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MEDICATION ADHERENCE PLATFORM FOR MEDICATION DETECTION AND DISCERNMENT

Abstract

A medication adherence platform that includes a pill case platform having a pill case container, a load cell, and circuitry that determines a weight of the pill case container, and a server that determines whether the pill case container contains specified quantities of one or more pill types based on the sensed weight, a patient medication schedule, and a database of pill weights. The server may determine a corrective quantity of one or more pill types and/or whether the pill case container contains an incorrect pill type. The database may include multiple pill weights for a pill type (e.g., crowd-sourced pill weights), and the server may evaluate the weight based further on a statistical analysis of the multiple pill weights. The server may provide alerts to the pill case platform and/or instructions/alerts/pill images to a user device. The pill case platform may include multiple pill case containers (e.g., **1**/day).

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Background/Summary

TECHNICAL FIELD

[0001] Examples of the present disclosure generally relate to medication devices and, more particularly, to a medication adherence platform for medication detection and discernment.

BACKGROUND

[0002] It has been reported that over 160 million Americans suffer from chronic diseases, more than 50% of whom report confusion regarding when, how, and why to take prescription medications. Failure to take prescription medications reportedly costs the U.S. economy hundreds of billions of dollars per year, results in over 100,000 preventable deaths per year, is responsible for 25% of hospital admissions, and 22% of nursing home admissions.

[0003] Medication containers (i.e., “pill cases”) with compartments for storing daily dosages of medications for a patient are not suitable for patients with cognitive decline, physical/motor disabilities, visual disabilities, and/or other disabilities. For such patients, it may be challenging to identify/load the correct number and types of medications in the appropriate compartments, and to remember which medications to take and when to take them.

SUMMARY

[0004] Medication adherence platforms for medication detection and discernment are described herein. One example is a system that includes a pill case platform having a pill case container, a load cell, and circuitry that determines a container weight of the pill case container based on an output of the load cell. The system further includes a host device that determines whether the pill case container contains specified quantities of multiple pill types of a patient medication schedule based on the container weight and a database of pill types and associated pill weights.

[0005] Another example described herein is a non-transitory computer readable medium encoded with a computer program that includes instructions to cause a processor to associate a pill case platform with a patient and with a user device, where the pill container platform includes multiple pill case containers, receive a medication schedule of the patient from the user device, determine specified quantities of multiple pill types of the patient medication schedule, for each of the pill case containers, based on the patient medication schedule, receive indications of container weights from the pill case platform, and determine whether the pill case containers contain the specified quantities of the multiple pill types of the patient medication schedule based on the container weights and a database of pill weights and associated pill types.

[0006] Another example described herein is a method that includes associating a pill case platform with a patient and with a user device, where the pill container platform a pill case container, a load cell, and circuitry that determines a container weight of the pill case container based on an output of the load cell, and determining whether the pill case container contains specified quantities of multiple pill types of a patient medication schedule based on the container weight and a database of pill types and associated pill weights.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0007] So that the manner in which the above recited features can be understood in detail, a more particular description, briefly summarized above, may be had by reference to example implementations, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical example implementations and are therefore not to be considered limiting of its scope.

[0008] FIG. **1** is a block diagram of a medication adherence platform, according to an embodiment.

[0009] FIG. **2** is a block diagram of pill case platform of the medication adherence platform, according to an embodiment.
[0010] FIG. **3** illustrates a method of ensuring patient adherence to a medication schedule, according to an embodiment.
[0011] FIG. **4** illustrates a method of determining weight detection events of a pill case container, according to an embodiment.
[0012] FIG. **5** illustrates a method of pre-processing sensed load data, according to an embodiment.
[0013] FIG. **6** is a block diagram of a host computer system, according to an embodiment.
[0014] To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to the figures. It is contemplated that elements of one example may be beneficially incorporated in other examples.

DETAILED DESCRIPTION

[0015] Various features are described hereinafter with reference to the figures. It should be noted that the figures may or may not be drawn to scale and that the elements of similar structures or functions are represented by like reference numerals throughout the figures. It should be noted that the figures are only intended to facilitate the description of the features. They are not intended as an exhaustive description of the features or as a limitation on the scope of the claims. In addition, an illustrated example need not have all the aspects or advantages shown. An aspect or an advantage described in conjunction with a particular example is not necessarily limited to that example and can be practiced in any other examples even if not so illustrated, or if not so explicitly described.
[0016] Embodiments herein describe a medication adherence platform for medication detection and discernment. The medication adherence platform may be useful to ensure that users (i.e., patients and/or care providers) load appropriate numbers of appropriate pill types in pill cases, and remove/dispense appropriate numbers of appropriate pill types at appropriate times.
[0017] As used herein, the term “pill type” refers to a pill of a medication type (e.g., acetaminophen), and a medication dosage. The term “medication dosage” refers to a weight of the medication type (e.g., 500 mg of acetaminophen). The term “pill weight” refers to the actual weight of the pill, which includes the weight of the medication (i.e., medication dosage), plus the weight of any fillers (i.e., additional ingredients that add weight to a pill type). The pill weight does not necessarily reflect the medication dosage of a pill. As an example, and without limitation, a pill containing 500 mg of acetaminophen may have a pill weight of approximately 1335 mg. The medication type and medication dosage may be represented by a National Drug Code or Universal Product Code.
[0018] In an example, a medication adherence platform includes one or more patient-specific pill case platforms for holding medications of a patient, an application program for respective user devices (e.g., mobile telephones, tablets, personal computers, and/or other smart devices), a host (e.g., a server) that provides back-end services, including pill detection and classification, pill weight database management, and an alert management system. The pill case platforms and respective user devices may communicate with one another and/or with the host over wireless communication channels.
[0019] The pill case platform includes one or more pill case containers (e.g., one for each day of the week) and one or more load cells (e.g., a load cell for per pill case container and/or a load cell for multiple pill case containers and corresponding circuitry/code to associate weight detection events with respective pill case containers). The pill case platform further includes circuitry that determines container weights and reports the container weights to the host. The circuitry may perform one or more other functions, such as, noise reduction, filtering, and/or adaptive taring (e.g., to compensate for load cell drift).
[0020] The host may provide instructions to the application to guide the user through loading and unloading the pill case containers. The host may include an aided loading mode, an aided unloading mode, an unaided loading mode, and/or an unaided unloading mode. In the aided loading

and unloading modes, the host provides detailed instructions. The host may provide instructions for each pill case container, and may include instructions for each of multiple pill types to be loaded into, or unloaded from, one or more of the pill case containers. The instructions may include images of the corresponding pills types. The host also determines whether the specified quantities of the specified pill types are properly loaded/unloaded, as the user loads or unloads the pill cases. Upon detection of an error, the host may determine the pill type and quantity that has been improperly loaded or unloaded based on the medication schedule and the database of pill weights, and may provide corrective instructions to the user. The corrective instructions may include text messages, push notifications, audio alarms, LED indicators, and/or images of affected pill types.

