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(54) **SYSTEM AND METHOD FOR TRACKING REFRIGERATOR INVENTORY**

(71) Applicant: **Springhouse Technologies Inc.**, McLean, VA (US)

(72) Inventors: **John Anderson**, Brooklyn, NY (US); **Tyler Sanborn**, Queens, NY (US); **Boris Kontorovich**, Brooklyn, NY (US); **Charles Parks**, Laramie, WY (US); **Jennifer O'Neil**, Boulder, CO (US); **Bryce Copenhaver**, Brooklyn, NY (US); **Robert Marsh**, Ponte Vedra Beach, FL (US); **Travis Ruddy**, Dayton, OH (US)

(73) Assignee: **Springhouse Technologies Inc.**, McLean, VA (US)

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(51) **Int. Cl.**

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G06T 7/292	(2017.01)
G06V 10/764	(2022.01)
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G06V 20/68	(2022.01)
H04N 7/18	(2006.01)
H04N 23/90	(2023.01)

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CPC ***F25D 29/005*** (2013.01); ***G06Q 10/087*** (2013.01); ***G06T 7/292*** (2017.01); ***G06V 10/764*** (2022.01); ***G06V 10/809*** (2022.01); ***G06V 20/68*** (2022.01); ***H04N 7/181*** (2013.01); ***H04N 7/188*** (2013.01); ***H04N 23/90*** (2023.01); *F25D 2500/06* (2013.01); *F25D 2700/06* (2013.01); *G06T 2207/10016* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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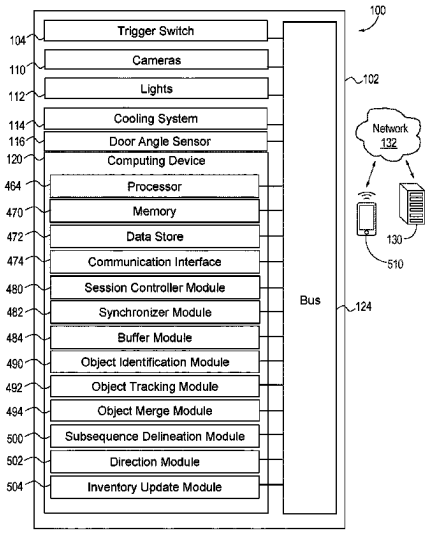
Primary Examiner — Gelek W Topgyal

(74) *Attorney, Agent, or Firm* — Rankin, Hill & Clark LLP

(57) **ABSTRACT**

A refrigerator includes a plurality of storage compartments within a refrigerated enclosure, a plurality of cameras mounted a main body or a door, and at least one computing device. The at least one computing device is configured to assign a direction to determine if an item is moving into, out of or internally within the refrigerated enclosure.

20 Claims, 5 Drawing Sheets



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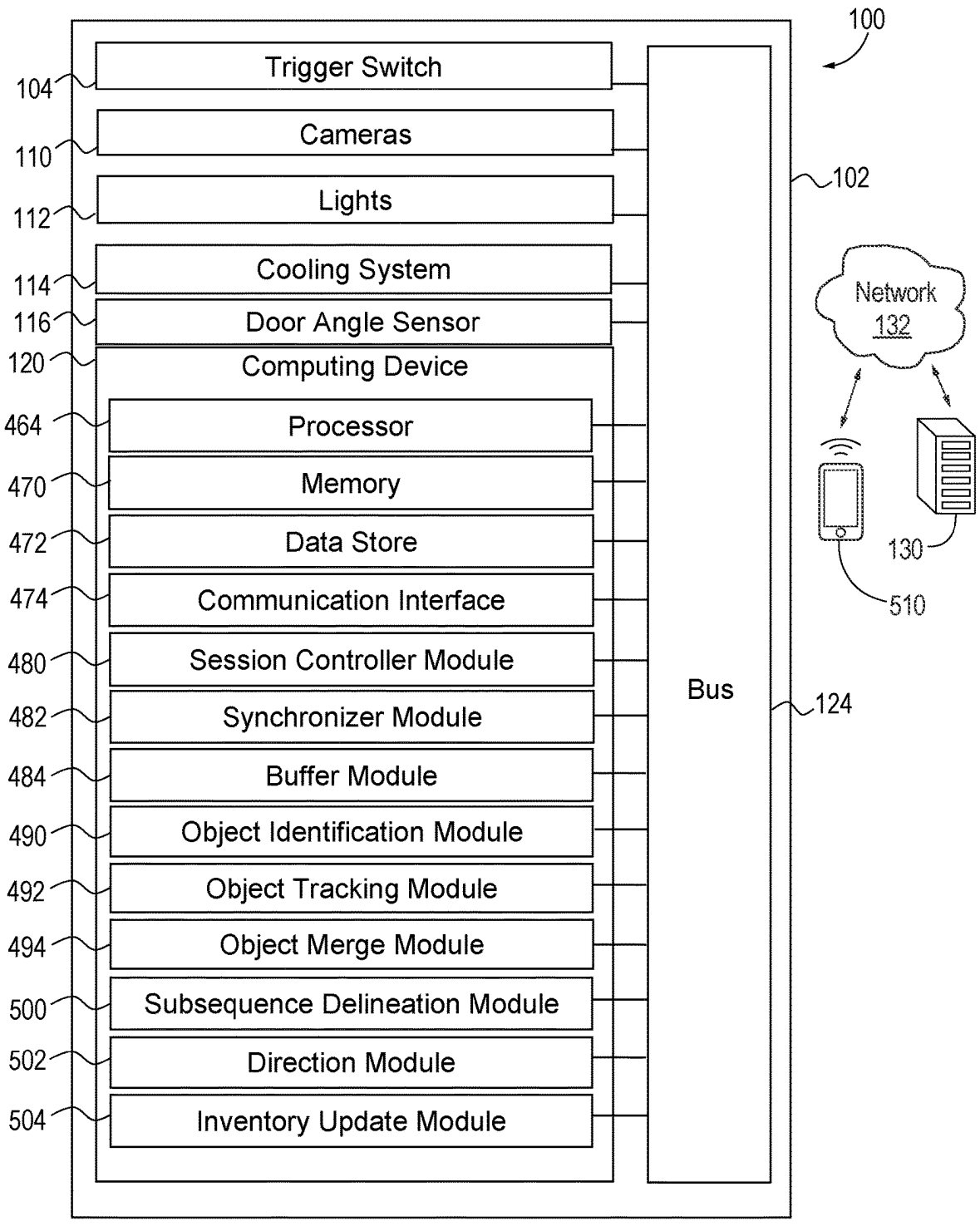
100
Trigger Switch
104
Cameras
110
Lights
112
Cooling System
114
Door Angle Sensor
116
120
Computing Device
Processor
464
Memory
470
Data Store
472
Communication Interface
474
Session Controller Module
480
Synchronizer Module
482
Buffer Module
484
Object Identification Module
490
Object Tracking Module
492
Object Merge Module
494
Subsequence Delineation Module
500
Direction Module
502
Inventory Update Module
504
Bus
124
102
Network
132
130
510

FIG. 1

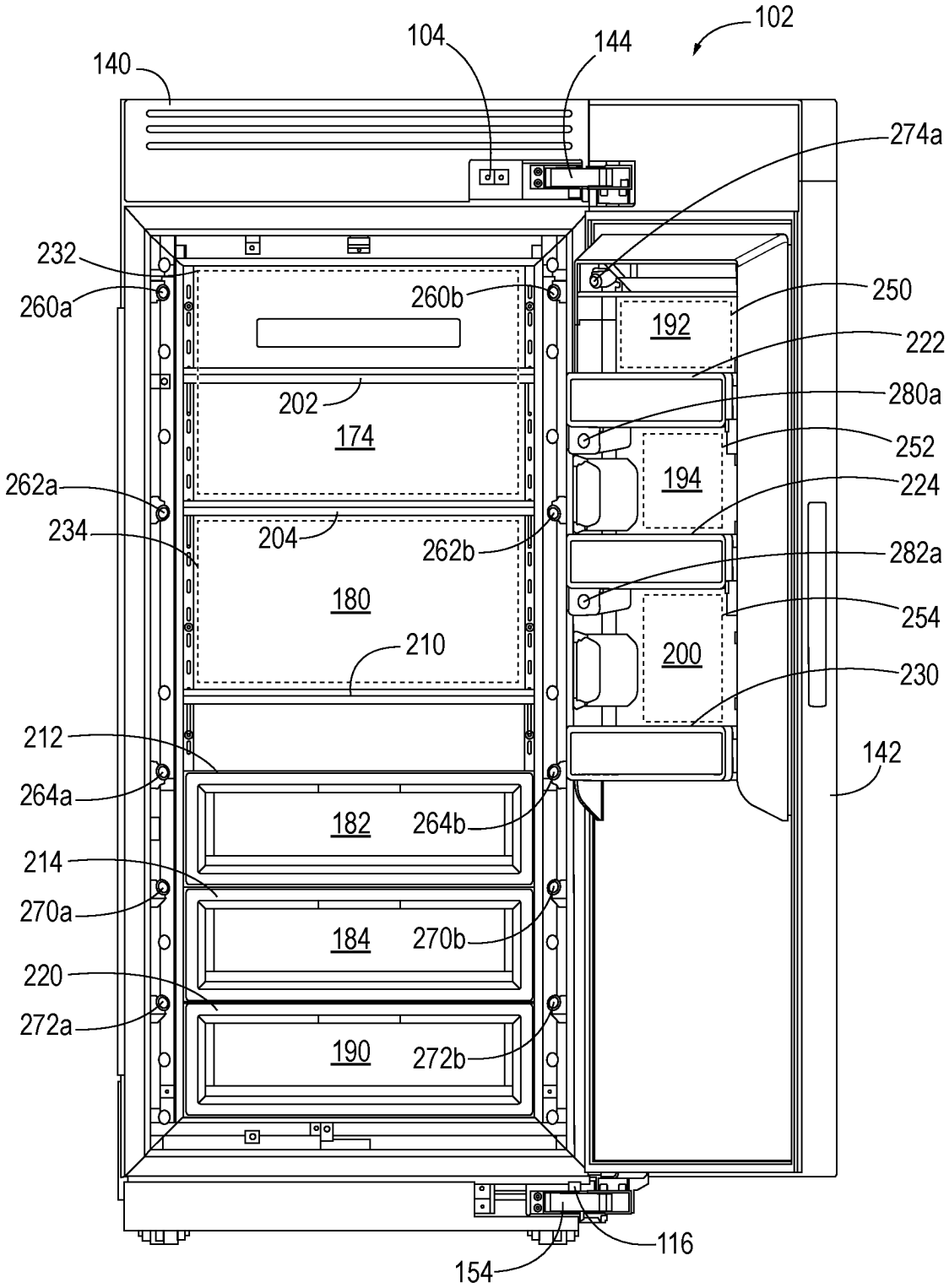
102
104
140
144
274a
232
260a
260b
250
192
222
202
174
280a
252
194
262a
224
234
204
262b
282a
180
254
210
200
230
212
142
264a
182
264b
214
270a
184
270b
220
272a
190
272b
116
154

