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Methods and systems for slide processing

Abstract

Various examples of systems and methods are provided for slide processing. In one example, among others, a system for processing microscope slides includes a slide positioner that can adjust a position of a slide and a slide treatment system that can dispense a micro stream of a fluid at a location on the slide when the slide is positioned beneath a jet nozzle of the slide treatment system. The system can include a slide sled that can align a smearing slide with a surface of the slide including a fluid sample is disposed, and support the smearing slide at a predefined angle with respect to the surface of the slide. In another example, a method includes obtaining a slide including a sample disposed on a surface, positioning the slide below to a jet nozzle, and dispensing a micro stream of a fluid onto the sample using the jet nozzle.

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS (1) This application is a continuation application of co-pending U.S. patent application Ser. No. 17/892,493, filed Aug. 22, 2022, which is a continuation application of U.S. patent application Ser. No. 16/240,579, filed Jan. 4, 2019, which is a divisional application of U.S. patent application Ser. No. 15/112,310, filed Jul. 18, 2016, which is the 35 U.S.C. § 371 national stage application of PCT Application No. PCT/US2015/011879, filed Jan. 17, 2015, which claims priority to, and the benefit of, U.S. provisional application entitled “METHODS AND SYSTEMS FOR SLIDE PROCESSING” having Ser. No. 61/928,566, filed Jan. 17, 2014; U.S. provisional application entitled “METHODS AND SYSTEMS FOR SLIDE PROCESSING” having Ser. No. 62/061,015, filed Oct. 7, 2014; and U.S. provisional application entitled “METHODS AND SYSTEMS FOR SLIDE PROCESSING” having Ser. No. 62/089,084, filed Dec. 8, 2014, all of which are hereby incorporated by reference in their entireties.

BACKGROUND

(1) Microscope slides are prepared by hand for examination under a microscope. After a sample has been transferred to the slide and dried, the sample can be stained using a pipet or a bath to aid in examination. Such processing can be labor intensive. After drying, the slide is positioned under a microscope for examination and evaluation. In some cases, the processed slide is physically shipped to another facility for examination and evaluation.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) Many aspects of the present disclosure can be better understood with reference to the following drawings. The components in the drawings are not necessarily to scale, emphasis instead being placed upon clearly illustrating the principles of the present disclosure. Moreover, in the drawings, like reference numerals designate corresponding parts throughout the several views.

(2) FIG. 1 is a drawing of an example of a slide processing unit in accordance with various embodiments of the present disclosure.

(3) FIG. 2 is a perspective view of an example of the interior of the slide processing unit of FIG. 1 in accordance with various embodiments of the present disclosure.

(4) FIGS. 3A-3D are perspective views of the interior of the slide processing unit of FIG. 2 illustrating positioning of a slide in accordance with various embodiments of the present disclosure.

- (5) FIGS. 4A-4F are perspective views of an example of a mounting plate and slide clamp that can be used in the slide processing unit of FIGS. 1 and 2 in accordance with various embodiments of the present disclosure.
- (6) FIGS. 5A and 5B-5D are front and perspective views (respectively) of an example of the interior of the slide processing unit of FIGS. 1 and 2 in accordance with various embodiments of the present disclosure.
- (7) FIGS. 6A and 6B-6C are front and perspective views (respectively) of an example of the interior of the slide processing unit of FIGS. 1 and 2 including a slide dispenser unit in accordance with various embodiments of the present disclosure.
- (8) FIGS. 7A-7H include various views of an example of a slide dispenser used in the slide processing unit of FIGS. 1 through 5D in accordance with various embodiments of the present disclosure.
- (9) FIGS. 8A-8D and 8E-8F are perspective and side views (respectively) of an example of the interior of the slide processing unit of FIGS. 1 and 2 including a slide treatment system in accordance with various embodiments of the present disclosure.
- (10) FIGS. 9A-9D are perspective, side, front and top internal views (respectively) of another slide treatment system of the slide processing unit of FIGS. 1 and 2 in accordance with various embodiments of the present disclosure.
- (11) FIG. 10 is a graphical representation of a system for remote access and storage of slide processing using a slide processing unit of FIGS. 1 and 2 in accordance with various embodiments of the present disclosure.
- (12) FIG. 11 is a schematic block diagram that illustrates an example of processing circuitry employed in the slide processing unit of FIGS. 1 and 2 in accordance with various embodiments of the present disclosure.