[0021] In the un-aided loading and unloading modes, the user loads and/or unloads each container of the pill case platform with little or no guidance from the host. Upon completion of unaided loading or unloading, the host determines if the pill case container contains the specified quantities of the specified pill types, based on the patient medication schedule and the database of pill weights. Upon detection of an incorrect weight of a pill case container, the host may determine which pill(s) are improperly loaded or unloaded, and may provide corrective instructions to the user. The corrective instructions may include text messages, push notifications, audio alarms, LED indicators, and/or images of affected pill types.

[0022] The host may discern amongst multiple pill types within a pill case container. The host may, for example, instruct the user to load or unload various quantities of multiple pill types in a given pill case container (e.g., designated Tuesday), and may determine whether the specified quantities of the specified pill types have been loaded or unloaded, based on the container weights. If the host determines that the container weights do not correspond to an expected weight, the host may further determine which pill type(s), and quantities, are incorrectly loaded or unloaded. The host may further provide corrective instructions to the user.

[0023] The pill weight of a pill type may vary due to one or more of a variety of factors such as, without limitation variations/changes in pill manufacturing, formulations, pill handling, environmental conditions, hardware, user characteristics, and/or other factors. In addition, sensed/detected weights for a pill type may vary amongst pill case platforms due to environmental and/or hardware-based variations. The host may capture variations in pill weights by populating and/or update the database with pill weights obtained from one or more of a variety of sources, including pill weights determined from prior container weights of the pill case platform and/or other pill case platforms (i.e., crowd-sourced pill weights). The host may further perform adaptive classification to account for the variations in pill weights. Adaptive pill classification may provide a tolerance (e.g., a weight range) for a pill type, which may be based on a median weight and a standard deviation amongst pills of the pill type.

[0024] The host may maintain multiple databases of pill types and pill weights that are specific to pill case platforms, pill case containers, users, geographic regions, and/or other factors/features, and may tailor pill classification methods/heuristics for the respective databases.

[0025] The medication adherence platform may process, store, and transmit medication information in compliance with government statutes/rules/regulations (e.g., the Health Insurance Portability and Accountability Act, or HIPAA).

[0026] The medication adherence platform may be useful to ensure that users (i.e., patients and/or care providers) load the appropriate pills in the pill case containers, and remove/dispense the appropriate pills at appropriate times.

[0027] FIG. **1** is a block diagram of a medication adherence platform **100**, according to an embodiment. Medication adherence platform **100** includes one or more pill case platforms, illustrated here as pill case platforms **101**-**1** through **101**-*m* (collectively, pill case platforms **101**), corresponding user devices **116**-**1** through **116**-*m* (collectively, user devices **116**), and a host **118** (e.g., a server computer system). Pill case platforms **101**-**1** through **101**-*m*, or a portion thereof, may be associated with m respective patients, where m is a positive integer. Medication adherence

platform **100** may represent a network of pill case platforms **101**.
[0028] Pill case platform **101-1** includes one or more pill case containers **102-1** through **102-*n*** (collectively, pill case containers **102**), where n is a positive integer. In an example, n equals 7 (e.g., one pill case container for each day of the week). Pill case platform **101-1** is not, however, limited to n=7.
[0029] Pill case container **102-1** includes a container body **104-1** and a lid **106-1** that secures an opening of container body **104-1**. Pill case container **102-1** further includes a load cell **108-1** that senses a load (e.g., a weight of a medication, such as tablets or pills) placed within container body **104-1**, and outputs a corresponding sensed load signal **112-1**. Pill case container **102-1** may further include a removable tray positioned within container body **104-1**, dimensioned to receive medication pills. The tray may rest upon load cell **108-1**. Load cell **108-1** may be a relatively inexpensive off-the-shelf load cell, and may be selected and/or optimized/customized for a target weight range and/or other criteria. Load cell **108-1** may output sensed load signal **112-1** as an analog signal.
[0030] Pill case container **102-1** further includes circuitry **110-1** that processes sensed load signal **112-1** and outputs container weights associated with loading and/or unloading of pills from pill case container **102-1**. In FIG. **1**, the container weights are represented as weight detection events **114-1**. Weight detection events **114-1** may include a measure of weight (e.g., a mean weight, a container weight, and/or a standard deviation) and/or other information, examples of which are provided further below. Circuitry **110-1** may perform one or more of other functions, such as, without limitation, noise reduction, filtering, weight detection, and/or adaptive taring, examples of which are provided further below. Circuitry **110** may include, without limitation, logic gates, a state machine, and/or a processor/controller and memory (e.g., firmware) encoded with instructions (i.e., code) that are executed by the processor/controller. Circuitry **110** may include a printed circuit board (PCB). Routing and/or a layout of the PCB may be optimized to minimize noise and crosstalk. Circuitry **110** may include a firmware-based state machine.
[0031] Pill case platform **101-1** may further include one or more signaling devices, such as light-emitting diodes (LEDs), buzzer, and/or a speaker. Pill case platform **101-1** may, for example, include, an external LED (e.g., a red LED for alert purposes) and/or an internal LED (e.g., on inner surfaces of lids **106** and/or other location(s) within pill case platform **101-1**).
[0032] User device **116-1** may include a hand-held user device (e.g., a mobile telephone), a stationary user device (e.g., a desk-top computer), and/or other user device. User device **116-1** may include an application **120** (i.e., a computer program or code) that interfaces with pill case platform **101-1** and/or host **118**. Application **120** may present a graphical user interface (GUI) **126** on a display of user device **116-1**.
[0033] Host **118** performs pill detection and classification functions based on weight detection events **114-1**. Host **118** may also interface with user device **116-1** and/or pill case platform **101-1**. Host **118** may, for example, provide pill loading instructions to user device **116-1** (e.g., aided loading and/or unloading instructions and/or corrective instructions), and/or may provide notifications/alerts to user device **116-1** and/or pill case platform **101-1**. Host **118** may also maintain/manage one or more databases of pill types (i.e., medication types and corresponding pill weights), examples of which are provided further below.
[0034] Pill case platform **101-1**, user device **116-1**, and host **118** may include respective communication circuitry to communicate with one another (directly and/or indirectly) over one or more communication links or channels, which may include a wired and/or a wireless communication channel. A wireless communication channel may include, without limitation, a short-range wireless channel, a near-field communication (NFC) channel, a wireless access point to the Internet, and/or other communication channel(s). In the example of FIG. **1**, pill case platform **101-1** further includes circuitry **111**, which may support (i.e., may be shared/amongst/used by) circuitry **110** of pill case containers **102-1** through **102-*n***. Circuitry **111** may include