FIG. 2

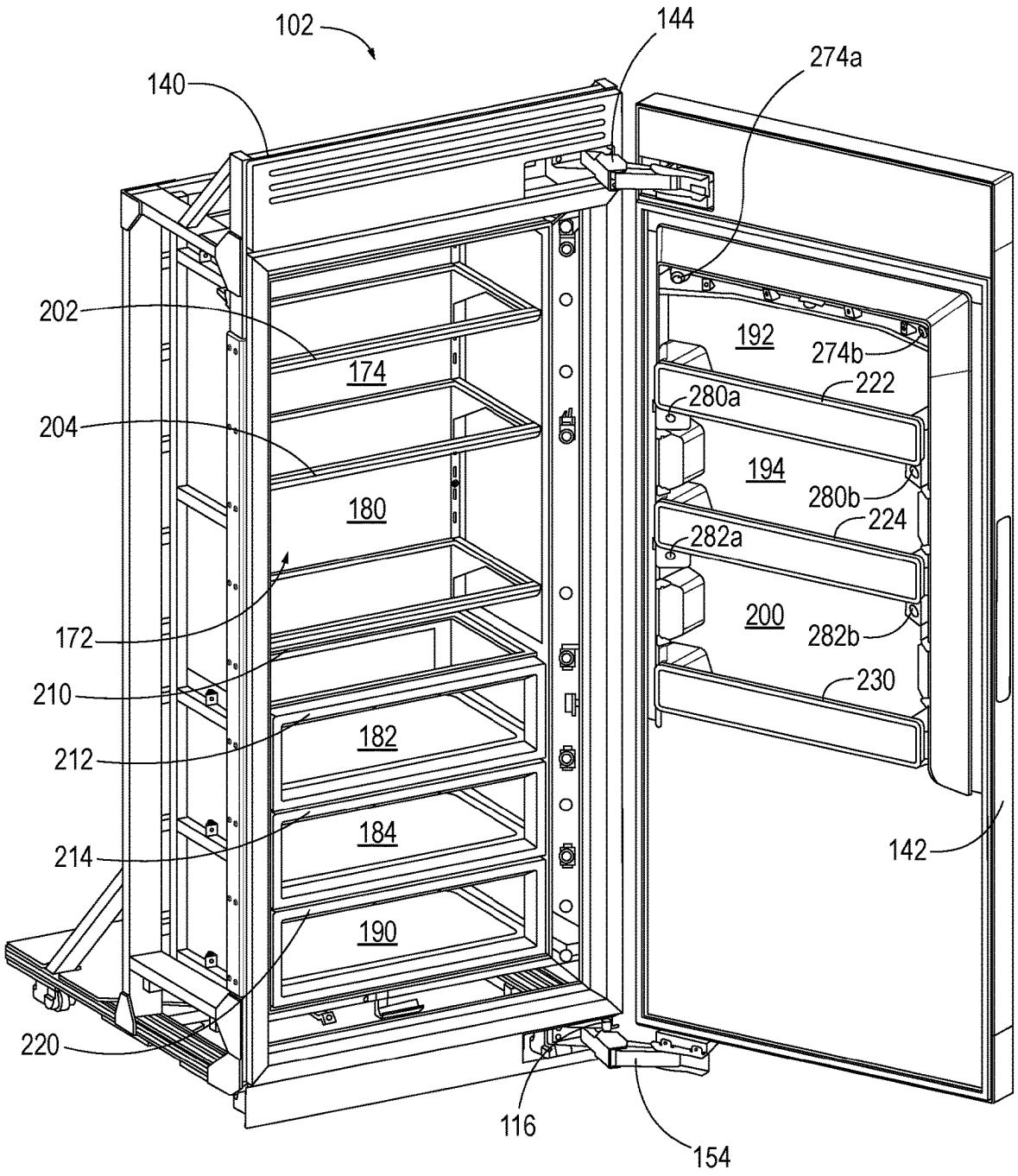
102
144
274a
140
202
174
204
180
172
210
212
182
214
184
190
220
116
154
192
274b
222
280a
194
280b
224
282a
200
282b
230
142

FIG. 3

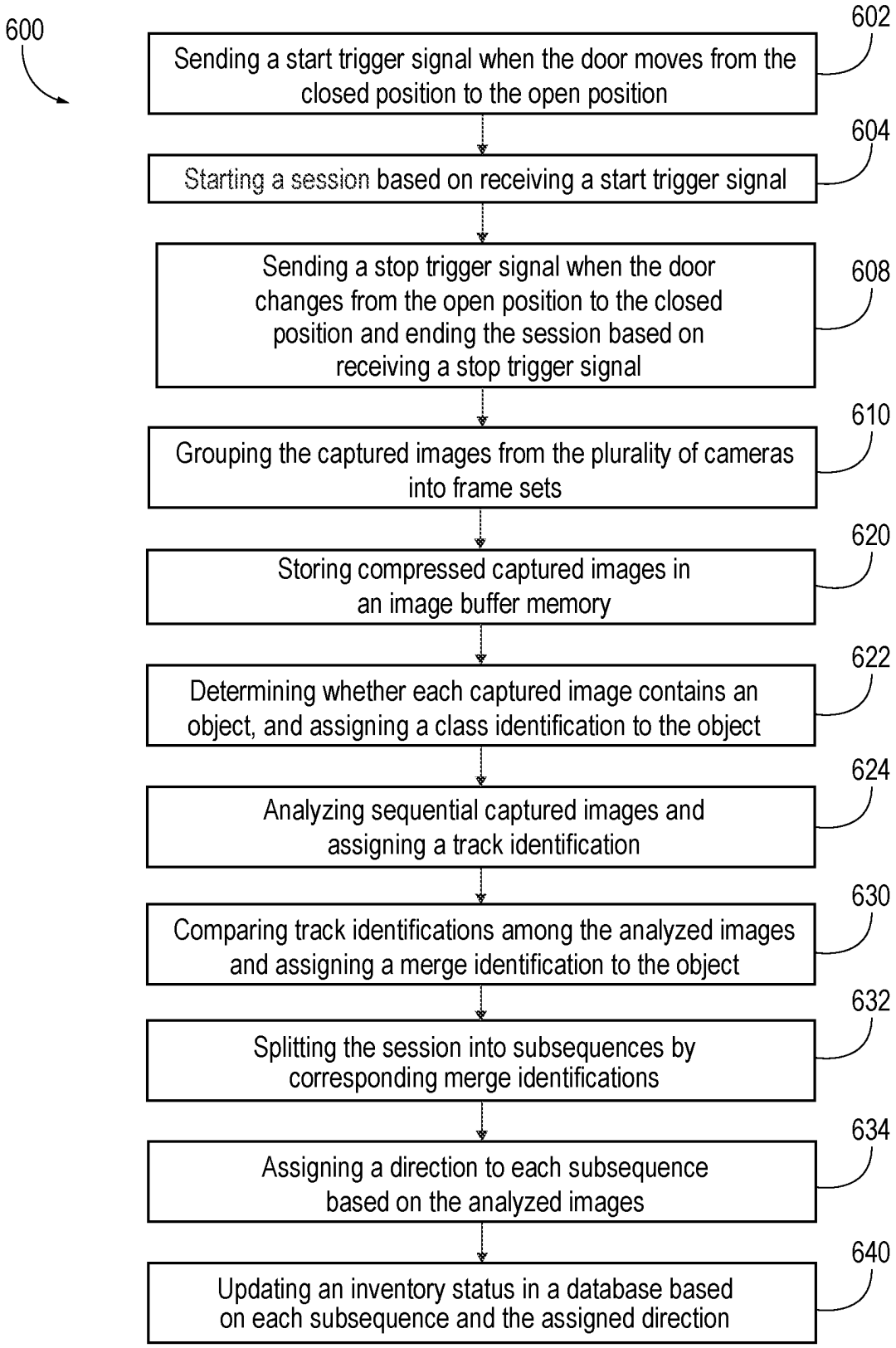
600
602
Sending a start trigger signal when the door moves from the closed position to the open position
604
Starting a session based on receiving a start trigger signal
608
Sending a stop trigger signal when the door changes from the open position to the closed position and ending the session based on receiving a stop trigger signal
610
Grouping the captured images from the plurality of cameras into frame sets
620
Storing compressed captured images in an image buffer memory
622
Determining whether each captured image contains an object, and assigning a class identification to the object
624
Analyzing sequential captured images and assigning a track identification
630
Comparing track identifications among the analyzed images and assigning a merge identification to the object
632
Splitting the session into subsequences by corresponding merge identifications
634
Assigning a direction to each subsequence based on the analyzed images
640
Updating an inventory status in a database based on each subsequence and the assigned direction

