting an auxiliary label within the detection region based on predefined visual attributes of the auxiliary label;

at the imaging controller, selecting one of the primary label indicators based on proximity between the auxiliary label and the selected primary label indicator;

updating the selected primary label indicator with an identifier of the auxiliary label; and

storing the updated primary label indicator in a memory.

2. The method of claim 1, wherein the reference indicator is the primary label indicator.

3. The method of claim 1, further comprising:

obtaining a support structure edge indicator defining a position of the support structure edge within the image;

wherein the support structure edge indicator is the reference indicator.

4. The method of claim 3, wherein selecting the detection region further comprises:

extracting an initial region of the image based on the support structure edge indicator;

identifying a blob in the extracted initial region; and

selecting the detection region corresponding to the blob.

5. The method of claim 1, wherein detecting the auxiliary label includes detecting an orientation of the auxiliary label relative to a reference orientation; the method further comprising:

determining whether the orientation exceeds a predefined threshold; and

when the orientation exceeds the predefined threshold, discarding the auxiliary label detection.

6. The method of claim 5, further comprising:

when the orientation does not exceed the threshold, storing an auxiliary label indicator in the memory, defining (i) a position of the auxiliary label within the image and (ii) a type of the auxiliary label.

7. The method of claim 1, wherein detecting the auxiliary label includes detecting a position and a type of the auxiliary label; and

wherein updating the primary label indicator includes inserting the type of the auxiliary label into the primary label indicator.

8. The method of claim 7, wherein selecting the one of the primary label indicators comprises:

determining an expected primary label position based on the position of the auxiliary label;

determining whether one of the primary label indicators is at the expected position; and

when one of the primary label indicators is at the expected position, selecting the one of the primary label indicators.

9. The method of claim 8, further comprising:

determining whether the selected primary label indicator is complete; and

when the selected primary label indicator is not complete, updating the primary label indicator with an obstructed status indicator.

10. A computing device for auxiliary label detection, the computing device comprising:

a memory storing (i) an image of a support structure and (ii) a plurality of primary label indicators each defining a position of a primary label within the image;

an imaging controller connected to the memory, the imaging controller configured to obtain the image of the support structure and the plurality of primary label indicators;

the imaging controller further configured to select a detection region from the image based on a reference indicator;

the imaging controller further configured to detect an auxiliary label within the detection region based on predefined visual attributes of the auxiliary label;

the imaging controller further configured to select one of the primary label indicators based on proximity between the auxiliary label and the selected primary label indicator;

the imaging controller further configured to update the selected primary label indicator with an identifier of the auxiliary label; and

the imaging controller further configured to store the updated primary label indicator in the memory.

11. The computing device of claim 10, further comprising:

a communications interface connected to the imaging controller;

wherein the imaging controller is further configured to transmit the updated primary label indicator via the communications interface.

12. The computing device of claim 10, wherein the reference indicator is the primary label indicator.

13. The computing device of claim 10, wherein the imaging controller is further configured to:

obtain a support structure edge indicator defining a position of the support structure edge within the image;

wherein the support structure edge indicator is the reference indicator.

14. The computing device of claim 13, wherein the imaging controller is further configured, to select, the detection region, to:

extract an initial region of the image based on the support structure edge indicator;

identify a blob in the extracted initial region; and

select the detection region corresponding to the blob.

15. The computing device of claim 10, wherein the imaging controller is further configured, to detect the auxiliary label, to detect an orientation of the auxiliary label relative to a reference orientation; and

wherein the imaging controller is further configured to:

determine whether the orientation exceeds a predefined threshold; and

when the orientation exceeds the predefined threshold, discard the auxiliary label detection.

16. The computing device of claim 15, wherein the imaging controller is further configured to:

when the orientation does not exceed the threshold, store an auxiliary label indicator in the memory, defining (i) a position of the auxiliary label within the image and (ii) a type of the auxiliary label.

17. The computing device of claim 10, wherein the imaging controller is further configured, to detect the auxiliary label, to detect a position and a type of the auxiliary label; and

wherein the imaging controller is further configured, to update the primary label indicator, to insert the type of the auxiliary label into the primary label indicator.

18. The computing device of claim 17, wherein the imaging controller is further configured, to select the one of the primary label indicators, to:

determine an expected primary label position based on the position of the auxiliary label;

determine whether one of the primary label indicators is at the expected position; and

when one of the primary label indicators is at the expected position, select the one of the primary label indicators.

19. The computing device of claim 18, wherein the imaging controller is further configured to:

determine whether the selected primary label indicator is complete; and

when the selected primary label indicator is not complete, update the primary label indicator with an obstructed status indicator.

20. A non-transitory computer-readable medium storing a plurality of computer-readable instructions executable by an imaging controller, wherein execution of the instructions causes the imaging controller to:

obtain (i) an image of a support structure and (ii) a plurality of primary label indicators each defining a position of a primary label within the image;

select a detection region from the image based on a reference indicator;

detect an auxiliary label within the detection region based on predefined visual attributes of the auxiliary label;

select one of the primary label indicators based on proximity between the auxiliary label and the selected primary label indicator;

update the selected primary label indicator with an identifier of the auxiliary label; and

store the updated primary label indicator in a memory.