communication circuitry that communicates with user device **116-1** over a communication channel **122**A and/or with host **118** over a communication channel **122**B. User device **116-1** and host **118** may communicate with one another over a communication channel **122**C. Communication channel **122**B and/or **122**C may include a packet-switched communication network **130** (e.g., the Internet).
[0035] In another embodiment, load cell **108-1** is shared amongst multiple pill case containers **102**, and circuitry **111** includes circuit that associates weight detection events with respective ones of the pill case containers.
[0036] Pill case platforms **101-2** through **102-***m* may be similar to, and/or identical to pill case platform **101-1**. In an example, pill case platforms **101-1** through **102-***m* have the same number of pill case containers, n. In another example, n may differ amongst pill case platforms **101-1** through **102-***m*.
[0037] One or more functions described herein with respect to circuitry **110-1** and/or circuitry **111** may be performed by application **120** and/or host **118**. Similarly, one or more functions described herein with respect to host **118**, or portions thereof, may be performed by pill case platforms **101** and/or user devices **116**.
[0038] FIG. **2** is a block diagram of pill case platform **101-1**, according to an embodiment. In the example of FIG. **2**, circuitry **111** includes communication circuitry **250**, and user device **116** and host **118** include corresponding communication circuitry **252** and **254**, to communicate with one another over corresponding communication channels **122**A, **122**B, and **122**C. Communication circuitry **250**, **252**, and **254** may include wireless transmitters and/or receivers (e.g., wireless transceivers).
[0039] In FIG. **2**, circuitry **110-1** includes an analog-to-digital converter (ADC) **202** that converts sensed load signal **112-1** to digital sensed load data **204**. Sensed load data **204** may include samples (e.g., of amplitudes) of sensed load signal **112-1**. ADC **202** may sample sensed load signal **112-1** at a constant rate (e.g., 80 Hertz). ADC **202** may include relatively inexpensive off-the-shelf ADC circuitry.
[0040] Circuitry **110-1** further includes a pre-processor **206** that performs initial weight detection functions. Pre-processor **206** may pre-process batches of samples of sensed load data **204**, and output corresponding batch weights **208**, such as described further below. Pre-processor **206** may perform other functions such as, without limitation, noise reduction and/or filtering.
[0041] Circuitry **110** further includes a weight event detector **210** that monitors batch weights **208** for weight detection events **114-1**. Weight event detector **210** may monitor batch weights **208** when lid **106-1** is open. Weight event detector **210** may detect a weight detection event **114-1** when batch weights **208** exceed a tare weight **216**. Weight event detector **210** may include a settling detector **212** that determines whether batch weights **208** that exceed tare weight **216** have sufficiently settled to be deemed reliable, such as described further below. Weight event detector **210** may further include an adaptive taring engine **214** that dynamically adapts a tare weight **216**, such as described further below.
[0042] In FIG. **2**, host **118** includes a management engine **220**, a pill detection and classification engine **222**, a database **224** of pill types and associated pill weights, and a patient medication schedule **226** associated with pill case platform **101-1**. Patient medication schedule **226** may include listing of one or more pill types (e.g., medication types and medication weight/dosage), and corresponding patient dosages (e.g., a daily and/or hourly dosage schedule).
[0043] Management engine **220** may interface with user device **116-1** over communication channel **122**C to receive patient medication schedule **226**, provisioning parameters, and/or configuration parameters, and/or may send messages (e.g., instructions, prompts, and/or alerts) to user device **116-1**. Management engine **220** may send instructions to user device **116-1** for presentation in GUI **126**, and/or may receive user input via GUI **126**.
[0044] Management engine **220** may interface with pill case platform **101-1** over communication channel **122**B. Management engine **220** may, for example, send prompts and/or alerts a signaling

device (e.g., an LED, a buzzer, and/or a speaker) of pill case platform **101-1**, to alert a user of a condition and/or to prompt the user to perform an action. Management engine **220** may prompt the user to load one or more pill case containers **102**, prompt the user to take a medication pill(s) from a specified one or more of pill cases containers **102**, and/or prompt the user to open or close one or more of lids **106**. As another example, management engine **220** may notify the user that one or more of lids **106** has been opened prematurely (i.e., prior to a time at which the user is to remove a pill from one of pill case containers **102**), and/or notify the user that a pill has not been removed from a pill case container **102** as instructed.

[0045] Host **118** (i.e., management engine **220** and/or pill detection and classification engine **222**) may populate database **224** with pill weights and images obtained from one or more of a variety of other sources such as, without limitation, pharmaceutical manufacturers, pharmaceutical distributors, retail pharmacies, compounding pharmacies, and pill case platforms **101** (i.e., crowd-sourced pill weights). Host **118** may incorporate external or third party data sets (e.g., an NDC database), explicit datasets (i.e. precise medication weights using calibrated precision equipment), and/or data modifications (i.e. some over the counter medications or supplements have looser manufacturing tolerances).

[0046] Pill detection and classification engine **222** classifies weight detection events **114-1** as corresponding to specific pill types based on the weight values of the weight detection events **114-1**, pill types contained in patient medication schedule **226**, and pill weights of database **224**. Host **118** (i.e., management engine **220** and/or Pill detection and classification engine **222**), determines whether pill case container **102-1** has been properly loaded and/or unloaded based on the classification and patient medication schedule **226**.