FIG. 4

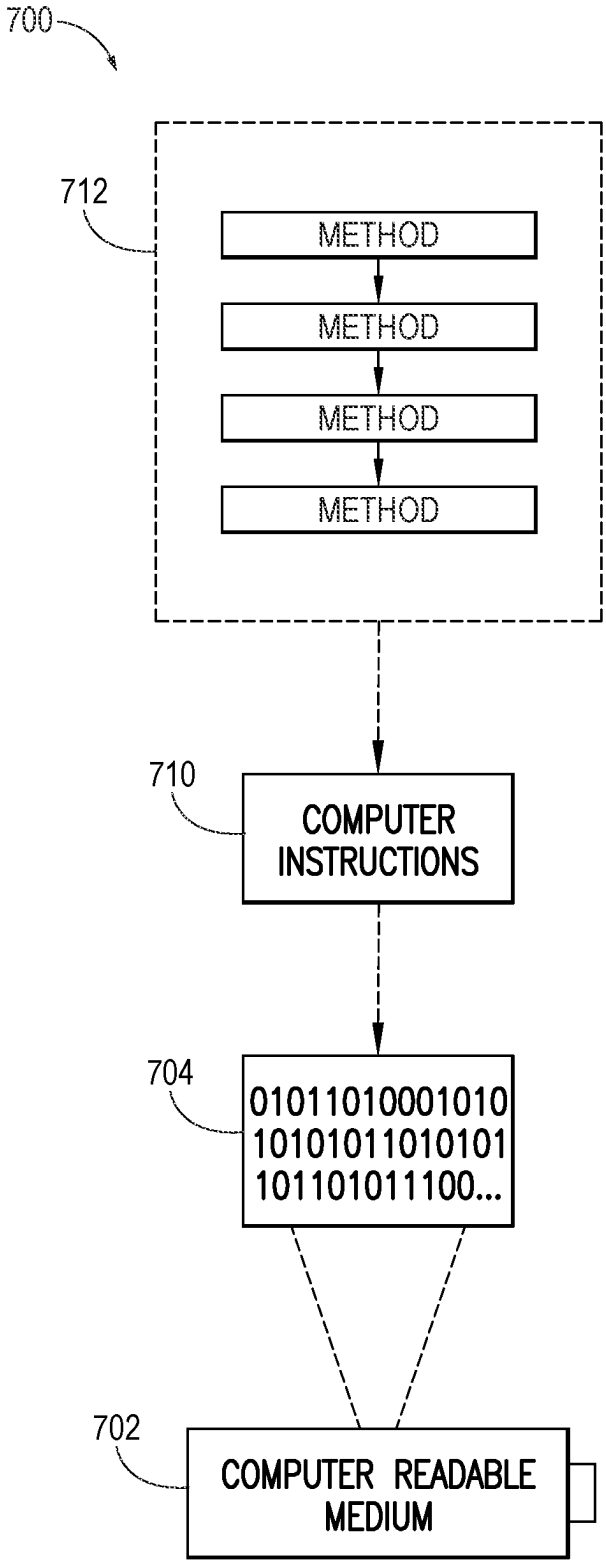
700
712
METHOD
METHOD
METHOD
METHOD
710
COMPUTER INSTRUCTIONS
704
01011010001010
10101011010101
101101011100...
702
COMPUTER READABLE MEDIUM

FIG. 5

SYSTEM AND METHOD FOR TRACKING REFRIGERATOR INVENTORY

BACKGROUND

Known refrigerators can include a camera for imaging and recording inventory disposed in an interior of the refrigerator. In known refrigerators including cameras for imaging and recording inventory, the cameras are located and designed to each have a field of view directed toward an interior of the refrigerator. When inventory items are placed in such refrigerators at locations that obscure view of other items from the camera, the camera has difficulty accurately recording the obscured inventory. Consequently, there is demand for a container with an inventory tracking system capable of accurately imaging, tracking, and recording inventory disposed therein.

SUMMARY

In view of the foregoing, a refrigerator includes a main body and a door pivotally mounted to and movable with respect to the main body between an open position and a closed position, the main body and the door defining a plurality of storage compartments within a refrigerated enclosure when the door is in the closed position. The refrigerator also includes a plurality of cameras mounted to at least one of the main body and the door. Each camera is positioned to have a field of view that includes an entrance opening leading to at least one storage compartment when the door is in the open position, the plurality of cameras being configured to capture images of an item passing through the entrance opening as the item is being loaded into or is being removed from the at least one storage compartment. The refrigerator also includes at least one computing device in operable connection with the plurality of cameras.

The at least one computing device includes a session controller module configured to start a session and to instruct each camera to begin capturing images based on a trigger signal received by the session controller. The at least one computing device also includes a synchronizer module configured to receive captured images from the plurality of cameras and to group the captured images into frame sets, with each frame set made up of respective captured images that were captured at a same time from different cameras among the plurality of cameras. The at least one computing device also includes an object identification module configured to determine whether each captured image in a respective frame set contains an object and to assign a class identification to the object.

The at least one computing device also includes an object tracking module configured to analyze sequential captured images from each camera and to assign track identifications to associate the object in one analyzed image to the object in other analyzed images per camera. The at least one computing device also includes an object merge module configured to compare the track identifications among the analyzed images from different cameras and to assign a merge identification to the object when the object is detected by the object identification module in captured images captured by multiple different cameras among the plurality of cameras. The at least one computing device also includes a subsequence delineation module configured to split the session into subsequences by corresponding merge identifications received from the object merge module. Each subsequence corresponds to an inventory change for the at least one storage compartment. The at least one computing device also includes a direction module configured to assign a direction to each subsequence based on the analyzed images to determine if the object is moving into, out of or internally within the refrigerated enclosure. The at least one computing device also includes an inventory update module configured to communicate with a database to update an inventory status of the at least one storage compartment based on each inventory change and the direction assigned thereto.

According to another aspect, a method for tracking inventory in a refrigerator includes starting a session based on receiving a trigger signal and capturing images using a plurality of cameras mounted to at least one of a main body and a door pivotally mounted to and movable with respect to the main body between an open position and a closed position. The main body and the door define a refrigerated enclosure when the door is in the closed position, each camera is positioned to have a field of view through an entrance opening plane of the refrigerated enclosure which is accessible when the door is in the open position, and the plurality of cameras is configured to capture images of an item passing through the entrance opening plane as the item is being loaded into or is being removed from the refrigerated enclosure.

The method also includes determining in a computing device in communication with the plurality of cameras whether each captured image contains an object. The method also includes analyzing in the computing device sequential captured images from each camera and assigning a track identification to associate the object in one analyzed image to the object in other analyzed images per camera. The method also includes comparing in the computing device track identifications among the analyzed images from different cameras and assigning a merge identification to the object when the object is detected in captured images captured by multiple different cameras among the plurality of cameras.

The method also includes splitting in the computing device the session into subsequences by corresponding merge identifications. Each subsequence corresponds to an inventory change within the refrigerated enclosure. The method also includes assigning in the computing device a direction to each subsequence based on the analyzed images to determine if the object is moving into, out of or internally within the refrigerated enclosure. The method also includes updating an inventory status in a database based on each subsequence and the direction assigned thereto.

According to another aspect, a non-transitory computer readable storage medium stores instructions that, when executed by a computer having a processor, cause the processor to perform the aforementioned method

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram representing an operating environment of a refrigerator including an inventory tracking system.

FIG. **2** is a front view of the refrigerator with a door shown in an open position.

FIG. **3** is a perspective view of the refrigerator with the door shown in the open position.

FIG. **4** is a process flow chart for tracking inventory in the refrigerator.

FIG. **5** is an illustration of a computer-readable medium or computer-readable device including processor-executable instructions configured to embody one or more of the provisions set forth herein.