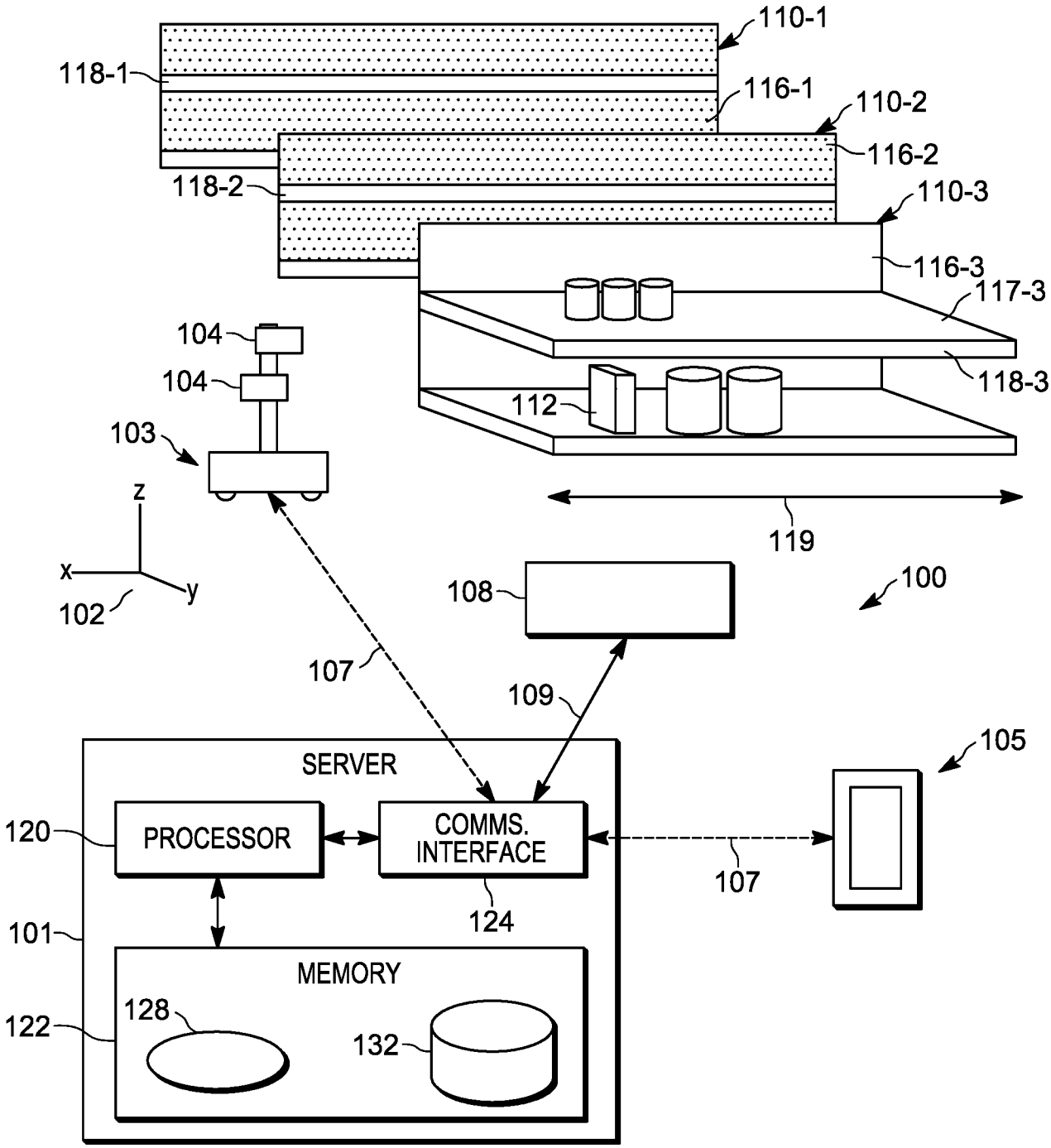

110-1
118-1
116-1
110-2
116-2
118-2
110-3
116-3
117-3
118-3
104
104
112
103
z
x
y
102
119
108
100
107
109
105
SERVER
120
PROCESSOR
COMMS. INTERFACE
107
124
101
MEMORY
128
122
132

FIG. 1

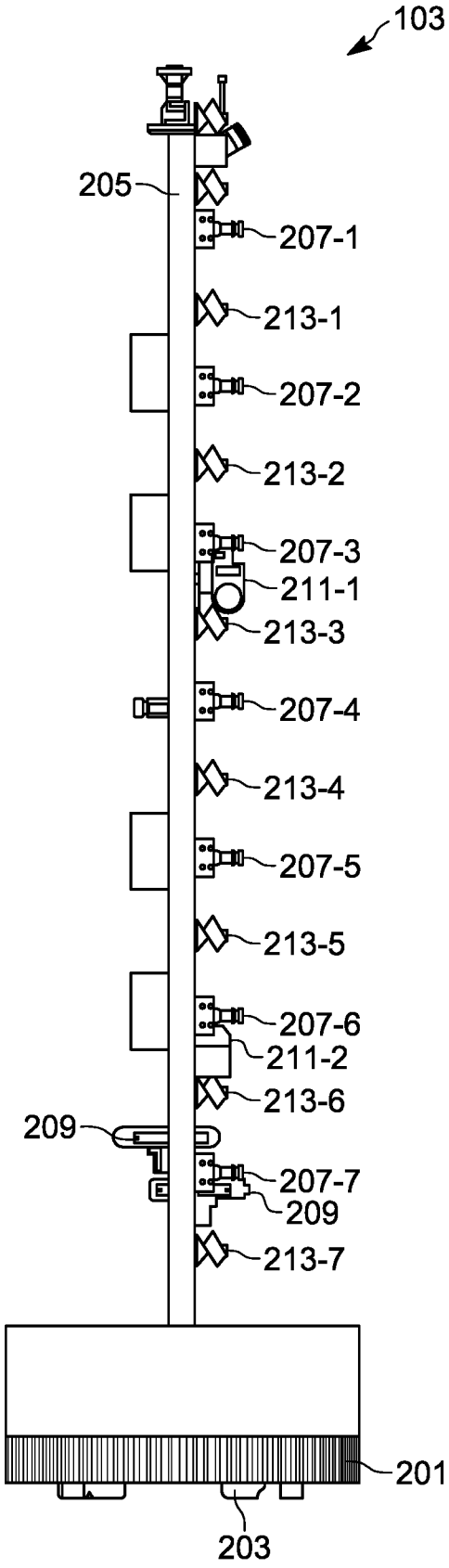

103
205
207-1
213-1
207-2
213-2
207-3
211-1
213-3
207-4
213-4
207-5
213-5
207-6
211-2
213-6
209
207-7
209
213-7
201
203