[0047] Pill detection and classification engine **222** may perform a statistical analysis of pill weights of database **224** to classify weight detection events **114-1** as corresponding to specific pill types. During subsequent loadings (aided loading and/or unaided loading), pill detection and classification engine **222** may incorporate weight detection events **114-1** into a medication classification method to provide a self-reinforcing medication classification method. The medication classification method and/or the self-reinforcing medication classification method may be useful to account for variations (e.g., subtle variations) in weights of a pill type. Such weight variations may be due to natural/inherent variability in characteristics amongst hardware of pill case platforms **101** and/or amongst pill case containers **102** of a pill case platform (e.g., load cell variability and/or ADC bias), environmental factors (e.g., humidity and/or temperature), variability amongst and/or within manufacturers and/or pharmacies, changes in pharmaceutical manufacturing processes, variability in characteristics of user behavior (e.g., loading technique and/or tablet cutting), and/or other factors.

[0048] Host **118** (i.e., management engine **220** and/or pill detection and classification engine **222**) may maintain database **224** as multiple databases of pill weights, and pill detection and classification engine **222** may maintain a medication classification method and/or a self-reinforcing medication classification method for each database. As an example, host **118** may maintain a unique hardware-specific database of pill weights for each pill case platform **101** and/or for each pill case container **102** of each pill case platform **101**. The hardware-specific databases may include records of weight detection events of the respective pill case containers **102** and/or pill case platforms **101**. As an example, for each weight detection event **114-1** of pill case container **102-1**, pill detection and classification engine **222** may perform a statistical analysis of a hardware-specific database associated with pill case platform **1011** and/or pill case container **102-1** to classify weight detection events **114-1** as corresponding to a specific pill type. During subsequent loadings (aided loading and/or unaided loading), pill detection and classification engine **222** may incorporate weight detection events **114-1** into a classification algorithm of the respective database to provide a self-reinforcing medication classification algorithm. Hardware-specific databases may be useful to accommodate the natural/inherent variability in hardware characteristics described

above. Hardware-specific databases may also be useful to accommodate one or more other factors described above.
[0049] Alternatively, or additionally, host **118** may maintain unique user-specific databases of pill weights. User-specific databases may be useful to accommodate variability in characteristics of user behavior (e.g., loading technique and/or tablet cutting), and/or other factors (e.g., pharmacy variations and/or environmental conditions).
[0050] Alternatively, or additionally, host **118** may maintain a global database of pill weights based on weight detection events of multiple pill case platforms **101**. The global database may serve as a crowd-sourced database of pill weights. The global database may be useful to incorporate pharmaceutical variability (e.g., regional differences in pharmaceutical manufacturing facilities and changes in pharmaceutical manufacturing processes), and/or regional variability (e.g., seasonal changes in temperature and humidity) into the medication classification algorithm for use during subsequent loadings (aided loading and/or unaided loading).
[0051] Host **118** may perform similar functions with respect to pill case platforms **101-2** through **101**-*m*.
[0052] FIG. **3** illustrates a method **300** of ensuring patient adherence to a medication schedule, according to an embodiment. Method **300** is described below with reference to FIGS. **1** and **2**, for illustrative purposes. Method **300** is not, however, limited to the examples of FIG. **1** or **2**.
[0053] At **302**, pill case platform **101-1** enters a provisioning mode. Where pill case platform **101-1** is factory-new or a factory-reset, pill case platform **101-1** may enter the provisioning mode when turned on or powered-up.
[0054] In the provisioning mode, communication circuitry **250** of pill case platform **101-1** may initiate a point-to-point communication service (e.g., a wireless Bluetooth GATT service) with application **120** of user device **116**. Communication circuitry **250** may advertise or broadcast the communication service. Thereafter, application **120** may detect or discover the communication service, and may establish a communication channel or session with pill case platform **101-1** over communication channel **122**A. Application **120** and pill case platform **101-1** may exchange cryptographic certificates to authenticate pill case platform **101-1**.
[0055] After pill case platform **101-1** is authenticated, communication circuitry **250** of pill case platform **101-1** may scan for available wireless access points of communication network **130** (e.g. WiFi, Zigbee, Thread or others). GUI **126** may prompt the user to select a detected access point. GUI **126** may also prompt the user to provide network access credentials such as password (e.g., a WPA2 passkey). GUI **126** may also prompt or permit the user to assign a name to pill case platform **101-1**. Thereafter, pill case platform **101-1** may establish a communication session with host **118**, via communication channel **122**B via the selected wireless access point. If Pill case platform **101-1** loses communication to host **118** via communication channel **122**B, pill case platform may also communicate with host **118** by proxy communication via user device **116-1** using communication channel **122**A and then from user device **116-1** to host **118** using communication channel **122**C.
[0056] At **304**, management engine **220** enters a configuration mode. Management engine **220** may enter the configuration mode based on user input via GUI **126**. In an example, the user may initiate the configuration mode at any time and/or for any reason subsequent to provisioning at **302**.
[0057] In the configuration mode, management engine **220** may prompt the user (i.e., via GUI **126**) to input a list of pill types for patient medication schedule **226**. Management engine **220** may permit the user to specify a pill type based on a National Drug Code (NDC) marking and/or a Universal Product Code (UPC) marking. Management engine **220** may permit the user to specify the medication via manual input via GUI **126**, and/or via an image capture device (e.g., a camera-based scanner of user device **116-1** and/or other device capable of scanning barcodes). Management engine **220** may permit the user to enter a brand name and/or generic name.
[0058] Based on user input, management engine **220** may search database **224** for the pill types identified by the user, and may return a list of pharmaceutical pills and/or over-the-counter pills, or

a filtered version of the list, to the user via GUI **126**. Management engine **220** may also provide descriptions and/or images of the pill types. GUI **126** may permit the user to select pill types from the list, and may confirm the user selections via GUI **126**.