DETAILED DESCRIPTION

Definitions

The following includes definitions of selected terms employed herein. The definitions include various examples and/or forms of components that fall within the scope of a term and that may be used for implementation. The examples are not intended to be limiting. Furthermore, the components discussed herein, may be combined, omitted, or organized with other components or into different architectures.

"Bus," as used herein, refers to an interconnected architecture that is operably connected to other computer components inside a computer or between computers. The bus may transfer data between the computer components. The bus may be a memory bus, a memory processor, a peripheral bus, an external bus, a crossbar switch, and/or a local bus, among others. The bus may also interconnect with components inside a device using protocols such as Media Oriented Systems Transport (MOST), Controller Area network (CAN), Local Interconnect network (LIN), among others.

"Component," as used herein, refers to a computer-related entity (e.g., hardware, firmware, instructions in execution, combinations thereof). Computer components may include, for example, a process running on a processor, a processor, an object, an executable, a thread of execution, and a computer. A computer component(s) may reside within a process and/or thread. A computer component may be localized on one computer and/or may be distributed between multiple computers.

"Computer communication," as used herein, refers to a communication between two or more communicating devices (e.g., computer, personal digital assistant, cellular telephone, network device, vehicle, connected thermometer, infrastructure device, roadside equipment) and may be, for example, a network transfer, a data transfer, a file transfer, an applet transfer, an email, a hypertext transfer protocol (HTTP) transfer, and so on. A computer communication may occur across any type of wired or wireless system and/or network having any type of configuration, for example, a local area network (LAN), a personal area network (PAN), a wireless personal area network (WPAN), a wireless network (WAN), a wide area network (WAN), a metropolitan area network (MAN), a virtual private network (VPN), a cellular network, a token ring network, a point-to-point network, an ad hoc network, a mobile ad hoc network, a vehicular ad hoc network (VANET), among others.

Computer communication may utilize any type of wired, wireless, or network communication protocol including, but not limited to, Ethernet (e.g., IEEE 802.3), WiFi (e.g., IEEE 802.11), communications access for land mobiles (CALM), WiMax, Bluetooth, Zigbee, ultra-wideband (UWAB), multiple-input and multiple-output (MIMO), telecommunications and/or cellular network communication (e.g., SMS, MMS, 3G, 4G, LTE, 5G, GSM, CDMA, WAVE, CAT-M, LoRa), satellite, dedicated short range communication (DSRC), among others.

"Communication interface" as used herein may include input and/or output devices for receiving input and/or devices for outputting data. The input and/or output may be for controlling different features, components, and systems. Specifically, the term "input device" includes, but is not limited to: keyboard, microphones, pointing and selection devices, cameras, imaging devices, video cards, displays, push buttons, rotary knobs, and the like. The term "input device" additionally includes graphical input controls that take place within a user interface which may be displayed by various types of mechanisms such as software and hardware-based controls, interfaces, touch screens, touch pads or plug and play devices. An "output device" includes, but is not limited to, display devices, and other devices for outputting information and functions.

"Computer-readable medium," as used herein, refers to a non-transitory medium that stores instructions and/or data. A computer-readable medium may take forms, including, but not limited to, non-volatile media, and volatile media. Non-volatile media may include, for example, optical disks, magnetic disks, and so on. Volatile media may include, for example, semiconductor memories, dynamic memory, and so on. Common forms of a computer-readable medium may include, but are not limited to, a floppy disk, a flexible disk, a hard disk, a magnetic tape, other magnetic medium, an ASIC, a CD, other optical medium, a RAM, a ROM, a memory chip or card, a memory stick, and other media from which a computer, a processor or other electronic device may read.

"Database," as used herein, is used to refer to a table. In other examples, "database" may be used to refer to a set of tables. In still other examples, "database" may refer to a set of data stores and methods for accessing and/or manipulating those data stores. In one embodiment, a database may be stored, for example, at a disk, data store, and/or a memory. A database may be stored locally or remotely and accessed via a network.

"Data store," as used herein may be, for example, a magnetic disk drive, a solid-state disk drive, a floppy disk drive, a tape drive, a Zip drive, a flash memory card, and/or a memory stick. Furthermore, the disk may be a CD-ROM (compact disk ROM), a CD recordable drive (CD-R drive), a CD rewritable drive (CD-RW drive), and/or a digital video ROM drive (DVD ROM). The disk may store an operating system that controls or allocates resources of a computing device.

"Display," as used herein may include, but is not limited to, LED display panels, LCD display panels, CRT display, touch screen displays, among others, that often display information. The display may receive input (e.g., touch input, keyboard input, input from various other input devices, etc.) from a user. The display may be accessible through various devices, for example, though a remote system. The display may also be physically located on a portable device or mobility device.

"Memory," as used herein may include volatile memory and/or nonvolatile memory. Non-volatile memory may include, for example, ROM (read only memory), PROM (programmable read only memory), EPROM (erasable PROM), and EEPROM (electrically erasable PROM). Volatile memory may include, for example, RAM (random access memory), synchronous RAM (SRAM), dynamic RAM (DRAM), synchronous DRAM (SDRAM), double data rate SDRAM (DDRSDRAM), and direct RAM bus RAM (DRRAM). The memory may store an operating system that controls or allocates resources of a computing device.

"Module," as used herein, includes, but is not limited to, non-transitory computer readable medium that stores instructions, instructions in execution on a machine, hardware, firmware, software in execution on a machine, and/or combinations of each to perform a function(s) or an action (s), and/or to cause a function or action from another module, method, and/or system. A module may also include logic, a software-controlled microprocessor, a discrete logic circuit, an analog circuit, a digital circuit, a programmed

logic device, a memory device containing executing instructions, logic gates, a combination of gates, and/or other circuit components. Multiple modules may be combined into one module and single modules may be distributed among multiple modules.

"Operable connection," or a connection by which entities are "operably connected," is one in which signals, physical communications, and/or logical communications may be sent and/or received. An operable connection may include a wireless interface, firmware interface, a physical interface, a data interface, and/or an electrical interface.

"Portable device," as used herein, is a computing device typically having a display screen with user input (e.g., touch, keyboard) and a processor for computing. Portable devices include, but are not limited to, handheld devices, mobile devices, smart phones, laptops, tablets, e-readers, smart speakers. In some embodiments, a "portable device" could refer to a remote device that includes a processor for computing and/or a communication interface for receiving and transmitting data remotely.

"Processor," as used herein, processes signals and performs general computing and arithmetic functions. Signals processed by the processor may include digital signals, data signals, computer instructions, processor instructions, messages, a bit, a bit stream, that may be received, transmitted and/or detected. Generally, the processor may be a variety of various processors including multiple single and multicore processors and co-processors and other multiple single and multicore processor and co-processor architectures. The processor may include logic circuitry to execute actions and/or algorithms. The processor may also include any number of modules for performing instructions, tasks, or executables.

"User" as used herein may be a biological being, such as humans (e.g., adults, children, infants, etc.).

System Overview

Referring now to the drawings, which are for purposes of illustrating one or more exemplary embodiments and not for purposes of limiting the same, FIG. **1** is an exemplary component diagram of an operating environment **100** of a refrigerator **102** including a trigger switch **104**, a plurality of cameras **110**, lights **112**, a cooling system **114**, a door angle sensor **116** and a computing device **120**.

Each of the trigger switch **104**, the plurality of cameras **110**, the lights **112**, the cooling system **114**, and the computing device **120** may be interconnected by a bus **124**. The components of the operating environment **100**, as well as the components of other systems, hardware architectures, and software architectures discussed herein, may be combined, omitted, or organized into different architectures for various embodiments.

The computing device **120** may be implemented as a part of the refrigerator **102** or another device, e.g., a remote server **130**, connected via a network **132**. The computing device **120** may be capable of providing wired or wireless computer communications utilizing various protocols to send and receive electronic signals internally to and from components of the operating environment **100**. Additionally, the computing device **120** may be operably connected for internal computer communication via the bus **124** (e.g., a Controller Area Network (CAN) or a Local Interconnect Network (LIN) protocol bus) to facilitate data input and output between the computing device **120** and the components of the operating environment **100**.

The cooling system **114** can be similar to those found in known refrigerators, and therefore will not be described in detail. The cooling system **114** can include temperature sensors for sensing temperatures within the refrigerator **102** and air blower fans supplying air cooled by cooling devices (not shown), which can include a compressor (not shown) compressing refrigerant, a condenser (not shown) condensing the compressed refrigerant, an expansion valve (not shown) decompressing the condensed refrigerant, and an evaporator (not shown) evaporating the decompressed refrigerant.

As shown in FIG. **2**, the refrigerator **102** includes a main body **140** and a door **142** pivotally mounted to and movable with respect to the main body **140** between an open position and a closed position similar to known refrigerators. The door **142** is connected to the main body **140** through an upper hinge **144** and a lower hinge **154**. The main body **140** and the door **142** define a plurality of storage compartments within a refrigerated enclosure **172** when the door **142** is in the closed position. The plurality of storage compartments includes a first storage compartment **174**, a second storage compartment **180**, a third storage compartment **182**, a fourth storage compartment **184**, a fifth storage compartment **190**, which are each located within the main body **140** in the illustrated embodiment. A sixth storage compartment **192**, a seventh storage compartment **194**, and an eighth storage compartment **200** are located on the door **142** in the illustrated embodiment. The number and location of the storage compartments **174**, **180**, **182**, **184**, **190**, **192**, **194** and **200** may differ from that shown in FIGS. **2** and **3**.

