fluid handling system can be configured to issue an alert or alarm and to not proceed in executing the protocol until corrective measures by an operator have been performed. In an example, the fluid handling system can adapt to liquid reagent vials being loaded into improper positions by adapting the programmed protocol. In other examples, the fluid handling system of the present disclosure can operate with the programmed protocol having to be programmed with specific liquid reagent vial locations.

[0012] The solutions of the present disclosure can improve fluid handling system efficiency and performance by: 1) eliminating operator errors when loading components onto fluid handling systems; 2) protecting expensive reagents; 3) minimizing technician time when loading fluid handling systems; 4) minimizing technician time in tracking reagent lots used on samples; 5) increasing flexibility by being adaptable to new and different kits; 6) determining if reagent vials are present within the fluid handling system; 7) detecting if caps have been removed from reagent vials loaded into the fluid handling system; and reducing reagent exposure time by allowing aliquoted reagents to be returned to storage, e.g., refrigeration, early after being identified and aliquoted.

Summary ~~of the Invention~~

[0013] In an example, a fluid handling system for preparing a sample according to a programmed protocol can comprise a deck having source locations and destination locations, a tube holder located on the deck and configured to receive a reagent vessel having a label with visual indicators of identifying features, an imaging device configured to create an image of the label on the reagent vessel in the tube holder, a pipettor configured to aspirate liquid from source locations on the deck of the fluid handling system and to dispense the aspirated liquids to destination locations on the deck, a non-transitory computer-readable storage medium including the programmed protocol, the programmed protocol specifying source locations and destination locations for different reagents on the deck, and a processor configured to prepare the sample by: recognizing the visual indicators in the image of the label and to identify a reagent in the reagent vessel based on the recognized visual indicators, determining the destination location specified for the identified reagent in the programmed protocol, directing the pipettor to aspirate a volume of liquid from the reagent vessel in the tube holder, and directing the pipettor to dispense the aspirated volume at the determined

destination location for the identified reagent. In some ~~embodiment~~examples, the imaging device can be configured to produce composite images. In some ~~embodiment~~examples, the imaging device can be configured to produce the composite images via slit-scan imaging. In some ~~embodiment~~examples, the imaging device can be configured to produce an unrolled image. In some ~~embodiment~~examples, the tube holder may comprise a carousel configured to hold a plurality of reagent vessels, wherein the carousel is rotatable along a center axis of the carousel. In some ~~embodiment~~examples, the tube holder may comprise a tray configured to hold a plurality of reagent vessels, wherein the tray is configured to linearly slide along an axis. In some ~~embodiment~~examples, the tube holder can include a turntable to rotate the reagent vessel along a central axis of the reagent vessel such that the imaging device can view an entire perimeter of the reagent vessel. In some ~~embodiment~~examples, a reagent on the tube holder can be aliquoted regardless of a position on the carousel into which the reagent is loaded. In some ~~embodiment~~examples, the imaging device may have a field of view configured to simultaneously image each of the plurality of reagent vessels. In some ~~embodiment~~examples, the imaging device may be one of a plurality of imaging devices. The plurality of imaging devices can be positioned such that all portions of the label are in view of at least one of the plurality of imaging devices. In some ~~embodiment~~examples, the fluid handling system may be configured to determine a level of liquid within the reagent vessel, and the processor may be configured to confirm sufficient volume of liquid has been loaded into the reagent vessel according to the protocol. In some ~~embodiment~~examples, the non-transitory computer-readable storage medium may include visual indicators for reagent vessels from different manufacturers. The visual indicators on the label may include lot information for the reagent vessel, the lot information including a lot number and an expiration date. The processor may be configured to provide a warning of an expired reagent.