DETAILED DESCRIPTION

- (13) Disclosed herein are various examples of methods and systems related to microscope slide processing. Reference will now be made in detail to the description of the embodiments as illustrated in the drawings, wherein like reference numbers indicate like parts throughout the several views.
- (14) Slide processing units can be used for automated processing and imaging samples on a slide. Samples can include fluids (e.g., blood or other bodily fluids), tissue or other types of samples. Once transferred to a slide, the sample can be processed and imaged for examination by a user. Images of the sample can be captured with a camera and displayed and/or stored for examination by the user. The images of the slide can be locally and/or remotely accessed by the user in real time, or can be accessed by the user after capture and storage. For example, images of the processed sample can be stored in memory and subsequently accessed by the user when his or her schedule allows.
- (15) Referring to FIG. 1, shown is a perspective view of an example of a slide processing unit (or slide processor) **100**, in accordance with various embodiments of the present disclosure. The slide processing unit **100** includes a display screen **103** for displaying and/or accessing information about the slide processing unit **100**. For example, the processing status of a slide (e.g., staining, drying, imaging, etc.) can be indicated on the display screen **103**. After the slide has been processed, an image of the sample can be provided through the display screen **103**. In some implementations, the image of the sample can be manipulated through the display screen **103**. The display screen **103** can be touch-sensitive to allow for user input through the display screen **103**. In other embodiments, a user interface unit (e.g., keyboard, mouse, touch pad, etc.) can be communicatively coupled to the slide processing unit **100** through a communications interface. The connection can be through a wireless link (e.g., WiFi, Bluetooth®, Klear, Infrared, etc.) or through a wired connection.
- (16) Processing of the slide can be carried out in an enclosed environment to reduce the chance of

contamination. A carriage **106** allows a user to insert a slide into the slide processing unit **100** for processing. With the carriage **106** pulled out of the slide processing unit **100**, a slide including a sample can be inserted into the carriage **106**. A guide or slot in the bottom of the carriage **106** can be used to hold the slide in the proper orientation for acquisition by a slide positioner that repositions the slide for processing and imaging within the slide processing unit **100**.

(17) Referring next to FIGS. **2** and **3A-3D**, show various perspective views of an example of a portion of the interior of the slide processing unit **100** with the cover including the display screen **103** removed. As shown in FIG. **2**, the slide processing unit **100** includes a slide positioner **203**, a light source **206**, one or more microscopic lenses **209** and an image capture unit **212**. The structure and operation of the slide positioner **203** is further illustrated in FIGS. **3A-3D**. As seen in FIG. **3A**, the slide positioner **203** includes a slide clamp **303** that grips the slide **306** when inserted through the carriage **106**. The slide clamp **303** is supported by a mounting plate **309** that can be positioned along the x-axis and y-axis using guide rails and stepper or servo motors with finely pitched jack screws (with a high number of threads per inch). A first pair of guide rails **312** support the mounting plate **309** and allow for its movement along the x-axis. The guide rails **312** are secured in position by end plates **315** that are supported by a second pair of guide rails **318**. The second pair of guide rails **318** allows movement of the first pair of guide rails **312**, and thus the mounting plate **309** and slide clamp **303**, along the y-axis.

(18) As can be seen in FIGS. **3B** and **3C**, a stepper or servo motor **321a** can be mounted to one of the end plates **315** to control movement along the first pair of guide rails **312**. The treads of the jack screw **324a** can engage with a threaded portion of a bracket **327a** (e.g., a threaded sleeve mounted to the bracket or a threaded opening through the bracket) secured to the mounting plate **309** such that rotation of the jack screw **324a** moves the mounting plate **309** along the first pair of guide rails **312**. Another stepper or servo motor **321b** can be mounted (e.g., to a support structure) to control movement of the assembly including the slide clamp **303**, mounting plate **309**, first pair of guide rails **312** and end plates **315** along the second pair of guide rails **318** as illustrated in the cutaway view of FIG. **3D**. The treads of the jack screw **324b** can engage with a threaded portion of a bracket **327b** (e.g., a threaded sleeve mounted to the bracket or a threaded opening through the bracket) secured to one of the end plates **315**. Rotation of the jack screw **324b** moves the assembly along the first pair of guide rails **312**.

(19) A low wear, low friction material such as a layer of polymer (e.g., polytetrafluoroethylene (PTFE), fluorinated ethylene propylene, etc.) or other appropriate material can be used to provide for smooth movement of the mounting plate **309** across the first pair of guide rails **312** and/or the end plates **315** across the second pair of guide rails **318**. The position of the slide positioner **203** can be detected using one or more sensors. For example, a sensor **333** (e.g., a capacitive sensor, a magnetic sensor, an infrared sensor, a photosensitive sensor, etc.) can be used to detect the position of an end plate **315** when it reaches a travel limit along the second pair of guide rails **318** as illustrated in FIG. **3D**. Similar sensors can be used to detect the position of the mounting plate **309** as it reaches a travel limit along the first pair of guide rails **312**. These sensors can also be used as reference points for calibration and/or control of the slide positioner **203**.