As illustrated in FIGS. **2** and **3**, a first shelf **202** and a second shelf **204** are disposed in the first storage compartment **174**. A third shelf **210** is disposed in the second storage compartment **180**. A first drawer **212** is disposed in the third storage compartment **182**. A second drawer **214** is disposed in the fourth storage compartment **184**. A third drawer **220** disposed in the fifth storage compartment **190**. A first bin **222** is disposed in the sixth storage compartment **192**. A second bin **224** is disposed in the seventh storage compartment **194**. A third bin **230** is disposed in the eighth storage compartment **200**.

Each storage compartment **174**, **180**, **182**, **184**, **190**, **192**, **194** and **200** defines a respective entrance opening through which items may be placed into and taken out of the corresponding storage compartment. More specifically and with reference to FIG. **2**, the first storage compartment **174** defines a first entrance opening **232** leading onto the first shelf **202** and the second shelf **204**, and the second storage compartment **180** defines a second entrance opening **234** leading onto the third shelf **210**. The third storage compartment **182** defines a third entrance opening (not visible in FIGS. **2** and **3**) leading into the first drawer **212**, the fourth storage compartment **184** defines a fourth entrance opening (not visible in FIGS. **2** and **3**) leading into the second drawer **214**, and the fifth storage compartment **190** defines a fifth entrance opening (not visible in FIGS. **2** and **3**) leading into the third drawer **220** when the respective drawers **212**, **214**, **220** are opened. The sixth storage compartment **192** defines a sixth entrance opening **250** leading into the first bin **222**, the seventh storage compartment **194** defines a seventh entrance opening **252** leading into the second bin **224**, and the eighth storage compartment **200** defines an eighth entrance opening **254** leading into the third bin **230**.

The plurality of cameras **110** is mounted to the main body **140** and the door **142** for capturing images of objects moving into and out of the plurality of storage compartments **174**, **180**, **182**, **184**, **190**, **192**, **194** and **200**. The plurality of cameras **110** includes a first set of cameras **260***a*, **260***b* mounted on the main body **140** associated with the first storage compartment **174**, a second set of cameras **262***a*,

262*b* mounted on the main body **140** associated the second storage compartment **180**, a third set of cameras **264***a*, **264***b* mounted on the main body **140** associated with the third storage compartment **182**, a fourth set of cameras **270***a*, **270***b* mounted on the main body **140** associated with the fourth storage compartment **184**, and a fifth set of cameras **272***a*, **272***b* mounted on the main body **140** associated with the fifth storage compartment **190**. As more clearly seen in FIG. **3**, the plurality of cameras **110** also includes a sixth set of cameras **274***a*, **274***b* mounted on the door **142** associated with the sixth storage compartment **192**, a seventh set of cameras **280***a*, **280***b* mounted on the door **142** associated with the seventh storage compartment **194**, and an eighth set of cameras **282***a*, **282***b* mounted on the door **142** associated with the eighth storage compartment **200**.

As shown between FIGS. **2** and **3**, the cameras with a suffix "a" are positioned at a left side of the corresponding storage compartment, and the cameras with a suffix "b" are positioned at a right side of the corresponding storage compartment. Instead of having a field of view towards the interior of the refrigerator **102**, each camera among the plurality of cameras **110** has a field of view directed away from the interior of the refrigerator **102**. The first set of cameras **260***a*, **260***b* are positioned in a top portion of the first storage compartment **174** above the first shelf **202** and the second shelf **204** with a field of view encompassing the first entrance opening **232**. The second set of cameras **262***a*, **262***b* are positioned at a top portion of the second storage compartment **180** above the third shelf **210** with a field of view encompassing the second entrance opening **234**. The third set of cameras **264***a*, **264***b* are positioned above the first drawer **212** with a field of view encompassing the third entrance opening (not visible in FIGS. **2** and **3**) leading into the first drawer **212** when the first drawer **212** is opened. The fourth set of cameras **270***a*, **272***b* are positioned above the second drawer **214** with a field of view encompassing the fourth entrance opening (not visible in FIGS. **2** and **3**) leading into the second drawer **214** when the second drawer **214** is opened. The fifth set of cameras **272***a*, **272***b* are positioned above the third drawer **220** with a field of view encompassing the fifth entrance opening (not visible in FIGS. **2** and **3**) leading into the third drawer **220** when the third drawer **220** is opened.

The sixth set of cameras **274***a*, **274***b* are mounted to the door **142** above the first bin **222** with a field of view encompassing the sixth entrance opening **250**. The seventh set of cameras **280***a*, **280***b* are mounted to the door **142** above the second bin **224** with a field of view encompassing the seventh entrance opening **252**. The eighth set of cameras **282***a*, **282***b* are mounted to the door **142** above the third bin **230** with a field of view encompassing the eighth entrance opening **254**. In this manner, each camera in the plurality of cameras **110** is positioned to have a field of view that includes a respective entrance opening leading to the corresponding storage compartment when the door **142** is in the open position. With this construction, the plurality of cameras **110** is configured to capture images of an item passing through any of the entrance openings as the item is being loaded into or is being removed from the corresponding storage compartment.

The computing device **120** controls the lights **112** (only depicted schematically in FIG. **1**, but similar to lights in known refrigerators) during a session for optimized processing by computer vision models described below. The computing device **120** also controls configuration aspects of each camera in the plurality of cameras **110** including a frame rate and an exposure for optimized processing by the computer vision models.

With reference to FIGS. **1** and **2**, the refrigerator **102** includes the trigger switch **104** mounted to the main body **140**. The trigger switch **104** is operably connected with the computing device **120** and configured for detecting a position of the door **142** to indicate whether the door **142** is in the open position or the closed position. In this manner, the trigger switch **104** is configured to send a trigger signal to the computing device **120** based on whether the door **142** is in the open position or the closed position. More specifically, the trigger switch **104** is configured to send a start trigger signal to the computing device **120** when the door **142** moves from the closed position toward the open position, and the trigger switch **104** is configured to send a stop trigger signal to the computing device **120** when the door **142** moves from the open position to the closed position. The trigger switch **104** may include at least one of various types of position sensors such as mechanical switches, potentiometers, piezoelectric sensors, Hall effect sensors, and eddy-current sensors without departing from the scope of the present disclosure. Also, while the trigger switch **104** is shown disposed on the main body **140**, the trigger switch **104** may additionally or alternatively be positioned on the door **142**.

The door angle sensor **116** is configured to determine the angle of the door **142** with respect to the main body **140**. The door angle sensor **116**, for example, could include a rotary encoder having a shaft the rotates as the door **142** pivots with respect to the main body **140** to output and communicate with the computing device **120** to communicate the relative angular position of the door **142** with respect to the main body **140**.

Referring back to FIG. **1**, the computing device **120** includes a processor **464**, a memory **470**, a data store **472**, and a communication interface **474**, which are each operably connected for computer communication via the bus **124**. The communication interface **474** provides software and hardware to facilitate data input and output between the components of the computing device **120** and other components, networks, and data sources, which will be described herein. The computing device **120** also includes a session controller module **480**, a synchronizer module **482**, a buffer module **484**, an object identification module **490**, an object tracking module **492**, an object merge module **494**, a subsequence delineation module **500**, a direction module **502**, and an inventory update module **504** for receiving image information from the plurality of cameras **110** and tracking inventory in the refrigerator **102**.

The computing device **120** is in operable connection with the plurality of cameras **110**. The session controller module **480** is configured to start a session and to instruct each camera in the plurality of cameras **110** to begin capturing images based on the start trigger signal received by the session controller module **480** from the trigger switch **104**. The plurality of cameras **110** begin capturing images after the session controller module **480** receives the start trigger signal from the trigger switch **104**, and the plurality of cameras **110** cease capturing images after the session controller module **480** receives the stop trigger signal from the trigger switch **104**. The plurality of cameras **110** are each configured to compress captured images, to assign a session identification (ID), to assign a camera identification (ID) and to assign a frame identification (ID) for each captured image and send the compressed images along with their respective session ID, camera ID and frame ID to the synchronizer

module **482**, which can occur during or after a session, which is the time between opening and closing of the door **142**. A session can be relatively long and may include the transferring of multiple items into and out of the refrigerator **102**.

The synchronizer module **482** is configured to receive captured images and the session ID, camera ID and frame ID associated with each captured image from the plurality of cameras **110**, and to group the captured images into frame sets based on the frame ID associated with each captured image. Each frame set is made up of respective captured images that were captured at the same time from different cameras among the plurality of cameras **110**. In an embodiment, the synchronizer module **482** groups captured images from the plurality of cameras **110** based on the frame ID associated with each image. In this regard, the same frame ID among different captured images indicates the images were taken at the same time albeit from different cameras.

The synchronizer module **482** receives the session ID and the camera ID, in addition to the frame ID for each captured image received from each camera in the plurality of cameras **110**. The session ID is associated with the session assigned by the session controller module **480**, the camera ID is associated with a particular camera among the plurality of cameras **110** that captured the captured image, and the frame ID, as mentioned above, is associated with a time at which the captured image was captured.