[0059] Management engine **220** may also prompt the user to provide a patient dosage schedule (e.g., pill quantity and pill day/time) for each pill type. Management engine **220** may permit the user to specify dosage times in terms of day(s) of the week, time(s) of day, and/or frequency. Management engine **220** may permit the user to specify a dosage frequency in terms of daily, every k days, and/or specific days of the week. Management engine **220** may permit the user to specify a precise dosage time (e.g.,8:00 am), and/or a window of time (e.g., +/−1 hour, or between 7:00 am and 9:00 am). Management engine **220** may permit the user to specify a pill reload time reminder in a similar fashion. Dosage scheduling and reload scheduling are not, however, limited to the foregoing examples. Management engine **220** may construct or populate patient medication schedule **226** for pill case platform **101-1** based on the foregoing configuration parameters received from the user.

[0060] At **306**, management engine **220** enters a medication loading mode.

[0061] Management engine **220** may enter one of multiple user-selectable loading modes, which may include, without limitation, an aided loading mode, an un-aided loading mode, and/or a midweek loading/unloading mode. A midweek loading/unloading mode may be useful if a pill type is added/removed from patient medication schedule **226** midweek (e.g., a doctor makes a change to a patient's medication regimen).

[0062] In the aided loading and unloading modes, management engine **220** provides detailed step-by-step instructions for loading and un-loading pills into pill case containers **102** based on patient medication schedule **226**, such that each of pill case container **102** contains the appropriate pill types and quantities for a respective day of the week (i.e., one or more of pill case containers **102** may include multiple pills of a given pill type and/or multiple pill types). As an example, and without limitation, management engine **220** may instruct the user to load or unload pills into/from pill case containers **102** in a serial fashion (e.g., one pill case at a time, one pill type at a time). Management engine **220** may initially instruct the user to open one or more of lids **106-1** through **106**-*n*. Management engine **220** may then instruct the user to load or unload a designated number of one or more pill types in/from pill case container **102-1**. Thereafter, management engine **220** may instruct the user to load or unload a designated number of one or more pill types in pill case container **102-2**, one-at-a time or multiple pills at a time.

[0063] Further in the aided loading and unloading modes, pill detection and classification engine **222** may classify/correlate weight detection events **114-1** to pill types of patient medication schedule **226** as the user loads or unload pills into/from pill case containers **102-1**. As an example, pill detection and classification engine **222** may determine an expected weight based on specified pill type(s) and quantities and corresponding pill weights from database **224**, and may compare the expected weight to weight values of weight detection events **114-1**.

[0064] If pill detection and classification engine **222** detects an error, pill detection and classification engine **222** or management engine **220** may alert the user via GUI **126**, via a signaling device of pill case platform **101-1**, and/or other method. For example, and without limitation, management engine **220** may send a push notification to user device **116-1** identifying pills that need to be added or removed from pill case container **102-1**. Alternatively, or additionally, management engine **220** may alert the user by activating a signaling device of pill case platform **101-1** and/or a signaling device of pill case container **102-1**. A push notification may identify loaded pill case container **102-1** as incorrectly loaded, and may further identify an incorrectly loaded pill type and quantity. The push notification may instruct the user to add or remove a corrective quantity of incorrectly loaded pill types to/from pill case container **102-1**. If applicable/appropriate, the message may further instruct the user to move a corrective quantity of incorrectly loaded pill types from pill case container **102-1** to another one of the pill case containers

102 (e.g., from Monday's pill case to Sunday's pill case). After the user corrects the loading error, pill detection and classification engine **222** may re-evaluate weight detection events **114-1**. When pill detection and classification engine **222** determines that pill case container **102-1** is properly loaded, management engine **220** may proceed to instruct the user to load or unload pills into/from remaining pill case containers **102-2** through **102-***n*, in a similar fashion.

[0065] In the un-aided loading mode, a user loads pill case containers **102** with quantities of pill types as specified in patient medication schedule **226**, without guidance from host **118**. The user may place the specified quantities of the specified pill types in pill case containers **102** in any order. When the user indicates that loading of pill case containers **102** is complete (e.g., by closing lids **106-1** to **106-***n*, and/or by other method), pill detection and classification engine **222** may evaluate weight detection events of pill case containers **102-1** through **102-***n* based on patient medication schedule **226** and database **224**. As an example, for pill case container **102-1**, pill detection and classification engine **222** may determine an expected weight based on specified quantities of specified pill types of patient medication schedule **226**, and corresponding pill weights from database **224**. Pill detection and classification engine **222** may compare the expected weight to weight values of weight detection events **114-1**.

[0066] If pill detection and classification engine **222** detects a loading error, management engine **220** may alert the user. Management engine **220** may alert the user via GUI **126**, via a signaling device of pill case platform **101-1**, via a signaling device of one or more incorrectly loaded pill case containers **102**, and/or other method, such as described above. The user adds and/or removes pill types and/or quantities in one or more pill case containers **102** as directed by management engine **220** instructions and/or alerts described above. When pill detection and classification engine **222** determines that pill case containers **102-1** through **102-***n* are properly loaded, management engine **220** may instruct the user to close lids **106-1** through **106-***n*, if any of lids **106** are open.

[0067] At **308**, management engine **220** enters a medication adherence mode, in which management engine **220** provides instructions to the user to remove pills from pill case containers **102-1** through **102-***n* based on patient medication schedule **226**. In the medication adherence mode, weight event detector **210** may monitor weights of pill case containers **102** such as described below.

[0068] FIG. **4** illustrates a method **400** of determining weight detection events **114-1**, according to an embodiment. Method **400** may be performed during aided loading/unloading, unaided loading/unloading, and/or upon completion of unaided loading/unloading. Method **400** may be performed for each pill case container **102** of pill case platforms **101-1** through **101-***m*, independent of one another. Method **400** is described below with reference to pill case container **102-1**. Method **400** is not, however, limited to the example of pill case container **102-1**.

[0069] In the example of FIG. **4**, method **400** includes a thresholding portion **401** and a batch weight processing portion **403**. Thresholding portion **401** is described below. Batch weight processing portion **403** is described further below.

[0070] At **402**, pre-processor **206** pre-processes sensed load data **204**, examples of which are provided further below with reference to FIG. **5**.

[0071] At **404**, pre-processor **206** computes batch weights **208** based on sensed load data **204**. Pre-processor **206** may compute batch weights **208** when one or more of lids **106** are open and/or upon another condition(s). Pre-processor **206** may compute batch weights **208** for batches of sensed load data **204** (i.e., samples of sensed load signal **112** within a window of time). Pre-processor **206** may also perform noise reduction and/or filtering, examples of which are provided further below.