[0013a] In ~~another example~~one aspect, the present disclosure refers to a fluid handling system for processing a sample using a reagent kit including a plurality of reagent vessels, each of the plurality of reagent vessels containing a corresponding liquid reagent, the fluid handling system comprising: a non-transitory, computer-readable storage medium including a programmed protocol for processing the sample, the programmed protocol including a listing of reagents for processing the sample, a vessel holder configured to receive the plurality of reagent vessels at a corresponding plurality of locations, each reagent vessel having visual indicators of identifying features located on an identification label; an imaging device configured to create

an image of each of the plurality of reagent vessels loaded into the vessel holder; and a processor configured to: recognize the visual indicators in each image and to identify the reagent in each of the plurality of reagent vessels based on the recognized visual indicators; ~~and~~ determine if appropriate reagents have been loaded into the vessel holder as specified in the listing of reagents; and adapt the programmed protocol if any reagent vessel is not loaded as specified in the listing of reagents.

[0013b] In another aspect, the present disclosure refers to a fluid handling system for preparing a sample according to a programmed protocol, the fluid handling system comprising, a deck having source locations and destination locations, a tube holder located on the deck and configured to receive a reagent vessel having a label with visual indicators of identifying features, an imaging device configured to create an image of the label on the reagent vessel in the tube holder, a pipettor configured to aspirate liquid from source locations on the deck of the fluid handling system and to dispense the aspirated liquids to destination locations on the deck, a non-transitory computer-readable storage medium including the programmed protocol, the programmed protocol specifying source locations and destination locations for different reagents on the deck, and a processor configured to prepare the sample by, recognizing the visual indicators in the image of the label and to identify a reagent in the reagent vessel based on the recognized visual indicators, determining the destination location specified for the identified reagent in the programmed protocol, directing the pipettor to aspirate a volume of liquid from the reagent vessel in the tube holder, and directing the pipettor to dispense the aspirated volume at the determined destination location for the identified reagent.

[0014] In an additional example, a fluid handling system for processing a sample using a reagent kit including a plurality of reagent vessels can comprise a non-transitory, computer-readable storage medium including a programmed protocol including a listing of reagent vials, wherein the programmed protocol specifies an expected location for each the plurality of reagent vessels for loading onto a carousel, a reagent carousel configured to receive the plurality of reagent vessels at a corresponding plurality of locations, each reagent vessel having visual indicators of identifying features located on an identification label, an imaging device configured to create an image of each of the plurality of reagent vessels loaded onto

the reagent carousel; and a processor configured to: recognize the visual indicators in each image and to identify the reagent in each of the plurality of reagent vessels based on the recognized visual indicators, and determine if a loaded location for each identified reagent corresponds to an expected location for that reagent as specified in the programmed protocol.

In some ~~embodiment~~examples, the imaging device can be configured to produce composite images via slit-scan imaging. In some ~~embodiment~~examples, the reagent carousel can be rotatable along a center axis of the reagent carousel. In some ~~embodiment~~examples, the imaging device may have a field of view configured to simultaneously image the plurality of reagent vessels in the reagent carousel. In some ~~embodiment~~examples, the non-transitory, computer-readable storage medium may include a database including visual indicators for reagent vessels from different manufacturers, including a lot number and an expiration date. The processor may be configured to compare visual indicators in the database to decipher the visual indicators in the images. The processor may be configured to compare the deciphered visual indicators in the images to information in the programmed protocol. In some ~~embodiment~~examples, the fluid handling system can be configured to determine a level of liquid within a reagent vessel, and the processor can be configured to confirm sufficient volume of liquid has been loaded into the reagent vessel according to the programmed protocol.

[0015] In ~~yet~~ another aspect~~example~~, the present disclosure refers to a method of identifying reagents loaded into a fluid handling system can comprise programming a protocol for preparing a sample into a controller of the fluid handling system, loading multiple reagent vessels into a vessel holder of the fluid handling system, imaging individual labels of the multiple reagent vessels with an imaging device to produce label images, comparing information in the label images to identification information located in a database in communication with the controller, ~~and~~ determining if appropriate reagents have been loaded into the carousel to perform the protocol, and adapt the programmed protocol if any reagent vessel is not loaded as specified in a listing of reagents, wherein the listing of reagents are included in the protocol for processing the sample. In some ~~embodiment~~examples, the multiple reagent vessels can be loaded into the vessel holder according to positional information in the protocol. In some ~~embodiment~~examples, determining if appropriate reagents have been loaded into the vessel holder to perform the protocol can comprise determining if appropriate reagents are loaded into the vessel holder at locations according to the protocol. In some ~~embodiment~~examples, the protocol can be performed based on a sequence of steps outlined in the protocol. In some