The buffer module **484** is configured to store compressed captured images as an image buffer memory, and is configured to send the compressed captured images to a remote server, e.g., the remote server **130** (FIG. **1**), for post processing after the session ends. With this construction, system resources of the computing device **120** may be directed to image capture during the session, and then directed to post processing when the session has ended, thereby reducing a capacity of the computing device **120** required for receiving image information from the plurality of cameras **110** and tracking inventory in the refrigerator **102**.

The object identification module **490** is configured to determine whether each captured image in a respective frame set contains an object, to define a bounding box around each object located in the respective captured image and to assign a class identification to the object. Class identifications assigned by the object identification module **490** indicate an inventory type of the object. The inventory type can be maintained in the memory **470** and/or data store **472** of the computing device **120**, or stored remotely and accessed via the network **132**. The inventory type may indicate a category of ingredient, food product, meal, dish, or other object type maintained in the database.

The object identification module **490** includes a computer vision model that outputs a bounding box around the object and the class identification for the object for each captured image. In an embodiment, the computer vision model is YOLOv5, however the object identification module **490** may include additional or alternative computer vision models for determining object presence and class identification in the refrigerator **102** without departing from the scope of the present disclosure.

The computer vision model used in the object identification module **490** can also be configured to remove images from frame sets received from the synchronizer module **482** that do not contain an object and to output an updated group of images to the object tracking module **492**. The updated group of images, which may include only captured images that contain an object, may include a lesser number of images as compared to the frame set received by object identification module **490** from the synchronizer module **482**. The first captured image that contains an object in the updated group of images can indicate the start of a sequence, which indicates one hand motion in or out of the refrigerator. The last captured image that contains an object in the updated group of images can indicate the end of the sequence. Where the object identification module **490** identifies no object, for example the object identification module **490** identifies an empty hand without any object to be loaded into or removed from the refrigerator, the last captured image containing the object can indicate the end of the sequence. Each sequence, or detected motion in or out of the refrigerator **102**, can contain multiple objects. For example, a person could insert two items, e.g., an apple and a cup of yogurt, into or out of the refrigerator in a single sequence. In such an instance, the object identification module **490** assigns a first class identification to the apple that appears as one object in the captured image and assigns a second class identification to the cup of yogurt that appears as another object in the captured image.

The object tracking module **492** is configured to analyze sequential captured images from each camera in the plurality of cameras **110** tracking objects among the sequential captured images per camera. In an embodiment, the object tracking module **492** compares a first n images captured in the updated group of images during a sequence to a last n images captured in the updated group of images during the sequence to track movement of objects during the sequence. Then number n of images in the illustrated embodiment is three, but the number could be higher or lower. Determination of the temporal sequence of captured images is based on the frame ID associated with each image. For example, captured images having a higher frame ID can be captured later in time as compared to those with a lower frame ID. Determination of the camera that captured a respective captured image is based on the camera ID associated with the respective captured image. In this regard, the object tracking module **492** associates an object with itself across sequential images per camera, thereby tracking movement of the object over time.

In an embodiment, the object tracking module **492** is also configured to assign track identifications to associate the object in one analyzed image to the object in other analyzed images per camera in the plurality of cameras **172**. Track identifications assigned by the object tracking module **492** are unique to each camera in the plurality of cameras **172**, and unique to each object captured by the plurality of cameras **172** in sequential captured images. With reference to the apple and cup of yogurt example discussed above, the object tracking module **492** is configured to assign a different track identification to the object that appears as the apple in the captured image than the track identification for the object that appears as the cup of yogurt in the captured image. Also, the track identification for the object that appears as the apple in the captured image from camera **260***a* of the first set of cameras **260***a*, **260***b* will be a different track identification for the object that appears as the apple in the captured image from camera **260***b*. In this manner, each track identification assigned by the object tracking module **492** identifies a single object across sequential captured images by a single camera in the plurality of cameras **172**.

The object tracking module **492** can employ an observation-centric simple online and real-time tracking (OCSORT) algorithm for analyzing the sequential captured images from each camera in the plurality of cameras **110**. With this construction, the object tracking module **492** receives the updated group of images with bounding boxes and class IDs

from the object identification module **490** and the OCSORT algorithm can process the updated group of images, and then output a further updated group of images with the bounding boxes, class IDs and additionally include associated track IDs for each object located in each captured image in the further updated group of images.

The object merge module **494** is configured to compare track IDs among analyzed images from different cameras in the plurality of cameras **110**, and to assign a merge ID to an object when the object is detected by the object identification module **490** in captured images captured by multiple different cameras in the plurality of cameras **110**. With reference to the apple and cup of yogurt example discussed above, the object merge module **494** is configured to compare the different track identifications for the object that appears as the apple in the captured images from camera **260***a* of the first set of cameras **260***a*, **260***b* with the different track identification for the object that appears as the apple in the captured images from camera **260***b* and to assign the same merge ID for the object that appears as the apple in the captured images from both cameras **260**, **260***b*. The object merge module **494** determines the merge ID based on each track ID of the same sequence.

Each merge ID assigned by the object merge module **494** is unique to a single object captured by the plurality of cameras **110** during a subsequence of a sequence. Where a sequence refers to one hand motion into or out of the refrigerator **102**, a subsequence refers to the transfer of an individual item into or out of the refrigerator **102**. As such, each merge ID assigned by the object merge module **494** associates an object with itself across images captured by multiple different cameras in the plurality of cameras **110** per sequence. The object merge module **494** is supported by an algorithm to analyze the object(s) in the bounding box(es) in each captured image in the further updated group of images and to assign the same merge ID to the same object detected in images captured from different cameras per sequence. With reference to the apple and cup of yogurt example discussed above, there will be a different merge ID associated with the apple as compared to with the cup of yogurt.

The subsequence delineation module **500** is configured to split a session into subsequences by corresponding merge IDs received from the object merge module **494**. Each subsequence defined by the subsequence delineation module **500** corresponds to a single merge identification, which corresponds to an inventory change with respect to a single item among the plurality of storage compartments **172**. As such, the subsequence delineation module **500** is configured to split the session in accordance with individual inventory changes among the plurality of compartments **172**.

The direction module **502** is configured to assign a direction to each subsequence based on the analyzed images to determine if the object is moving into, out of or internally within the refrigerated enclosure. In an embodiment, the direction module **502** uses a transformer based classifier, e.g., a vision transformer such as CSWin Transformer, and compares the first n analyzed images to the last n analyzed images during a subsequence to determine the direction, where n can be three images. Because the analyzed images are those that contain the object, the first n analyzed images are indicate of the object entering a particular camera's field of view and the last n images are indicative to the object leaving the particular camera's field of view. For example, the direction module **502** is configured to locate the centroid of the bounding box around the object within the first n analyzed images and the last n analyzed images. The location of the centroid within each analyzed image and the change of location of the centroid from one analyzed image to another provides an indication of movement and the direction of movement of the object that is bound by the bounding box. Because the cameras **274***a*, **274***b*, **280***a*, **280***b*, **282***a*, **282***b* mounted to the door **142** can move with respect to the main body **140**, knowing the door angle, which can be calculated using the door angle sensor **116**, provides accurate dimensions for determining the movement of the centroid of the bounding box among the analyzed images. Moreover, because the location of the cameras **260***a*, **260***b*, **262***a*, **262***b*, **264***a*, **264***b*, **272***a*, **272***b* mounted to the main body **140** are known with respect to their location relative to the plurality of storage compartments **174**, **180**, **182**, **184**, **190** in the main body and can be determined based on the door angle with respect to the plurality of storage compartments **192**, **194** and **200**, the movement of the centroid of the bounding boxes over the analyzed images can be used to detect the direction of the object within the bounding box over the **2***n* images being analyzed.

In another embodiment, the direction module **502** can determine the direction of the object with reference to a corresponding entrance opening **232**, **234**, **250**, **252**, **254** in a three-dimensional grid space, over time between sequential images, and across multiple cameras in the plurality of cameras **110**. In an embodiment, the direction module **502** compares the first captured image to the last captured image by the plurality of cameras **110** during a subsequence to determine the direction.

The direction module **502** is supported by an algorithm configured to determine of the direction of movement of the object within the subsequence based on knowing the location of each camera of the plurality of cameras **110** with respect to the entrance openings **232**, **234**, **250**, **252**, **254**. For example, and with reference back to FIGS. **2** and **3**, the location of the first set of cameras **260***a*, **260***b* with respect to the first entrance opening **232** is known due to the mounting location of the first set of cameras **260***a*, **260***b* on the main body **140** with respect to the first entrance opening **232**. Because the location of the first set of cameras **260***a*, **260***b* with respect to the first entrance opening **232** is known, the location of the first entrance opening **232** within each cameras' **260***a*, **260***b* field of view is also known. If the first captured image of the subsequence detects the object on internal side of a plane defined by the first entrance opening **232** and the last captured of the subsequence detects the object on an external side of the plane defined by the first entrance opening **232**, then the direction module **502** can assign a direction for the object as going out of the refrigerator **102**. In contrast, if the first captured image of the subsequence detects the object on the external side of the plane defined by the first entrance opening **232** and the last captured of the subsequence detects the object on the internal side of the plane defined by the first entrance opening **232**, then the direction module **502** can assign a direction for the object as going into the refrigerator **102**.