(20) Referring to FIGS. **4A-4G**, shown are various perspective views of a rotator assembly including the slide clamp **303** and mounting plate **309**. A stepper or servo motor **330** can be mounted to a lower side of the mounting plate **309** as illustrated in FIGS. **3A** and **3B**. The shaft of the stepper or servo motor **330** can extend through the mounting plate **309**. With the slide clamp **303** secured to the shaft of the motor **330**, the motor **330** can be used to control rotation of the slide clamp **303** about the z-axis defined by the motor shaft. The slide clamp **303** includes an alignment arm **403** on a first side and a clamping arm **406** on a second side. The sample slide **306** can be inserted between the two arms **403** and **406**. The alignment arm **403** is fixed in position to align one side of the slide, while the clamping arm **406** applies pressure to the opposite side the sample slide **306** to hold it in position against the alignment arm **403** during processing by the slide processing

unit **100**. A spring can be used to apply a clamping force with the clamping arm **406**. As illustrated in FIGS. **4E** and **4F**, the clamping arm **406** can include a textured edge **409** that can help grip the slide **306**. In some implementations, the textured edge **409** can be provided by a flexible material (e.g., rubber) that aids in gripping the slide **306**.

(21) The mounting plate **309** acts as a stage for microscopic examination of the sample slide **306**. As shown in FIGS. **4A-4F**, the mounting plate **309** includes an opening **412** that allows the light source **206** to illuminate the sample during image capture, when the slide **306** is positioned over the opening **412**. The slide clamp **303** can utilize a spring assembly (e.g., a hold down spring) to apply downward pressure on the slide **306** to hold it against the mounting plate, which acts as a stage during microscopic imaging of the sample. A pressure plate **415** (FIGS. **4E** and **4F**) that extends over the alignment arm **403** and clamping arm **406** can be used to secure the hold down spring (or other spring assembly) in position on the slide clamp **303**. A lower edge **418** (FIG. **4A**) of the clamping arm **406** and/or the alignment arm **403** can be beveled outward to aid in holding the slide **306** against the surface of the mounting plate **309**.

(22) As previously discussed, the stepper or servo motor **330** (FIGS. **3A-3B**) can be used to control rotation of the slide clamp **303**. The position of the slide clamp **303** can be detected using one or more sensors. In the example of FIGS. **4E** and **4F**, a sensor **421** is used to detect when the slide clamp **303** has been rotated to a reference position where the slide clamp **303** is aligned to receive a sample slide **306** from or return the sample slide **306** to the carriage **106** (FIG. **1**). A tab **424** affixed to the slide clamp **303** can be used to detect the position of the slide clamp **303** with the sensor **421** (e.g., a capacitive sensor, a magnetic sensor, an infrared sensor, a photosensitive sensor, etc.). For example, the tab **424** extends from a side of the slide clamp **303** such that it can be detected by the sensor **421** when the slide clamp **303** is oriented with the carriage **106**, where can receive a sample slide **306**. With the reference position known, the stepper or servo motor **330** can be controlled to position the sample slide **306** in the proper orientation for processing and for imaging.

(23) For imaging, the sample slide **306** is positioned over the opening **412** of the mounting plate **309**. To ensure that the alignment of the sample slide **306** over the opening **412** is repeatable, the mounting plate **309** can include a guide shoulder **427** opposite from the slide clamp **303** as illustrated in FIGS. **4A** and **4B**. The guide shoulder **427** can be machined or otherwise formed on the mounting plate **309** so that, as a sample slide **306** is rotated over the opening **412**, the distal end of the slide **306** opposite the slide clamp **303** contacts the guide shoulder **427** to align the position along the longitudinal axis of the slide **306**. The downward pressure applied by the spring assembly of the slide clamp **303** can hold the slide **306** against the mounting plate **309** and prevent the distal end of the slide **306** from moving over the guide shoulder **427**. A slide stop **430** can be used to prevent the distal end of the slide **306** from moving beyond the desired orientation. The slide stop **430** can be machined or otherwise formed on the mounting plate **309** adjacent to the guide shoulder **427**. The combination of the alignment arm **303**, guide shoulder **427** and slide stop **430** allows for consistent positioning of sample slides **306** on the mounting plate **309** during imaging with the microscopic lenses **209** and image capture unit **212** (FIG. **3C**). In addition, a sample slide **306** can be reinserted and positioned for reexamination at the same location at different times. The mounting plate **309** can include a backside groove (shoulder or boss) with a clamp stop **433** to provide a hard stop to ensure a 90 degree alignment and prevent over-rotation during positioning of the slide **306** under the digital microscope. Consistency of positioning allows the slide processing unit **100** to relocate image positions on the sample slide **306** after it has been removed and replaced.