~~embodiment~~examples, the multiple reagent vessels can be loaded into the vessel holder in arbitrary positions. In some

~~embodiment~~examples, determining if appropriate reagents have been loaded into the vessel holder to perform the protocol can comprise determining if sufficient reagents are loaded into the vessel holder to perform the protocol. In some ~~embodiment~~examples, the protocol can be performed based on a sequence of steps determined based on locations of the reagents in the vessel holder. In some ~~embodiment~~examples, imaging individual labels of the multiple reagent vessels with the imaging device to produce label images can comprise imaging the individual labels with a slit-scan process to generate a panoramic image. Imaging individual labels of the multiple reagent vessels with the imaging device to produce label images can further comprise rotating individual reagent vessels to obtain the panoramic images. The method may further comprise calibrating a rotational speed of individual reagent vessels using a geometric calibration label. In some ~~embodiment~~examples, comparing information in the label images to identification information located in the database in communication with the controller can comprise comparing visual indicator information to manufacturer information stored in the database. In some ~~embodiment~~examples, the method may further comprise determining a destination location specified for reagents in the protocol, directing a pipettor to aspirate a volume of liquid from a reagent vessel in the vessel holder, and directing the pipettor to dispense the aspirated volume at the determined destination location for the identified reagent. In some ~~embodiment~~examples, the method may further comprise determining from images of the vessel holder if sufficient volume of liquid has been loaded into the reagent vessels to perform the protocol, and providing an alarm if insufficient liquid remains in a reagent vessel. In some ~~embodiment~~examples, the method may further comprise determining from images of the vessel holder if caps have been removed from the reagent vessels, and providing an alarm if a cap has not been removed from a reagent vessel. In some ~~embodiment~~examples, the method can further comprise determining image quality for images of the vessel holder, and providing an alarm if images of the vessel are insufficiently clear to determine information from images of labels in the images of the vessel holder. In some ~~embodiment~~examples, the method may further comprise a user overriding alarms generated by the system after manual or visual confirmation.

Brief Description of the Drawings

[0016] FIG. 1 is a block diagram of a fluid handling system according to an example of the present disclosure.

Claims

What is claimed is:

1. A fluid handling system for processing a sample using a reagent kit including a plurality of reagent vessels, each of the plurality of reagent vessels containing a corresponding liquid reagent, the fluid handling system comprising:

a non-transitory, computer-readable storage medium including a programmed protocol for processing the sample, the programmed protocol including a listing of reagents for processing the sample,

a vessel holder configured to receive the plurality of reagent vessels at a corresponding plurality of locations, each reagent vessel having visual indicators of identifying features located on an identification label;

an imaging device configured to create an image of each of the plurality of reagent vessels loaded into the vessel holder; and

a processor configured to:

recognize the visual indicators in each image and to identify the reagent in each of the plurality of reagent vessels based on the recognized visual indicators; ~~and~~

determine if appropriate reagents have been loaded into the vessel holder as specified in the listing of reagents; and~~.~~

adapt the programmed protocol if any reagent vessel is not loaded as specified in the listing of reagents.

2. The fluid handling system of claim 1, wherein the programmed protocol further specifies an expected location for each the plurality of reagent vessels for loading into the vessel holder, wherein the processor is further configured to determine if a loaded location of the reagent~~reaction~~ vessel for each identified reagent corresponds to the expected location for that reagent vessel as specified in the programmed protocol.

3. The fluid handling system of any one of claims 1 to 2, wherein each of the plurality of reagent vessels loaded into the vessel holder is rotatable along a central axis of the reagent vessel.

4. The fluid handling system of claim 3, wherein the imaging device is configured to produce a composite image of each of the plurality of reagent vessels via slit-scan imaging.