The inventory update module **504** is configured to communicate with the memory **470** and/or the data store **472** via the bus **124** and/or the remote server **130** via the network **132** to update an inventory status of at least one storage compartment in the plurality of storage compartments **172** based on each inventory change and the direction assigned thereto. The inventory update module **504** can also be configured to send all captured images of a session to the remote server **130** via a data pipeline routed through the network **132**. The inventory update module **504** can also be configured to package corresponding subsequence data including object identification information, track identifica-

tion information, and direction information for each merge identification, and to send the subsequence data to the object storage service with the captured images.

When an object is detected as going out of the refrigerator **102** by the direction module **502**, then the item that was located in the refrigerator and was the object associated with that particular item, is removed from the inventory of the refrigerator. This inventory information can be stored in the memory **470**, the data store **472** and/or the remote server **130** and can be output to an application accessible by a portable device **510** for viewing the inventory information on a display of the portable device **510**.

Methods for Tracking Inventory

Referring to FIG. **4**, a method **600** for tracking inventory in the refrigerator **102** will be described according to an exemplary embodiment. FIG. **4** will be described with reference to FIGS. **1-3**. For simplicity, the method **600** will be described as a sequence of blocks, but the elements of the method **600** can be organized into different architectures, elements, stages, and/or processes.

At block **602**, the method **600** includes sending a start trigger signal when the door **142** moves from the closed position to the open position. In this regard, the trigger switch **104** sends a start trigger signal to the session controller module **480** when the trigger switch **104** detects a position of the door **142** to be in the open position.

At block **604**, the method **600** includes starting a session based on receiving the start trigger signal. In this regard, the session controller module **480** starts a session in response to receiving a start trigger signal from the trigger switch **104**.

At block **606**, the method **600** includes capturing images using the plurality of cameras **110** mounted to at least one of the main body **140** and the door **142** after the start trigger signal has been received by the session controller module **480**. The main body **140** and the door **142** define a refrigerated enclosure when the door **142** is in the closed position, and each camera is positioned to have a field of view through an entrance opening plane of the refrigerated enclosure which is accessible when the door is in the open position. As such, the plurality of cameras **110** is configured to capture images of an object passing through the entrance opening plane during the session, as the object is being loaded into or is being removed from the refrigerated enclosure.

At block **608**, the method **600** includes sending a stop trigger signal when the door **142** changes from the open position to the closed position. In this regard, the trigger switch **104** sends a stop trigger signal to the session controller module **480** when the position sensor **454** detects the door **142** has moved from the open position to the closed position. At block **608**, the method **600** further includes ending the session started at block **604** based on receiving a stop trigger signal. In this regard, the session controller module **480** ends the session started at block **602** when the session controller module **480** receives the stop trigger signal from the trigger switch **104** and the session controller **480** can update so that the next session is identified with a new session ID. The plurality of cameras **110** cease capturing images after the session controller module **480** receives the stop trigger signal.

At block **610**, the method **600** includes grouping the captured images taken from the plurality of cameras **110** at block **606**. In this regard, the synchronizer module **482** receives the compressed images from the plurality of cameras **110**, and outputs frame sets to the buffer module **484** and to the object identification module **490**. In this regard, the synchronizer module **482** groups the captured images into frame sets, where each frame set is made up of captured images that were captured at a same time from different cameras among the plurality of cameras **110**. With continued reference to block **610**, the method **600** also includes receiving a session identification, a camera identification, and a frame identification for each captured image received from each camera of the plurality of cameras **110**. The session identification is associated with the session, the camera identification is associated with a particular camera among the plurality of cameras **110** that captured the image, and the frame identification is associated with a time at which the captured image was captured. In this regard, the synchronizer module **482** groups the captured images based on the session identification, the camera identification, and the frame identification for each captured image.

At block **620**, the method **600** includes storing compressed captured images that were captured in block **606** in an image buffer memory. The compressed images can be sent to post processing after the session ends. In this regard, the buffer module **484** stores the images captured by the plurality of cameras **110** during the session started at block **604**, and sends the compressed images to the synchronizer module **482** for post processing after the session ends.

At block **622**, the method **600** includes determining whether each captured image from block **606** contains an object, and assigning a class identification to the object. With continued reference to block **622**, the method **600** also includes using a computer vision model to output a bounding box around the object and the class identification for the object for each captured image. In this regard, the object identification module **490** receives frame sets output from the synchronizer module **482** to determine whether each captured image in a respective frame set contains the object, assigns a class identification to the object, and outputs a bounding box around the object.

At block **624**, the method **300** includes analyzing sequential captured images from each camera in the plurality of cameras **172** and assigning a track identification associated with the object in each analyzed image per camera. In this regard, the object tracking module **492** receives the sequential captured images from the object identification module **490** for assigning track identifications, and outputs the track identifications to the object merge module **494**. In an embodiment, the object tracking module **492** analyzes sequential captured images and assigns a track identification using an observation-centric simple online and real-time tracking algorithm.

At block **630**, the method **600** includes comparing track identifications among the analyzed images from different cameras in the plurality of cameras **172** and assigning a merge identification to the object when the object is detected in captured images captured by multiple different cameras in the plurality of cameras **172**. In this regard, the object merge module **494** receives and compares track identifications from the object tracking module **492**, and outputs merge identifications to the subsequence delineation module.

At block **632**, the method **600** includes splitting the session into subsequences by corresponding merge identifications, where each subsequence corresponds to an inventory change within the refrigerated enclosure. In this regard, the subsequence delineation module **500** receives the merge identifications from the object merge module **494**, and outputs subsequences to the direction module **502**.

At block **634**, the method **600** includes assigning a direction to each subsequence based on the analyzed images to determine if the object is moving into, out of or internally within the refrigerated enclosure. In this regard, the direction module **502** receives subsequences from the subsequence

delineation module **500**, and outputs assigned directions to the inventory update module **504**.

At block **640**, the method **600** includes updating an inventory status in a database based on each subsequence and the direction assigned thereto. In this regard, the inventory update module **504** receives subsequences from the subsequence delineation module **502**, and receives assigned directions from the direction module **502** to update an inventory status maintained on the database.

An aspect of the present disclosure involves a computer-readable medium including processor-executable instructions configured to implement at least one aspect of the techniques presented herein. An aspect of a computer-readable medium or a computer-readable device devised in these ways is illustrated in FIG. **5**, where an implementation **700** includes a computer-readable medium **702**, such as a CD-R, DVD-R, flash drive, a platter of a hard disk drive, etc., on which is encoded computer-readable data **704**. This encoded computer-readable data **704**, such as binary data including a plurality of zero's and one's as shown in FIG. **5**, in turn includes a set of processor-executable computer instructions **710** configured to operate according to one or more of the principles set forth herein. In this implementation **700**, the processor-executable computer instructions **710** may be configured to perform a method **712**, such as the method **600** of FIG. **4**. In another aspect, the processor-executable computer instructions **710** may be configured to implement a system, such as the operating environment **100** of FIG. **1**. Many such computer-readable media may be devised by those of ordinary skill in the art that are configured to operate in accordance with the techniques presented herein.

As used in this application, the terms "component", "module," "system", "interface", and the like are generally intended to refer to a computer-related entity, either hardware, a combination of hardware and software, software, or software in execution. For example, a component may be, but is not limited to being, a process running on a processor, a processing unit, an object, an executable, a thread of execution, a program, or a computer. By way of illustration, both an application running on a controller and the controller may be a component. One or more components residing within a process or thread of execution and a component may be localized on one computer or distributed between two or more computers.

Further, the claimed subject matter is implemented as a method, apparatus, or article of manufacture using standard programming or engineering techniques to produce software, firmware, hardware, or any combination thereof to control a computer to implement the disclosed subject matter. The term "article of manufacture" as used herein is intended to encompass a computer program accessible from any computer-readable device, carrier, or media. Of course, many modifications may be made to this configuration without departing from the scope or spirit of the claimed subject matter.

The term "computer readable media" includes communication media. Communication media typically embodies computer readable instructions or other data in a "modulated data signal" such as a carrier wave or other transport mechanism and includes any information delivery media. The term "modulated data signal" includes a signal that has one or more of its characteristics set or changed in such a manner as to encode information in the signal.

Although the subject matter has been described in language specific to structural features or methodological acts, it is to be understood that the subject matter of the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example aspects. Various operations of aspects are provided herein. The order in which one or more or all of the operations are described should not be construed as to imply that these operations are necessarily order dependent. Alternative ordering will be appreciated based on this description. Further, not all operations may necessarily be present in each aspect provided herein.

As used in this application, "or" is intended to mean an inclusive "or" rather than an exclusive "or". Further, an inclusive "or" may include any combination thereof (e.g., A, B, or any combination thereof). In addition, "a" and "an" as used in this application are generally construed to mean "one or more" unless specified otherwise or clear from context to be directed to a singular form. Additionally, at least one of A and B and/or the like generally means A or B or both A and B. Further, to the extent that "includes", "having", "has", "with", or variants thereof are used in either the detailed description or the claims, such terms are intended to be inclusive in a manner similar to the term "comprising".