(24) Referring back to FIGS. **3A-3D**, the movement of a slide **306** by the slide positioner **203** is illustrated. As shown in FIG. **3A**, the slide positioner **203** includes a slide clamp **303** that grips a sample slide **306** when inserted through the carriage **106**. With the carriage **106** closed, a proximal end of the sample slide **306** extends into the slide processing unit **100**. With the slide clamp **303** rotated to the reference position as detected by sensor **421** (FIGS. **4E-4F**), the stepper or servo motors **321** can be controlled to align the slide clamp **303** with, but offset from, the proximal end of

the sample slide **306**. In some embodiments, this can be a default position when no slide **306** is being handled by the slide processing unit **100**. The slide positioner **203** can then be advanced along the y-axis by stepper or servo motor **321b** to secure the proximal end of the sample slide **306** between the alignment arm **403** and clamping arm **406** of the slide clamp **303**. Pressure from the clamping arm **406** forces the opposite side of the slide **306** against the alignment arm **403**, which properly orients the slide **306** in the slide clamp **303**.

(25) The slide clamp **303** can also include a spring assembly for holding the slide **306** in position on the mounting plate. For example, a hold down spring can be configured to apply downward pressure on the top of the slide **306** to avoid twisting of the slide **306** in the slide clamp **303**. In other embodiments, the inner surface of the alignment and clamping arms **403** and **406** can be tapered or beveled outward from top to bottom such that a force is applied to the top edges of the sides of the slide **306** to avoid twisting in the slide clamp **303**. With the slide clamp **303** holding the proximal end of the sample slide **306**, the slide positioner **203** can then be retracted along the y-axis by stepper or servo motor **321b** to remove the slide **306** from the carriage **106**. With the sample slide **306** clear of the carriage **106**, the slide positioner **203** can reposition the slide **306** along the x-axis and y-axis by moving along the rails **312** and **318**, as well as by rotating the slide **306** about the z-axis.

(26) For example, a small drop of blood can be placed on an enumerated location on an unprepared glass microscope slide **306**. The sample slide **306** can then be placed in the carriage **106** (FIGS. 1-2) and inserted into the slide processing unit **100**. The slide clamp **303** may then be positioned to grip the proximal end of the slide **306** as illustrated in FIG. 3A. The carriage **106** is not shown for illustration. Pressure from the clamping arm **406** forces the slide **306** against the alignment arm **403** as depicted. The slide positioner **203** can then draw the slide **306** out of the carriage **106** and reposition it for processing of the sample. For example, the slide clamp **303** can rotate about 90 degrees for smearing and/or treatment of the blood sample as shown in FIG. 3B.

(27) In one embodiment, the sample slide **306** is positioned so that a second smearing slide (not shown) drops down to contact the slide at a predefined angle (e.g., about 45 degrees). With the smearing slide resting on the sample slide **306**, the slide processing unit **100** can advance the mounting plate **309** along the first pair of slide rails **312** such that the sample slide **306** moves forward until a short edge of the smearing slide reaches the enumerated location, where it contacts and waits momentarily for capillary action to fully engage the blood droplet along the edge of the smearing slide. In some implementations, the slide processing unit **100** can be configured to optically detect when the sample has reached the smearing slide using one or more sensors and/or light sources. The slide **306** is then backed out from under the smearing slide, allowing capillary action to smear the blood along the length of the slide **306**. In this way, a monolayer of cells can be achieved along at least a portion of the resulting sample smear. The slide **306** with the sample continues to be retracted until the smearing slide drops off the end of the sample slide **306** and falls to the bottom of the slide processing unit **100** where it becomes waste. In some implementations, a drawer in the bottom of the slide processing unit **100** can catch the falling slides so that they can be retrieved by a user for disposal or cleaning and reuse. The mounting plate **309** can again position the slide **306** for further processing of the sample.