FIG. 2A

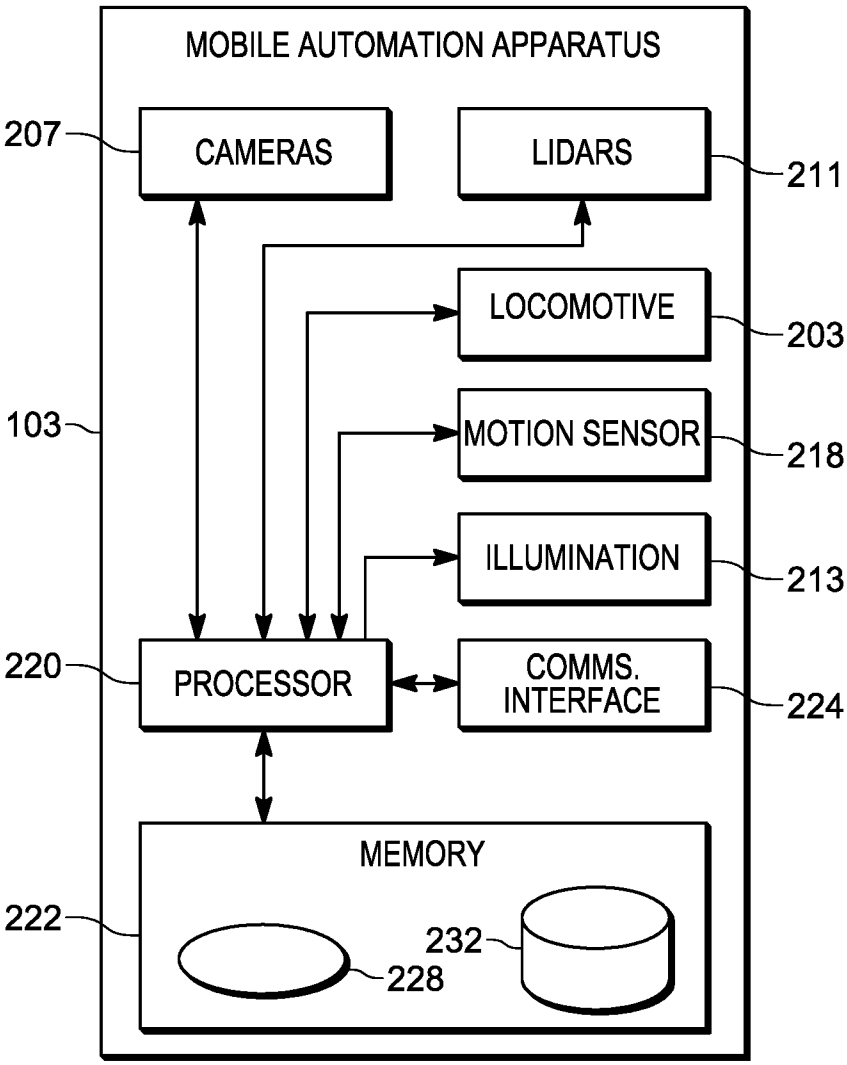

MOBILE AUTOMATION APPARATUS
207
CAMERAS
LIDARS
211
LOCOMOTIVE
203
103
MOTION SENSOR
218
ILLUMINATION
213
220
PROCESSOR
COMMS. INTERFACE
224
MEMORY
222
232
228

FIG. 2B

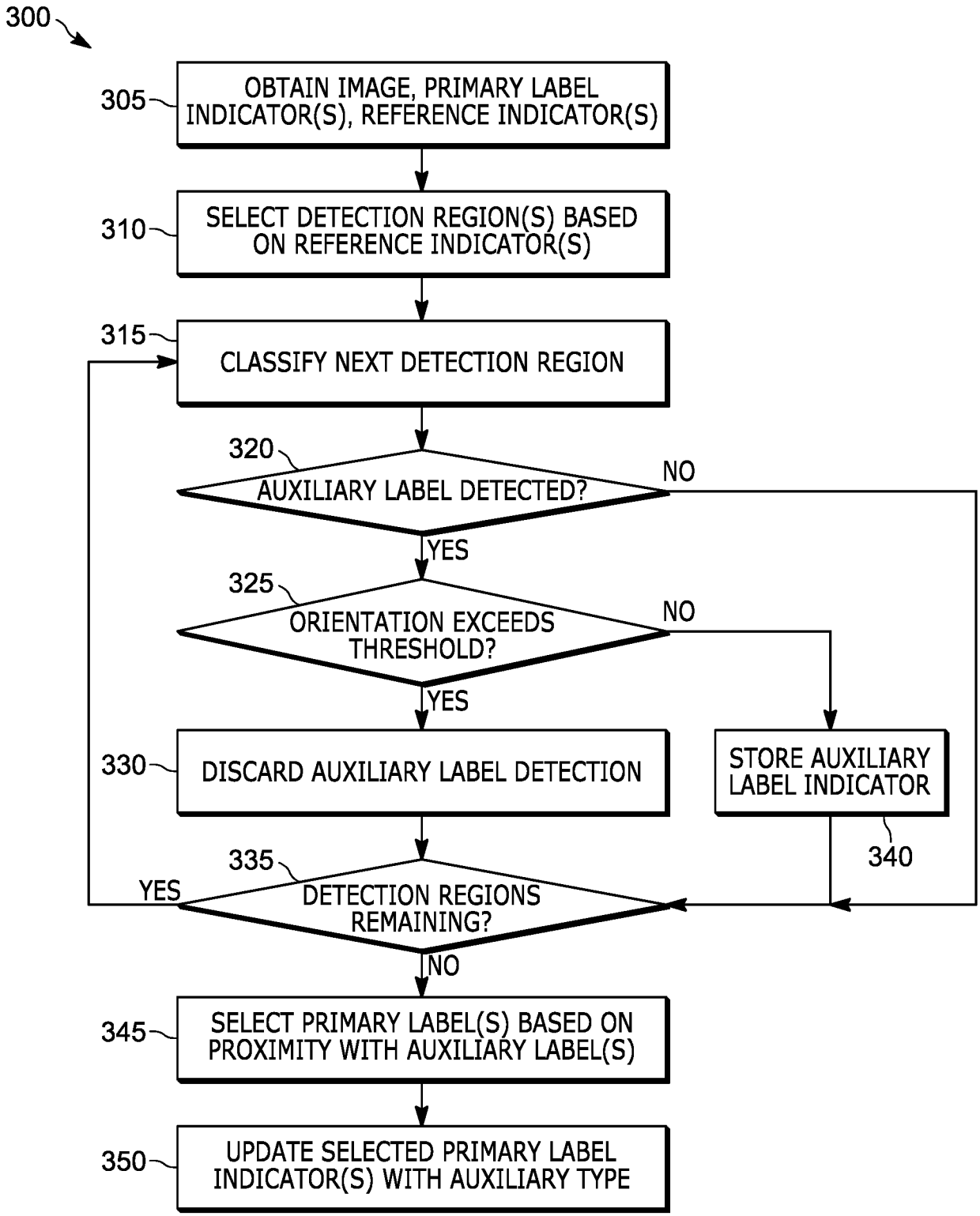

300
305
OBTAIN IMAGE, PRIMARY LABEL INDICATOR(S), REFERENCE INDICATOR(S)
310
SELECT DETECTION REGION(S) BASED ON REFERENCE INDICATOR(S)
315
CLASSIFY NEXT DETECTION REGION
320
AUXILIARY LABEL DETECTED?
NO
YES
325
ORIENTATION EXCEEDS THRESHOLD?
NO
YES
330
DISCARD AUXILIARY LABEL DETECTION
STORE AUXILIARY LABEL INDICATOR
340
335
DETECTION REGIONS REMAINING?
YES
NO
345
SELECT PRIMARY LABEL(S) BASED ON PROXIMITY WITH AUXILIARY LABEL(S)
350
UPDATE SELECTED PRIMARY LABEL INDICATOR(S) WITH AUXILIARY TYPE