[0072] At **406**, weight event detector **210** compares a batch weight **208** to a detection threshold. The detection threshold may be set to a relatively low value (e.g., a value that is equal to or less than a weight of a lightest pill weight of patient medication schedule **226**). A relatively low threshold may be useful to distinguish between batch weights **208** of newly added pills, and batch weights **208** that do not represent newly added pills. As described below, batch weights **208** that do

not represent newly added tablets may be used for adaptive taring.
[0073] If the batch weight **208** does not meet the detection threshold, processing proceeds to **408**, where an adaptive taring engine **214** adapts tare weight **216** based on the batch weight **208**. Adaptive taring engine **214** may, for example, accumulate the batch weight **208** with other batch weights **208** of sensed load data **204** that do not meet the detection threshold, and may low-pass filter the accumulated batch weights to provide tare weight **216**. Sensed load signal **112-1** may drift over time (i.e., load cell drift) due to temperature and/or other factors. Adapting tare weight **216** based on low-pass filtering of batch weights **208** that do not meet the detection threshold may be useful to compensate for load cell drift.
[0074] If the batch weight **208** meets the detection threshold, processing proceeds to **410**, where weight event detector **210** accumulates the batch weight **208** with other batch weights **208** of sensed load data **204** that meet the detection threshold at **406**.
[0075] A batch weight **208** that meets the detection threshold at **406** does not necessarily represent a newly loaded pill. For example, a batch weight **208** may meet the detection threshold due, at least in part, to pressure applied by a user when placing a pill in pill case container **102-1** and/or motion of pill case container **102-1** (e.g., as a user loads a pill into pill case container **102-1**, initial batch weighs **208** of sensed load data **204** may spike or fluctuate due to user motion/pressure, but will eventually settle to a relatively steady/stable value).
[0076] Thus, at **412**, as weight event detector **210** accumulates batch weights **208** of sensed load data **204** that meet the detection threshold, settling detector **212** determines whether the accumulated batch weights **208** have settled. Settling detector **212** may consider, for example and without limitation, median and/or standard deviation values of the accumulated batch weights **208**, and/or may low-pass filter the accumulated batch weights **208**. If the accumulated batch weights **208** settle, processing proceeds to **414** where weight event detector **210** computes a settled weight based on the accumulated batch weights **208** that meet the detection threshold. Because the underlying accumulated batch weights **208** have settled, the settle weight may be computed with a relatively high degree of confidence.
[0077] At **416**, weight event detector **210** computes a container weight for pill case container **102-1** based on a difference between the settled weight and tare weight **216**.
[0078] At **418**, adaptive taring engine **214** saves tare weight **216** as a saved tare weight **218**, and sets tare weight **216** to the settled weight. In other words, adaptive taring engine **214** dynamically adapts tare weight **216** based on current contents of pill case container **102-1**. Thus, going forward, tare weight **216** includes the weight of any pills contained within pill case container **102-1**. In this way, if another pill is subsequently added to pill case container **102-1**, weight event detector **210** will compute a corresponding container weight that excludes pre-existing contents of pill case container **102-1** (i.e., the container weight will correspond to a newly added pill).
[0079] At **420**, weight event detector **210** reports the container weight as a weight detection event **114-1**. The weight detection event **114-1** may include the container weight and an identifier associated with pill case container **102-1**.
[0080] At **422**, pill detection and classification engine **222** evaluates weight detection event **114-1** to classify/correlate weight detection event **114-1** to a pill type. If weight detection event **114-1** occurs as a user is loading or unloading pill case container **102-1**, pill detection and classification engine **222** may evaluate weight detection event **114-1** based on corresponding loading or unloading instructions provided to the user and corresponding pill weights of database **224**.
[0081] Pill detection and classification engine **222** may classify/correlate weight detection event **114-1** to a single pill of a pill type, a quantity of pills of a pill type, and/or a combination of one or more pills of each of multiple pill types. Pill detection and classification engine **222** may evaluate weight detection event **114-1** based on pill weights of one or more databases **224** (e.g., a hardware-specific pill weight database, a user-specific pill weight database, and/or a global pill weight database). Pill detection and classification engine **222** may evaluate weight detection events **114-1**

based on one or more of a variety of methods, which may include a hardware-specific method, a user-specific method, a global method, a proprietary method, and/or other method. In an embodiment, weight detection events **114-1** include container weights computed by weight event detector **210** (e.g., mean weights, container weights, and/or standard deviations), and pill detection and classification engine **222** incorporates these values into a medication classification method to provide a self-reinforcing pill classification method, such as described further above.

[0082] Returning to **412**, if the accumulated batch weights **208** that meet the detection threshold do not settle, processing proceeds to **424** where adaptive taring engine **214** sets tare weight **216** based on saved tare weight **218** (i.e., reverts tare weight **216** to saved tare weight **218** and resumes adaptive taring function), and discards accumulated batch weights **208** of pill case container **102-1**. Reverting tare weight **216** to saved tare weight **218** may be useful for discarding/filtering weights that are not a direct result of a single pill (or multiple pills) being loaded/unloaded (e.g. artificial weight induced by user pressure and/or motion) while continuing to account for load cell drift. As an example, and without limitation, if tare weight **216** is x, an artificial/unintended weight is y, and load cell drift is z, z may be computed based on x+y+Z-y . . . . Otherwise z would be lost during the +y and −y artificial events.

[0083] FIG. **5** illustrates a method **500** of pre-processing sensed load data, according to an embodiment (e.g., **402** in FIG. **4**). Method **500** is described below with reference to pill case container **102-1**. Method **500** is not, however, limited to the example of pill case container **102-1**.

[0084] At **502**, pre-processor **206** computes the standard deviation of a batch of samples sensed load data **114**. Pre-processor **206** may compute the standard deviation based on amplitudes of the samples. The batch of samples may include successive samples of sensed load data **114** or sensed load signal **112** within a window of time. The samples may represent amplitudes of sensed load signal **112-1**.

[0085] At **504**, pre-processor **206** compares the standard deviation to a deviation threshold to determine whether the samples within the batch are relatively consistent with one another. If the standard deviation exceeds the deviation threshold, processing proceeds to **506**, where pre-processor **206** discards one or more outlier samples of the batch. Pre-processor **206** may compare each sample of the batch to the standard deviation to identify the most egregious outlier(s) to discard.