5. The fluid handling system of claim 4, wherein the processor is further configured to calibrate a rotational speed of individual reagent vessels in the vessel holder using a geometric calibration label.

6. The fluid handling system of any one of claims 1 to 5, wherein the vessel holder is a reagent carousel rotatable along a central axis of the reagent carousel.

7. The fluid handling system of any one of claims 1 to 6, wherein the imaging device has a field of view configured to simultaneously image the plurality of reagent vessels in the vessel holder.

8. The fluid handling system of any one of claims 1 to 7, wherein the non-transitory, computer-readable storage medium includes a database including visual indicators for reagent vessels from different manufacturers including a lot number and an expiration date.

9. The fluid handling system of claim 8, wherein the processor is configured to compare visual indicators in the database to decipher the visual indicators in the images.

10. The fluid handling system of claim 9, wherein the processor is configured to compare the deciphered visual indicators in the images to information in the programmed protocol.

11. The fluid handling system of any one of claims 1 to 10, wherein:

the fluid handling system is configured to determine a level of liquid within a reagent vessel; and

the processor is further configured to confirm sufficient volume of liquid is contained in the reagent vessel according to the programmed protocol.

12. The fluid handling system of any one of claims 1 to 11, wherein the recognized visual indicators comprise alphanumeric characters.

13. The fluid handling system of any one of claims 1 to 12, further comprising:

a deck having source locations and destination locations; and

a pipettor configured to aspirate liquid from source locations on the deck and to dispense the aspirated liquids to destination locations on the deck,

wherein the programmed protocol further specifies a destination location for the corresponding reagent in each of the plurality of reagent vessels loaded into the vessel holder, and

wherein the processor is further configured, for each of the plurality of reagent vessels loaded into the vessel holder, to:

determine the destination location specified for the identified reagent in the programmed protocol;

direct the pipettor to aspirate a volume of liquid from the reagent vessel in the vessel holder, and

direct the pipettor to dispense the aspirated volume at the determined destination location for the identified reagent.

14. The fluid handling system of claim 13, wherein the processor is further configured, for each reagent vessel loaded into the vessel holder, to direct the pipettor to aspirate the volume of liquid from the reagent vessel and to dispense the aspirated volume at the determined destination location regardless of the position in the vessel holder into which the reagent vessel has been loaded.

15. The fluid handling system of any one of claims 1 to 14, wherein the processor is further configured to determine, from images of the vessel holder, if caps have been removed from the reagent vessels, and to provide an alarm if a cap has not been removed from a reagent vessel.

16. A fluid handling system for preparing a sample according to a programmed protocol, the fluid handling system comprising:

a deck having source locations and destination locations;

a tube holder located on the deck and configured to receive a reagent vessel having a label with visual indicators of identifying features;

an imaging device configured to create an image of the label on the reagent vessel in the tube holder;

a pipettor configured to aspirate liquid from source locations on the deck of the fluid handling system and to dispense the aspirated liquids to destination locations on the deck;

a non-transitory computer-readable storage medium including the programmed protocol, the programmed protocol specifying source locations and destination locations for different reagents on the deck; and

a processor configured to prepare the sample by:

recognizing the visual indicators in the image of the label and to identify a reagent in the reagent vessel based on the recognized visual indicators;

determining the destination location specified for the identified reagent in the programmed protocol;

directing the pipettor to aspirate a volume of liquid from the reagent vessel in the tube holder, and

directing the pipettor to dispense the aspirated volume at the determined destination location for the identified reagent.

17. A method of identifying reagents loaded into a fluid handling system, the method comprising:

programming a protocol for preparing a sample into a controller of the fluid handling system;

loading multiple reagent vessels into a vessel holder of the fluid handling system;

imaging individual labels of the multiple reagent vessels with an imaging device to produce label images;

comparing information in the label images to identification information located in a database in communication with the controller; ~~and~~

determining if appropriate reagents have been loaded into the vessel holder to perform the protocol; and~~.~~

adapting the programmed protocol if any reagent vessel is not loaded as specified in a listing of reagents, wherein the listing of reagents are included in the protocol for processing the sample.