FIG. 3

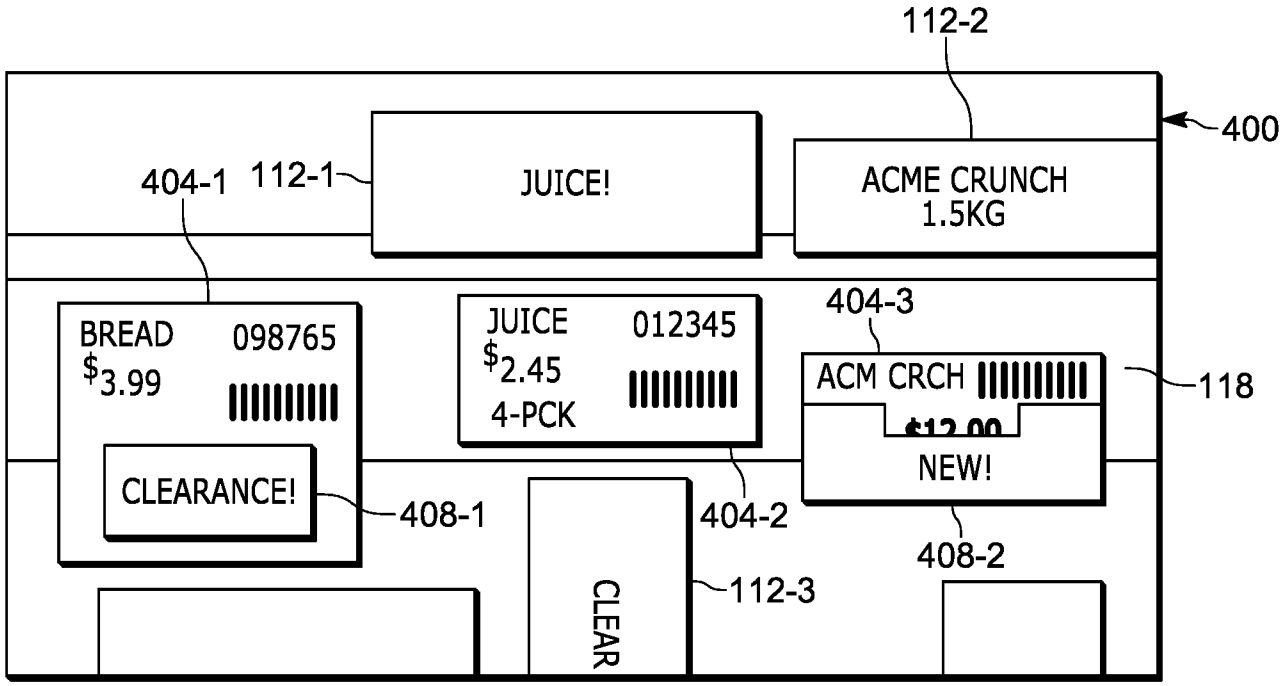

112-2
400
404-1
112-1
JUICE!
ACME CRUNCH
1.5KG
BREAD
$3.99
098765
JUICE
$2.45
4-PCK
012345
404-3
ACM CRCH
NEW!
118
CLEARANCE!
408-1
404-2
408-2
CLEAR
112-3

FIG. 4A

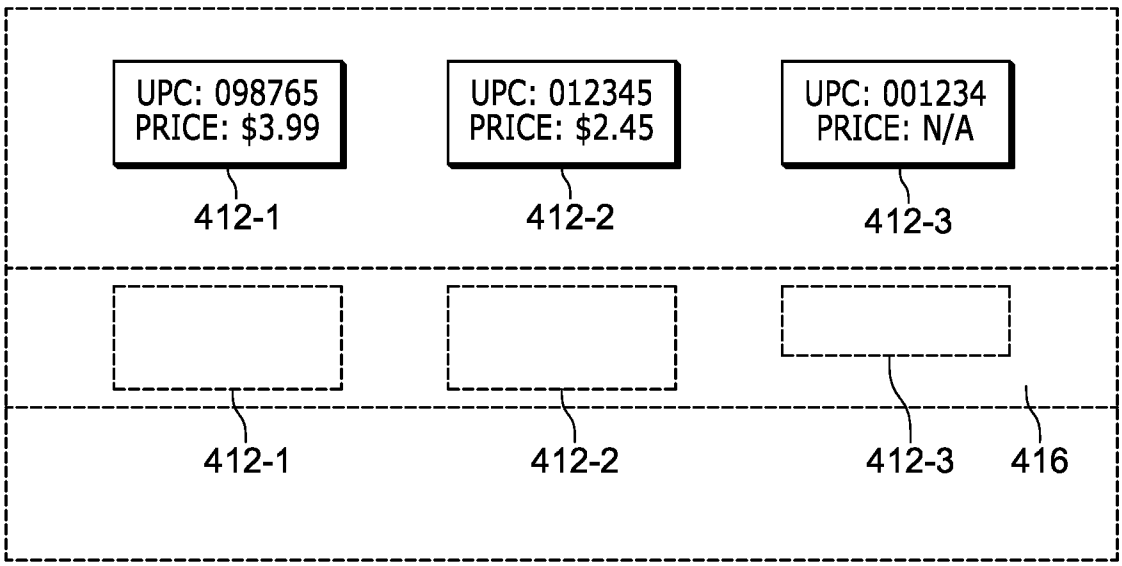

UPC: 098765
PRICE: $3.99
UPC: 012345
PRICE: $2.45
UPC: 001234
PRICE: N/A
412-1
412-2
412-3
412-1
412-2
412-3
416

FIG. 4B

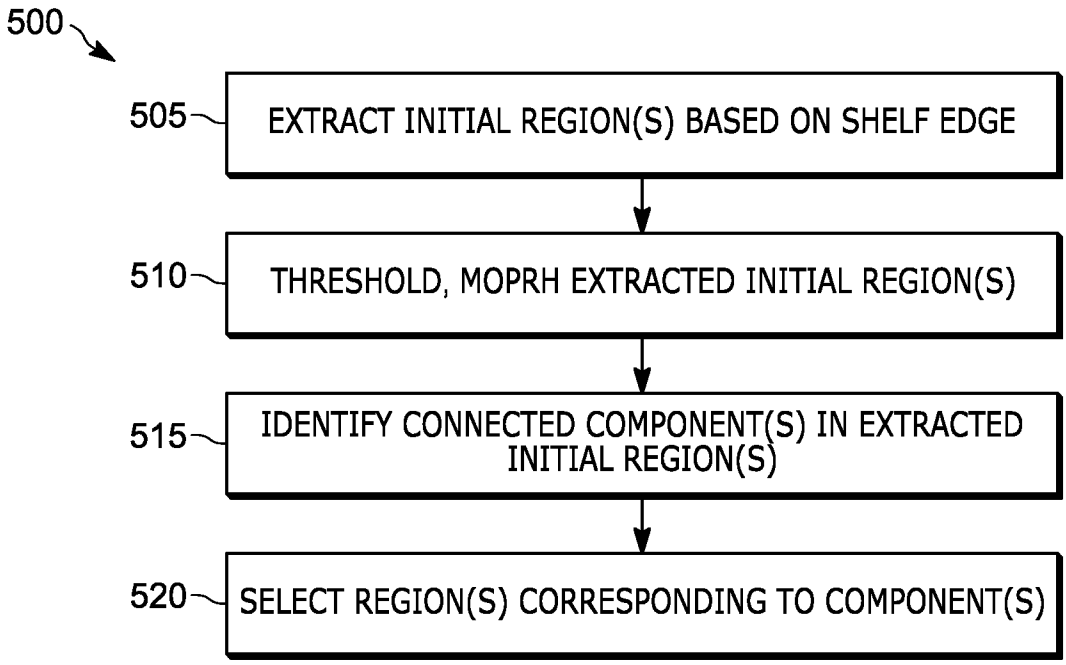

500
505
EXTRACT INITIAL REGION(S) BASED ON SHELF EDGE
510
THRESHOLD, MOPRH EXTRACTED INITIAL REGION(S)
515
IDENTIFY CONNECTED COMPONENT(S) IN EXTRACTED INITIAL REGION(S)
520
SELECT REGION(S) CORRESPONDING TO COMPONENT(S)