[0086] At **507**, pre-processor **206** re-computes the standard deviation of remaining samples of the batch. Processing then returns to **504**, where pre-processor **206** compares the re-computed standard deviation to the deviation threshold. Pre-processor **206** may repeat **504**, **506**, and **507** until a re-computed standard deviation meets the deviation threshold.

[0087] When the standard deviation of the original batch of samples, or when a re-computed standard deviation meets the deviation threshold, processing proceeds to **508**, where pre-processor **206** compares the number of remaining samples of the batch to a minimum batch size threshold. If the number of samples or remaining samples of the batch does not meet the minimum batch size threshold, processing proceeds to **510**, where pre-processor **206** discards the remaining samples of the batch. Processing then returns to **502**, where pre-processor **206** evaluates another batch of sensed load data **204**.

[0088] If the number of remaining samples of the batch meet the minimum batch size threshold at **504**, processing proceeds to **512**, where pre-processor **206** computes a batch weight **208** based on the remaining samples of the batch. Pre-processor **206** may compute batch weight **208** as an average of the amplitudes of the remaining samples. Processing then returns to **502**, where pre-processor **206** evaluates another batch of sensed load data **204**.

[0089] FIG. **6** is a block diagram of host computer system **600**, according to an embodiment. Host computer system **600** may represent an example embodiment or implementation of host **118**. In the example of FIG. **6**, host computer system **600** includes one or more instruction processors, illustrated here as a processor **602**, that executes instructions of a host computer program **606**

encoded within a non-transitory computer-readable medium, illustrated here as memory **604**. Memory **604** further includes data **608**, which may be used by processor **602** while executing host computer program **606**, and/or generated by processor **602** while executing host computer program **606**.

[0090] In FIG. **6**, host computer program **606** includes management instructions **610** that cause processor **602** to perform management functions, such as described with respect to management engine **220** in one or more examples above. Host computer program **606** further includes pill detection and classification instructions **612** that cause processor **602** to perform pill detection and classification functions, such as described with respect to pill detection and classification engine **222** in one or more examples above.

[0091] Host computer system **600** further includes communications infrastructure **640** to communicate amongst devices and/or resources of host computer system **600**. Host computer system **600** further includes one or more input/output (I/O) devices and/or controllers (I/O) **642** that interfaces between host computer system **600** with one or more other systems (e.g., pill case platforms **101** and user devices **116**), such as described in one or more examples above.

[0092] In the preceding, reference is made to embodiments presented in this disclosure. However, the scope of the present disclosure is not limited to specific described embodiments. Instead, any combination of the described features and elements, whether related to different embodiments or not, is contemplated to implement and practice contemplated embodiments. Furthermore, although embodiments disclosed herein may achieve advantages over other possible solutions or over the prior art, whether or not a particular advantage is achieved by a given embodiment is not limiting of the scope of the present disclosure. Thus, the preceding aspects, features, embodiments and advantages are merely illustrative and are not considered elements or limitations of the appended claims except where explicitly recited in a claim(s).

[0093] As will be appreciated by one skilled in the art, the embodiments disclosed herein may be embodied as a system, method or computer program product.

[0094] Accordingly, aspects may take the form of an entirely hardware embodiment, an entirely software embodiment (including firmware, resident software, micro-code, etc.) or an embodiment combining software and hardware aspects that may all generally be referred to herein as a “circuit,” “module” or “system.” Furthermore, aspects may take the form of a computer program product embodied in one or more computer readable medium(s) having computer readable program code embodied thereon.

[0095] Any combination of one or more computer readable medium(s) may be utilized. The computer readable medium may be a computer readable signal medium or a computer readable storage medium. A computer readable storage medium may be, for example, but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. More specific examples (a non-exhaustive list) of the computer readable storage medium would include the following: an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, a portable compact disc read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing. In the context of this document, a computer readable storage medium is any tangible medium that can contain, or store a program for use by or in connection with an instruction execution system, apparatus or device.

[0096] A computer readable signal medium may include a propagated data signal with computer readable program code embodied therein, for example, in baseband or as part of a carrier wave. Such a propagated signal may take any of a variety of forms, including, but not limited to, electro-magnetic, optical, or any suitable combination thereof. A computer readable signal medium may be any computer readable medium that is not a computer readable storage medium and that can

communicate, propagate, or transport a program for use by or in connection with an instruction execution system, apparatus, or device.

[0097] Program code embodied on a computer readable medium may be transmitted using any appropriate medium, including but not limited to wireless, wireline, optical fiber cable, RF, etc., or any suitable combination of the foregoing.

[0098] Computer program code for carrying out operations for aspects of the present disclosure may be written in any combination of one or more programming languages, including an object oriented programming language such as Java, Smalltalk, C++ or the like and conventional procedural programming languages, such as the “C” programming language or similar programming languages. The program code may execute entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the user's computer through any type of network, including a local area network (LAN) or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider).

[0099] Aspects of the present disclosure are described below with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems) and computer program products according to embodiments presented in this disclosure. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer program instructions. These computer program instructions may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

[0100] These computer program instructions may also be stored in a computer readable medium that can direct a computer, other programmable data processing apparatus, or other devices to function in a particular manner, such that the instructions stored in the computer readable medium produce an article of manufacture including instructions which implement the function/act specified in the flowchart and/or block diagram block or blocks.

[0101] The computer program instructions may also be loaded onto a computer, other programmable data processing apparatus, or other devices to cause a series of operational steps to be performed on the computer, other programmable apparatus or other devices to produce a computer implemented process such that the instructions which execute on the computer or other programmable apparatus provide processes for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

[0102] The flowchart and block diagrams in the Figures illustrate the architecture, functionality, and operation of possible implementations of systems, methods, and computer program products according to various examples of the present invention. In this regard, each block in the flowchart or block diagrams may represent a module, segment, or portion of instructions, which comprises one or more executable instructions for implementing the specified logical function(s). In some alternative implementations, the functions noted in the block may occur out of the order noted in the figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved. It will also be noted that each block of the block diagrams and/or flowchart illustration, and combinations of blocks in the block diagrams and/or flowchart illustration, can be implemented by special purpose hardware-based systems that perform the specified functions or acts or carry out combinations of special purpose hardware and computer instructions.