Further, unless specified otherwise, "first", "second", or the like are not intended to imply a temporal aspect, a spatial aspect, an ordering, etc. Rather, such terms are merely used as identifiers, names, etc. for features, elements, items, etc. For example, a first channel and a second channel generally correspond to channel A and channel B or two different or two identical channels or the same channel. Additionally, "comprising", "comprises", "including", "includes", or the like generally means comprising or including, but not limited to.

It will be appreciated that variations of the above-disclosed embodiments and other features and functions, or alternatives or varieties thereof, may be desirably combined with many other different systems or applications. Also, various presently unforeseen or unanticipated alternatives, modifications, variations or improvements therein may be subsequently made by those skilled in the art which are also intended to be encompassed by the following claims.

The invention claimed is:

1. A refrigerator comprising:

a main body and a door pivotally mounted to and movable with respect to the main body between an open position and a closed position, the main body and the door defining a plurality of storage compartments within a refrigerated enclosure when the door is in the closed position;

a plurality of cameras mounted to at least one of the main body and the door, each camera positioned to have a field of view that includes an entrance opening leading to at least one storage compartment when the door is in the open position, the plurality of cameras being configured to capture images of an object passing through the entrance opening as the object is being loaded into or is being removed from the at least one storage compartment; and

at least one computing device in operable connection with the plurality of cameras, the at least one computing device including:

a session controller module configured to start a session and to instruct each camera to begin capturing images based on a trigger signal received by the session controller;

a synchronizer module configured to receive captured images from the plurality of cameras and to group the captured images into frame sets, each frame set

made up of respective captured images that were captured at a same time from different cameras among the plurality of cameras;

an object identification module configured to determine whether each captured image in a respective frame set contains the object and to assign a class identification to the object;

an object tracking module configured to analyze sequential captured images from each camera and to assign track identifications to associate the object in one analyzed image to the object in other analyzed images per camera;

an object merge module configured to compare the track identifications among the analyzed images from different cameras and to assign a merge identification to the object when the object is detected by the object identification module in captured images captured by multiple different cameras among the plurality of cameras;

a subsequence delineation module configured to split the session into subsequences by corresponding merge identifications received from the object merge module, wherein each subsequence corresponds to an inventory change for the at least one storage compartment;

a direction module configured to assign a direction to each subsequence based on the analyzed images to determine if the object is moving into, out of or internally within the refrigerated enclosure; and

an inventory update module configured to communicate with a database to update an inventory status of the at least one storage compartment based on each inventory change and the direction assigned thereto.

2. The refrigerator of claim **1**, wherein the plurality of cameras mounted to the main body each have a field of view directed away from the refrigerated enclosure.

3. The refrigerator of claim **1**, wherein the plurality of cameras each have a field of view encompassing at least a portion of at least one entrance opening leading to at least one storage compartment among the plurality of storage compartments.

4. The refrigerator of claim **1**, wherein each storage compartment among the plurality of storage compartments is associated with at least one camera among the plurality of cameras such that the at least one camera has a field of view encompassing at least a portion of a respective entrance opening of a particular storage compartment among the plurality of storage compartments.

5. The refrigerator of claim **4**, wherein each storage compartment among the plurality of storage compartments is associated with at least two cameras mounted on opposite sides of each respective storage compartment.

6. The refrigerator of claim **1**, wherein the direction module assigns the direction to each subsequence based on a known mounting location of each camera on the main body.

7. The refrigerator of claim **6**, further comprising a door angle sensor configured to determine an angle of the door with respect to the main body when the door is in the open position, and the direction module assigns the direction to each subsequence based on the angle of the door with respect to the main body.

8. The refrigerator of claim **1**, wherein the object identification module is configured to determine whether each captured image in a respective frame set contains multiple objects and to assign a different class identification to each different object;

wherein the object tracking module is configured to assign different track identifications to the different objects in each analyzed image per camera; and

wherein the object merge module is configured to compare the different track identifications among the analyzed images from different cameras and to assign a same merge identification to a same object when the same object is detected by the object identification module in captured images captured by multiple different cameras among the plurality of cameras.

9. The refrigerator of claim **8**, wherein the subsequence delineation module configured to split the session into different subsequences by corresponding merge identifications received from the object merge module, wherein each different subsequence corresponds to an inventory change for the at least one storage compartment.

10. A method for tracking inventory in a refrigerator, the method comprising:

starting a session based on receiving a trigger signal;

capturing images using a plurality of cameras mounted to at least one of a main body and a door pivotally mounted to and movable with respect to the main body between an open position and a closed position, wherein the main body and the door define a refrigerated enclosure when the door is in the closed position, each camera is positioned to have a field of view through an entrance opening plane of the refrigerated enclosure which is accessible when the door is in the open position, and the plurality of cameras is configured to capture images of an item passing through the entrance opening plane as the item is being loaded into or is being removed from the refrigerated enclosure;

determining in a computing device in communication with the plurality of cameras whether each captured image contains an object;

analyzing in the computing device sequential captured images from each camera and assigning track identifications to associate the object in one analyzed image to the object in other analyzed images per camera;

comparing in the computing device the track identifications among the analyzed images from different cameras and assigning a merge identification to the object when the object is detected in captured images captured by multiple different cameras among the plurality of cameras;

splitting in the computing device the session into subsequences by corresponding merge identifications, wherein each subsequence corresponds to an inventory change within the refrigerated enclosure;

assigning in the computing device a direction to each subsequence based on the analyzed images to determine if the object is moving into, out of or internally within the refrigerated enclosure; and

updating an inventory status in a database based on each subsequence and the direction assigned thereto.

11. The method of claim **10**, further comprising sending a start trigger signal when the door moves from the closed position to the open position, and sending a stop trigger signal when the door moves from the open position to the closed position, wherein the plurality of cameras begin capturing images after receiving the start trigger signal and the plurality of cameras cease capturing images after receiving the stop trigger signal.

12. The method of claim **10**, further comprising receiving a session identification, a camera identification, and a frame identification for each captured image received from each camera of the plurality of cameras, wherein the session

identification is associated with the session, the camera identification is associated with a particular camera among the plurality of cameras, and the frame identification is associated with a time at which the captured image was captured.

13. The method of claim **10**, further comprising grouping the captured images from the plurality of cameras into frame sets, wherein each frame set is made up of captured images that were captured at a same time from different cameras among the plurality of cameras.

14. The method of claim **10**, further comprising assigning a class identification to the object, and using a computer vision model to output a bounding box around the object and the class identification for the object for each captured image.

15. The method of claim **10**, wherein analyzing sequential captured images and assigning a track identification is performed using an observation-centric simple online and real-time tracking algorithm.

16. The method of claim **10**, further comprising determining an angle of the door with respect to the main body when the door is in the open position, and assigning the direction to each subsequence further includes assigning the direction to each subsequence based on the angle of the door with respect to the main body.

17. The method of claim **10**, wherein updating the inventory status includes determining an inventory change based on corresponding item classification information, merge identification information, and direction information, then recording the inventory change in the database.

18. The method of claim **10**, wherein determining in the computing device in communication with the plurality of cameras whether each captured image contains an object includes determining whether each captured image contains multiple objects; and

wherein analyzing in the computing device sequential captured images from each camera and assigning track identifications to associate the object in one analyzed image to the object in other analyzed images per camera includes assigning different track identifications to different objects.

19. The method of claim **18**, wherein comparing in the computing device the track identifications among the analyzed images from different cameras and assigning a merge identification to the object when the object is detected in captured images captured by multiple different cameras among the plurality of cameras includes assigning a different merge identification to different objects; and

wherein splitting in the computing device the session into subsequences by corresponding merge identifications, includes splitting the session into different subsequences by corresponding merge identifications.

20. A non-transitory computer readable storage medium storing instructions that, when executed by a computer having a processor, cause the processor to perform a method comprising:

starting a session based on receiving a trigger signal;

capturing images using a plurality of cameras mounted to at least one of a main body and a door pivotally mounted to and movable with respect to the main body between an open position and a closed position, wherein the main body and the door define a refrigerated enclosure when the door is in the closed position, each camera is positioned to have a field of view through an entrance opening plane of the refrigerated enclosure which is accessible when the door is in the open position, and the plurality of cameras is configured to capture images of an item passing through the entrance opening plane as the item is being loaded into or is being removed from the refrigerated enclosure;

determining in a computing device in communication with the plurality of cameras whether each captured image contains an object;

analyzing in the computing device sequential captured images from each camera and assigning track identifications to associate the object in one analyzed image to the object in other analyzed images per camera;

comparing in the computing device the track identifications among the analyzed images from different cameras and assigning a merge identification to the object when the object is detected in captured images captured by multiple different cameras among the plurality of cameras;

splitting in the computing device the session into subsequences by corresponding merge identifications, wherein each subsequence corresponds to an inventory change within the refrigerated enclosure;

assigning in the computing device a direction to each subsequence based on the analyzed images to determine if the object is moving into, out of or internally within the refrigerated enclosure; and

updating an inventory status in a database based on each subsequence and the direction assigned thereto.

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