FIG. 5

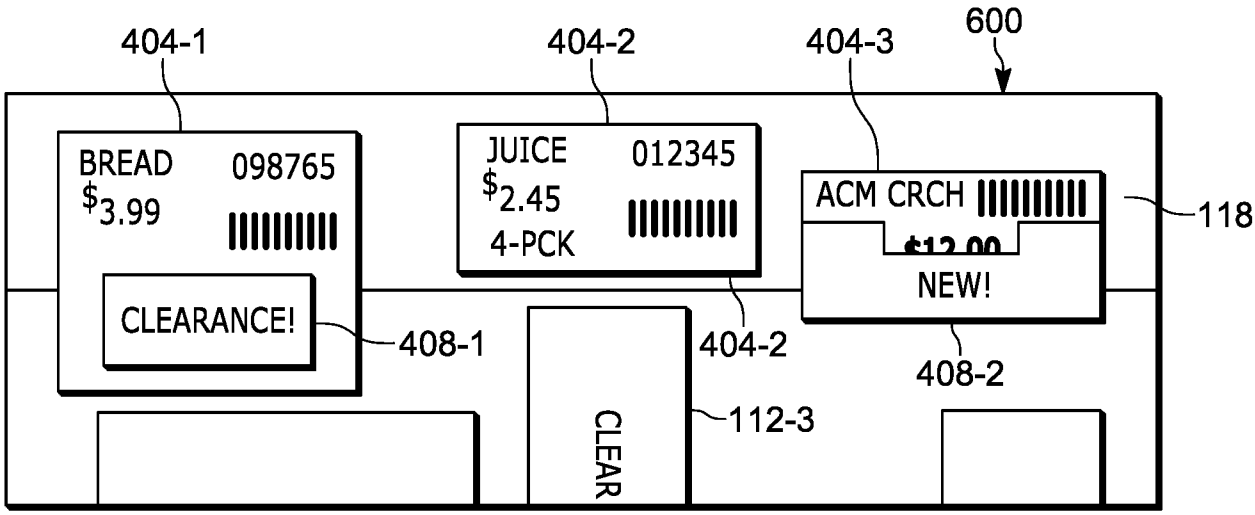

404-1
404-2
404-3
600
BREAD
$3.99
098765
JUICE
$2.45
4-PCK
012345
ACM CRCH
NEW!
118
CLEARANCE!
408-1
404-2
408-2
CLEAR
112-3