[0103] While the foregoing is directed to specific examples, other and further examples may be

devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

Claims

1. A system, comprising: a pill case platform comprising a pill case container, a load cell, and circuitry configured to determine a container weight of the pill case container based on an output of the load cell; and a host device configured to determine whether the pill case container contains specified quantities of multiple pill types of a patient medication schedule based on the container weight and a database of pill types and associated pill weights.
2. The system of claim 1, wherein the host device is further configured to determine a corrective quantity of one or more of the multiple pill types if the host device determines that the pill case container does not contain the specified quantities of the multiple pill types of the patient medication schedule.
3. The system of claim 1, wherein the host device is further configured to determine whether the pill case container contains an incorrect pill type based on the container weight, the patient medication schedule, and the database of pill types and associated pill weights.
4. The system of claim 1, wherein the database comprises multiple pill weights for one or more of the multiple pill types of the patient medication schedule, and wherein the host device is further configured to: determine whether the pill case container contains the specified quantities of the multiple pill types of the patient medication schedule based further on a statistic determined based on the multiple pill weights.
5. The system of claim 4, wherein the multiple pill weights are based on one or more of: prior container weights of the pill case platform and the patient medication schedule; and container weights of other pill case platforms and patient medication schedules associated with the other pill case platforms.
6. The system of claim 4, wherein the statistic comprises one or more of a standard deviation of the multiple pill weights and a mean of the multiple pill weights.
7. The system of claim 1, wherein the host device is further configured to determine whether the pill case container contains the specified quantities of the multiple pill types of the patient medication schedule by: computing an expected weight of the pill case container based on the specified quantities of the multiple pill types of the patient medication schedule and corresponding pill weights of the database; comparing the container weight to the expected weight; and determining that the pill case container contains the specified quantities of the multiple pill types of the patient medication schedule if the container weight matches the expected weight within a statistical measure of certainty.
8. The system of claim 7, wherein the host device is further configured to determine a corrective quantity of one or more of the multiple pill types of the patient medication schedule if the container weight does not match the expected weight within the statistical measure of certainty, including to: compute alternative expected weights of the pill case container based on various quantities of the multiple pill types of the patent medication schedule and the corresponding pill weights of the database; compare the container weight to the alternative expected weights; and determine that the pill case container contains an incorrect quantity of one or more of the multiple pill types of the patient medication schedule if the container weight matches one of the alternative expected weights within the statistical measure of certainty.
9. The system of claim 8, wherein the host device is further configured to: determine the corrective quantity based on the alternative expected weight that matches the expected weight within the statistical measure of certainty.
10. The system of claim 8, wherein the host device is further configured to: determine that the pill case container contains an incorrect pill type if the container weight does not match any of the

alternative expected weights within the statistical measure of certainty.

11. The system of claim 1, wherein the host device is further configured to send an alert to the pill container platform if the host device determines that the pill case container does not contain the specified quantities of the multiple pill types of the patient medication schedule.

12. The system of claim 1, wherein the host device is further configured to provide a corrective instruction to a user device associated with the pill case platform if the host device determines that the pill case container does not contain the specified quantities of the multiple pill types of the patient medication schedule, and wherein the corrective instruction comprises one or more of: an instruction to add a corrective quantity of one or more of the multiple pill types of the patient medication schedule to the pill case container; an instruction to remove a corrective quantity of one or more of the multiple pill types of the patient medication schedule from the pill case container; and an instruction to remove a corrective quantity of an incorrect pill type from the pill case container.

13. The system of claim 12, wherein the host device is further configured to: provide an image of the one or more pill types identified in the corrective instruction, to the user device.

14. The system of claim 1, wherein the host device is further configured to: provide an instruction for loading the pill case container with the specified quantities of the multiple pill types of the patient medication schedule, to a user device associated with the pill case platform; and provide images of the multiple pill types with the instruction.

15. The system of claim 1, wherein the pill case platform comprises multiple pill case containers, and wherein the host device is further configured to: provide instructions for loading respective ones of the pill case containers based on the patient medication schedule, serially.

16. The system of claim 1, wherein the pill case platform comprises multiple pill case containers, and wherein the host device is further configured to: provide instructions for loading respective ones of the multiple pill types of the patient medication schedule, to a user device associated with the pill case platform.

17. The system of claim 1, wherein the pill case platform comprises multiple pill case containers, and wherein the host device is further configured to: determine whether the pill case containers contain respective specified quantities of the multiple pill types of the patient medication schedule based on respective container weights, the database of pill types and associated pill weights, and an indication that the pill cases are loaded in accordance with the pill schedule; wherein the indication comprises one or more of, an indication from the pill case platform that lids of the pill case containers are closed, and an indication from a user device that the pill cases are loaded in accordance with the pill schedule.

18. A non-transitory computer readable medium encoded with a computer program that comprises instructions to cause a processor to: associate a pill case platform with a patient and with a user device, wherein the pill container platform comprises multiple pill case containers; receive a medication schedule of the patient from the user device; determine specified quantities of multiple pill types of the patient medication schedule, for each of the pill case containers, based on the patient medication schedule; receive indications of container weights from the pill case platform; and determine whether the pill case containers contain the specified quantities of the multiple pill types of the patient medication schedule based on the container weights and a database of pill weights and associated pill types.

19. The non-transitory computer readable medium of claim 18, further comprising instructions to cause the processor to: send a confirmation to one or more of the user device and the pill case platform if the pill case containers contain the specified quantities of the multiple pill types of the patient medication schedule; and determine a determine a corrective quantity of one or more of the multiple pill types for one or more of the pill case containers and provide a corrective instruction to the user device if one or more of the pill case containers do not contain the specified quantities of the multiple pill types of the patient medication schedule.

20. The non-transitory computer readable medium of claim 18, further comprising instructions to cause the processor to: provide instructions for loading the specified quantities of the multiple pill types of the patient medication schedule to the user device.

21. The non-transitory computer readable medium of claim 18, further comprising instructions to cause the processor to: determine whether the pill case container contains an incorrect pill type based on the container weight, the patient medication schedule, and the database of pill types and associated pill weights.