FIG. 6A

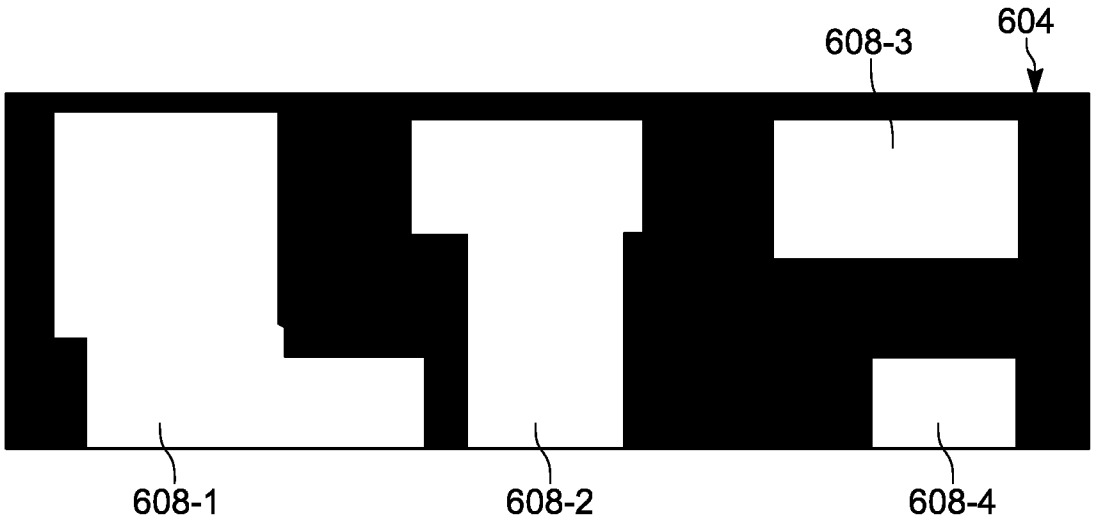


FIG. 6B

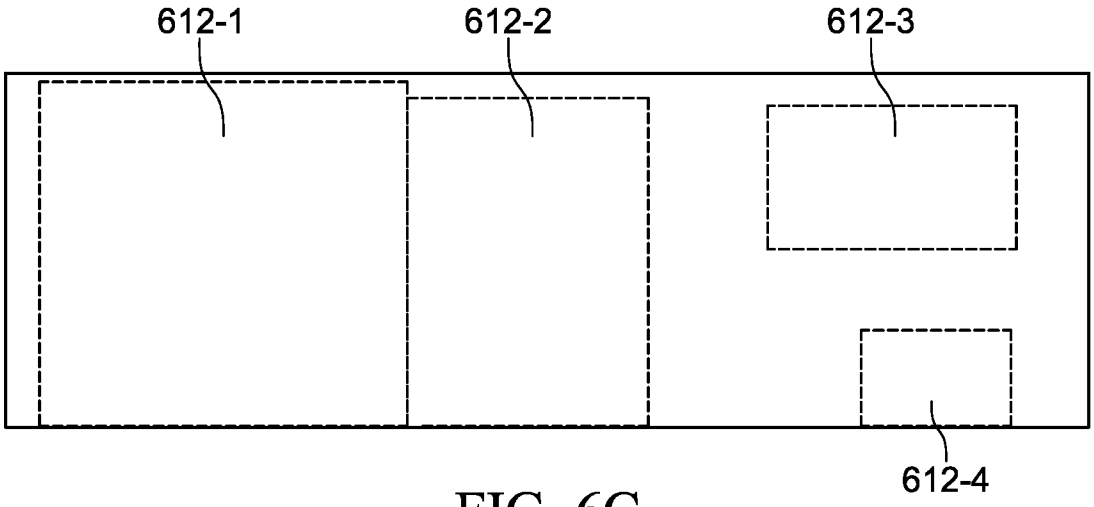


FIG. 6C


700
SELECT DETECTION REGION(S) BASED ON PRIMARY LABEL INDICATORS

FIG. 7A

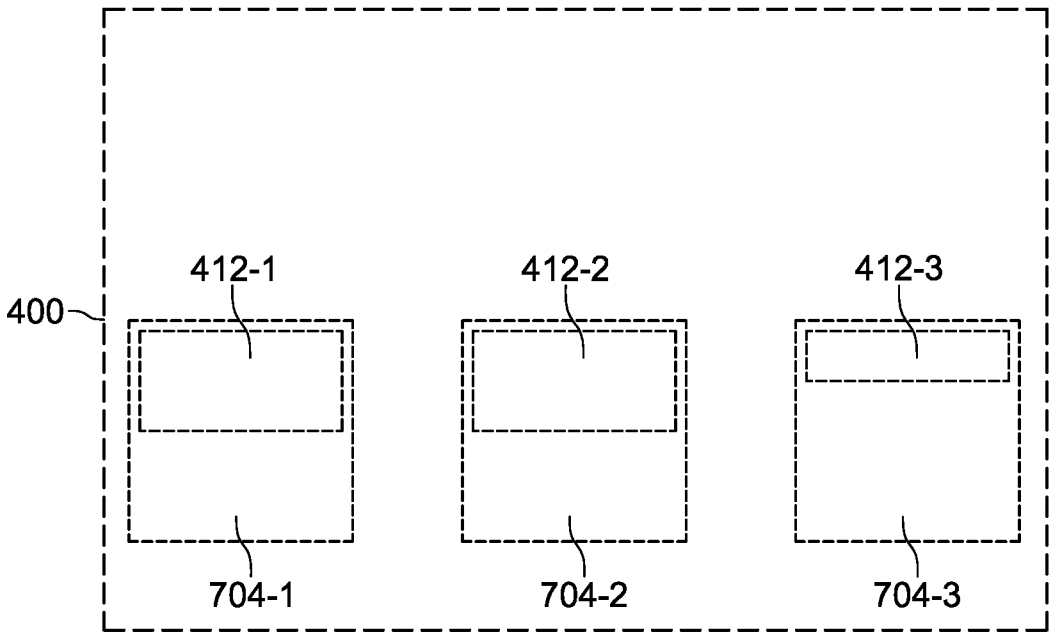

400
412-1
412-2
412-3
704-1
704-2
704-3

FIG. 7B

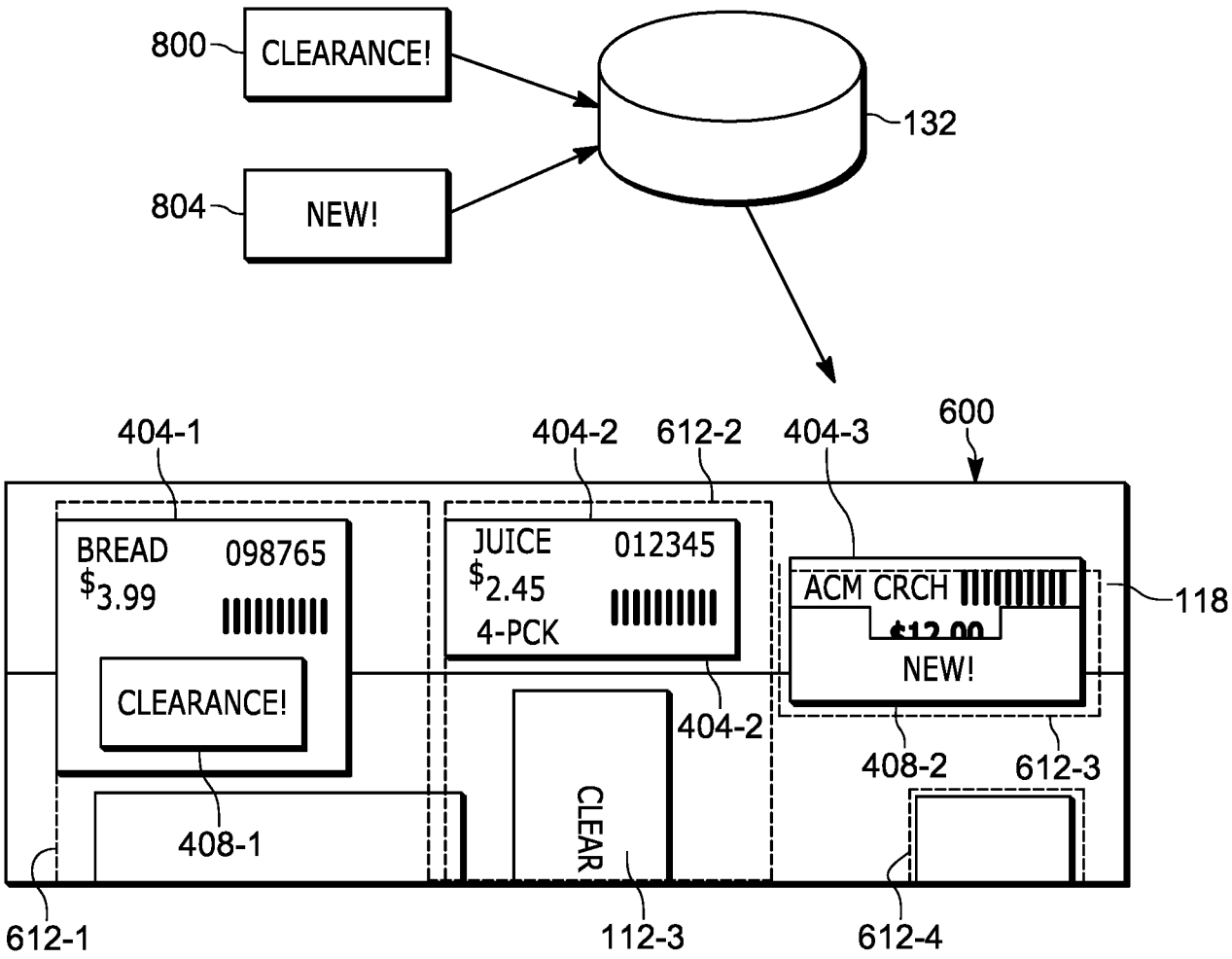

800
CLEARANCE!
804
NEW!
132
404-1
404-2
612-2
404-3
600
BREAD
098765
$3.99
CLEARANCE!
JUICE
012345
$2.45
4-PCK
ACM CRCH
NEW!
118
404-2
408-2
612-3
408-1
CLEAR
612-1
112-3
612-4

FIG. 8A

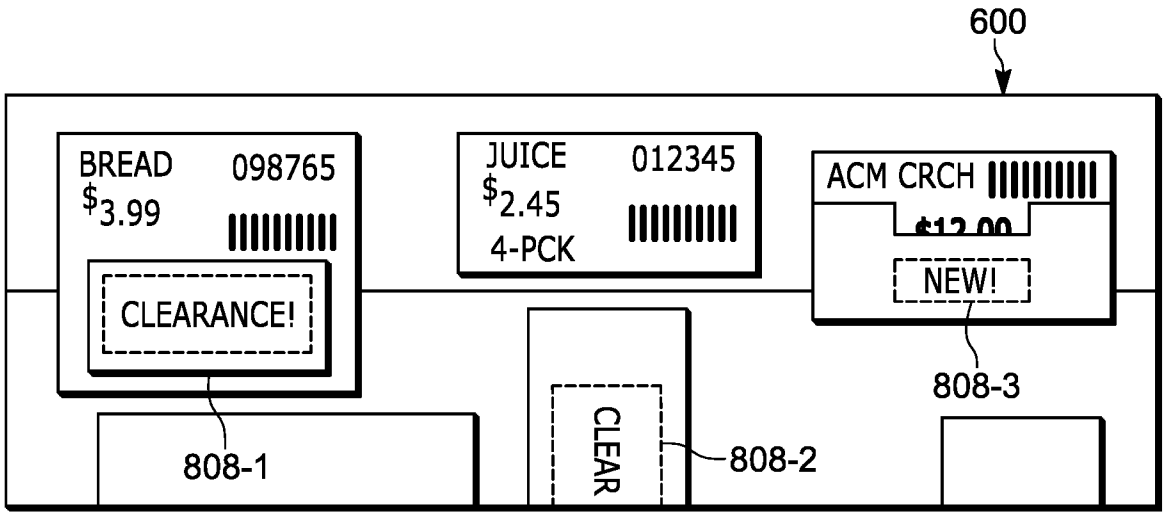

600
BREAD
098765
$3.99
CLEARANCE!
JUICE
012345
$2.45
4-PCK
ACM CRCH
NEW!
808-3
808-1
CLEAR
808-2

FIG. 8B

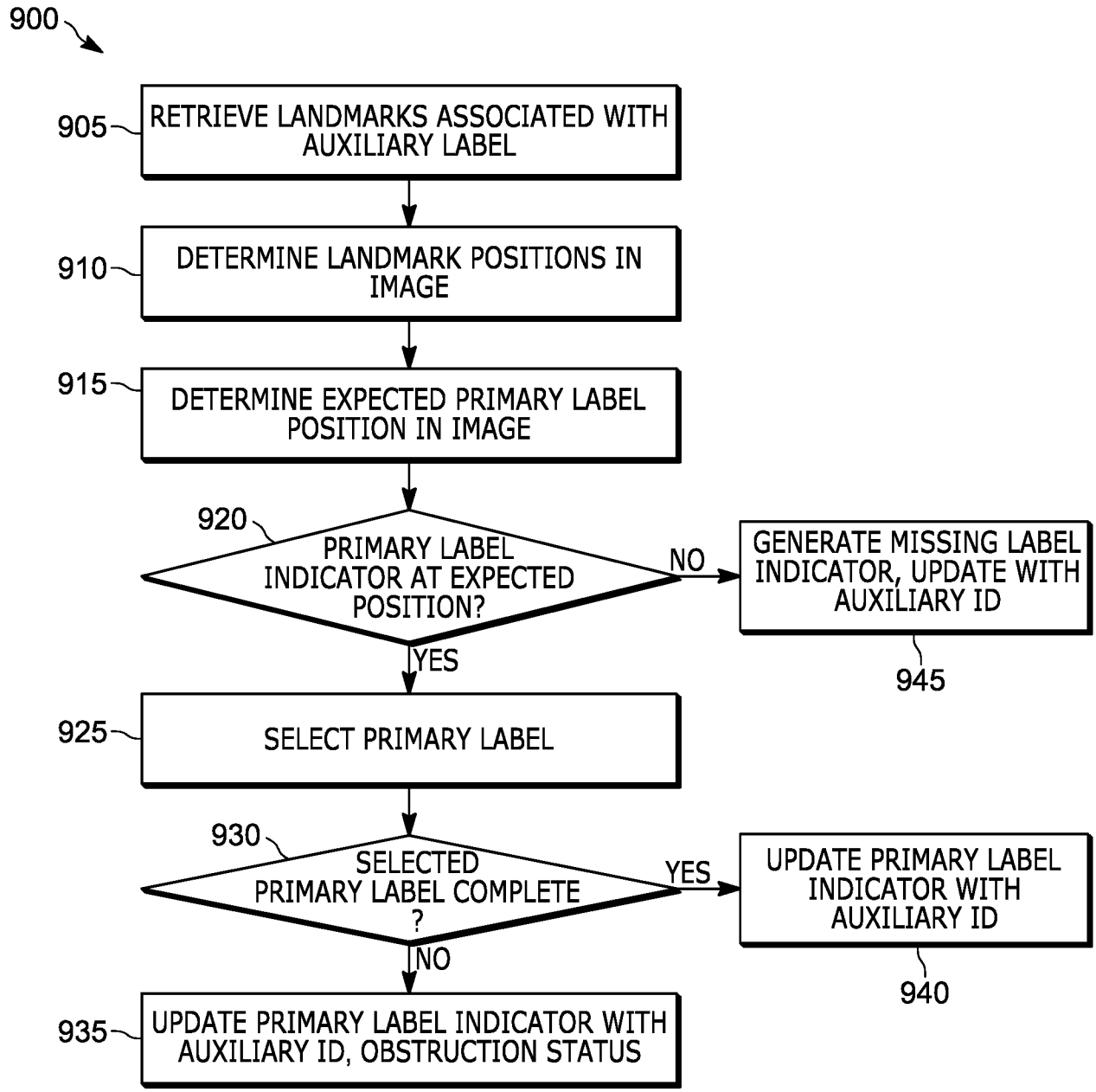

900
905
RETRIEVE LANDMARKS ASSOCIATED WITH AUXILIARY LABEL
910
DETERMINE LANDMARK POSITIONS IN IMAGE
915
DETERMINE EXPECTED PRIMARY LABEL POSITION IN IMAGE
920
PRIMARY LABEL INDICATOR AT EXPECTED POSITION?
NO
GENERATE MISSING LABEL INDICATOR, UPDATE WITH AUXILIARY ID
945
YES
925
SELECT PRIMARY LABEL
930
SELECTED PRIMARY LABEL COMPLETE ?
YES
UPDATE PRIMARY LABEL INDICATOR WITH AUXILIARY ID
940
NO
935
UPDATE PRIMARY LABEL INDICATOR WITH AUXILIARY ID, OBSTRUCTION STATUS

FIG. 9

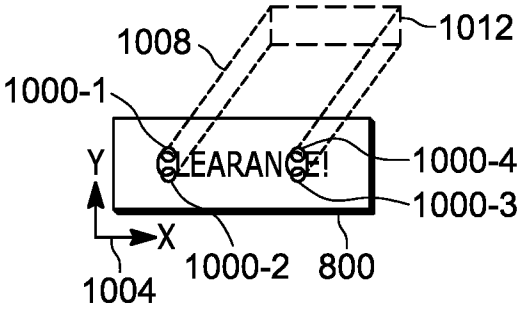


FIG. 10A

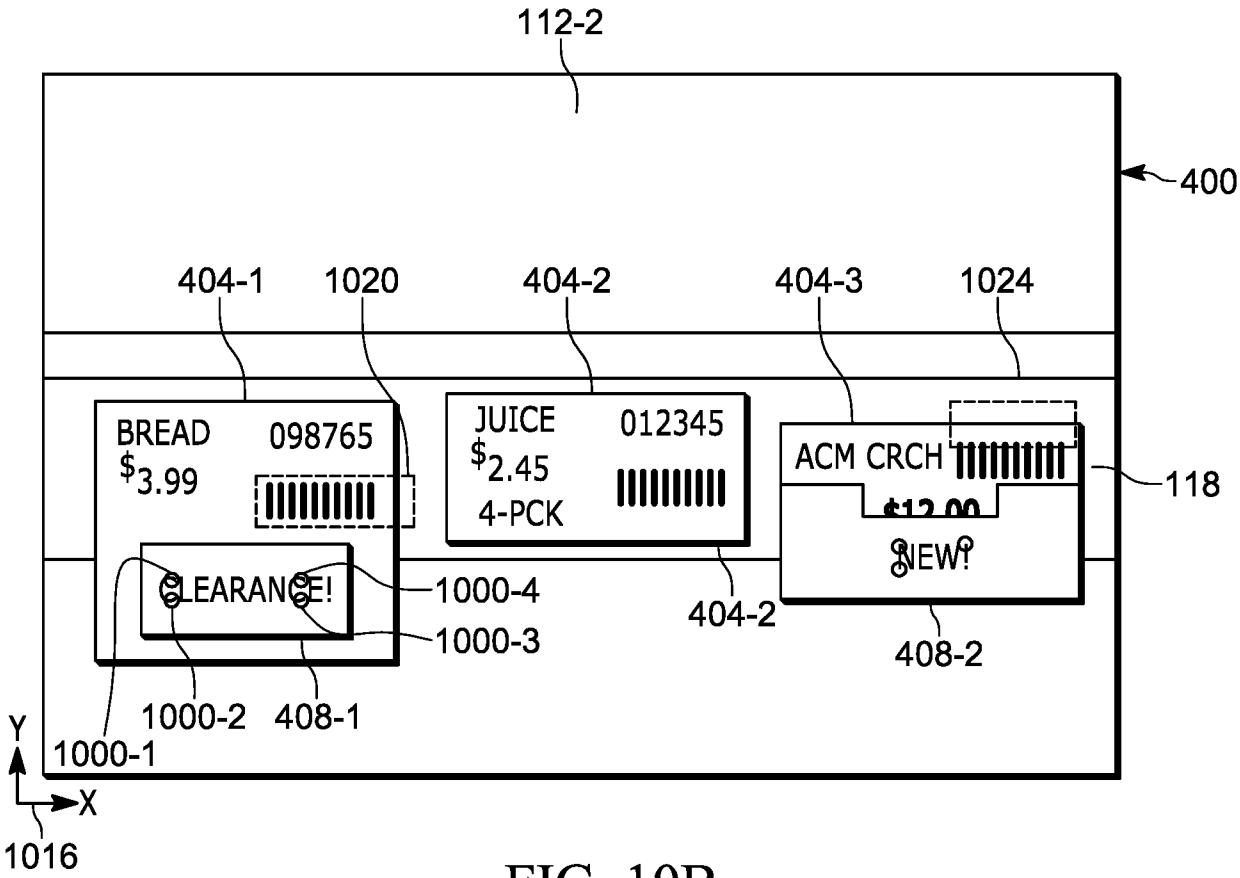


FIG. 10B

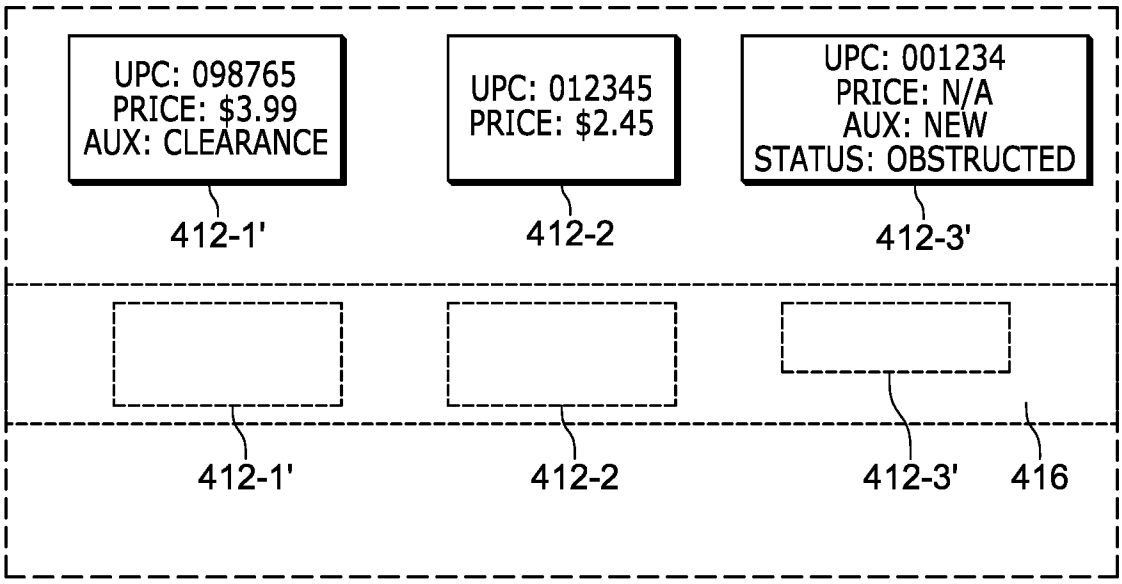

UPC: 098765
PRICE: $3.99
AUX: CLEARANCE
UPC: 012345
PRICE: $2.45
UPC: 001234
PRICE: N/A
AUX: NEW
STATUS: OBSTRUCTED
412-1'
412-2
412-3'
412-1'
412-2
412-3'
416

FIG. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 19/64020

A. CLASSIFICATION OF SUBJECT MATTER

IPC - G06K 9/00 (2020.01)

CPC - G06K 9/6892, G06T 7/149, G06K 9/469, G06T 7/12, G06K 9/6211, G06T 2207/30048, G06K 2209/05

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
See Search History document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2015/0363625 A1 (Xerox Corporation) 17 December 2015 (17.12.2015), entire document, especially FIG. 1; FIG. 6; FIG. 9; FIG. 10; Para [0054],[0057],[0069]-[0070],[0077],[0079]-[0080],[0085],[0091],[0094],[0097],[0100]-[0101],[0102],[0108]-[0109],[0114]-[0115],[0118],[0121],[0125]	1-5, 10-15, 20 ---------- 6-9, 16-19
Y	US 2003/0094494 A1 (Blanford et al.) 22 May 2003 (22.05.2003), entire document, especially FIG. 2; FIG. 6; Para [0005],[0011],[0020]-[0021],[0025],[0029]	6-9, 16-19

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 January 2020 (20.01.2020)	19 FEB 2020
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Lee Young Telephone No. PCT Helpdesk: 571-272-4300