(28) The slide **306** with the smeared sample can be moved to a desiccation position where it is air or vacuum desiccated for a brief period of time by a small fan in the slide processing unit **100**. Once the smeared sample is desiccated, the slide **306** travels forward as shown in FIG. 3B to be positioned under a slide treatment system containing, e.g., methanol which is sprayed, using micro streams of fluid, over the entire surface of the slide **306**. The position of the slide **306** can be incrementally controlled along the x-axis and y-axis by the stepper or servo motors **321**. This process “fixes” the slide **306**. The slide **306** can then be returned to the desiccation position and the methanol evaporated using forced air. In some embodiments, a vacuum can be used to desiccate the treated sample by drawing air across the slide **306** towards a suction tube located adjacent to the

slide **306**.

(29) The slide **306** can then be moved forward to one or more treatment positions that each can, in sequence, spray a liquid stain (or other chemical treatment) onto all or a portion of the sample. Various stains or other treatments can be discharged through electronically controlled jet nozzles. Additional rinsing with alcohol and/or other solvents can be accomplished as previously described to provide for Gram staining of slides. A reservoir in the bottom of the slide processing unit **100** can collect any overflow liquid from the slide **306**. A drain connection can allow the overflow liquid to drain from the reservoir into an appropriate disposal system.

(30) When the slide preparation is completed, the slide **306** can be moved under a digital microscope as shown in FIG. **3C**. The digital microscope includes lenses **209** and image capture unit **212**, which includes mirrors, lenses, and/or an imaging device **803** such as, e.g., CCD's or CMOS circuitry. An image of the sample on the slide **306** can be digitized automatically in a mosaic fashion and stored in memory. The digitized image can be made visible to either the local operator on the display screen **103** (e.g., a self-contained high resolution color monitor) and/or sent via the Internet and/or intranet for review by others skilled in the art of pathology. Focus may be adjusted by adjusting the position of the microscopic lenses **209** over the slide **306**. The light source **206** illuminates the sample during image capture. FIG. **3D** illustrates the position of the slide **306** over the light source **206** with the image capture unit **212** removed from view.

(31) Referring to FIGS. **5A** through **5D**, shown are various views of an interior of the slide processing unit **100** that illustrate the orientation of the smearing slide **503** with respect to the sample slide **306**. As can be seen in FIG. **5A**, the sample slide **306** is positioned so that the smearing slide **503** makes contact at a predefined angle (e.g., about 45 degrees). By allowing the smearing slide **503** to freely move or rock when making contact with the sample slide, the short edge of the smearing slide **503** can rest evenly across the width of the sample slide **306**. With the smearing slide **503** resting on the sample slide **306**, the slide processing unit **100** can advance the mounting plate **309** along the first pair of slide rails **312** such that the sample slide **306** moves forward until a short edge of the smearing slide contacts the blood droplet and allows capillary action to draw it across the edge of the smearing slide **503**. After waiting for a predefined period to allow for the capillary action, the slide processing unit **100** can retract the mounting plate **309** along the first pair of slide rails **312** such that the sample slide **306** moves backward, which smears the blood sample along the length of the sample slide **306**. As the sample slide **306** is retracted from under the smearing slide **503**, the smearing slide **503** can drop to the bottom of the slide processing unit **100** where it can be retrieved from at a later time. For example, a drawer or other access can be included to allow the discarded slides to be retrieved by a user for cleaning and reuse or for appropriate disposal.

(32) In other implementations, the smearing slide **503** can be advanced on the sample slide **306** until the short edge reaches the enumerated location and then withdrawn to smear the blood along the length of the slide **306**. In some embodiments, a filament (e.g., a multi-fiber or mono filament) may be used instead of the smearing slide. The filament can extend across the width of, and resting on top of, the slide **306** between two spools (e.g., a dispensing spool and a take-up spool). The slide **306** can be advanced and withdrawn to smear the blood along the length of the slide **306**. After the filament is clear of the slide **306**, the soiled portion of the filament may be wound up on the take-up spool while a clean portion of the filament is uncoiled from the dispensing spool.

(33) FIGS. **6A** through **6D** illustrate an example of a slide dispenser unit **603** that can be used to dispense smearing slides **503** onto the sample slide **306**. In this embodiment, the slide dispenser unit **603** includes a smearing slide magazine **606** configured to hold one or more smearing slides **503** and discharge single smearing slides **503** into a slide sled **609** from an end of the smearing slide magazine **606**. After a sample slide **306** with a sample is received by the slide clamp **303**, the slide positioner **203** can reposition it for smearing of the sample. A smearing slide **503** can be dispensed from the smearing slide magazine **606** by moving down a slide sled **609** and contacting

the sample slide **306** at an angle in the range of about 30 degrees to about 60 degrees (e.g., 45 degrees). The smearing slide **503** can be dispensed from the smearing slide magazine **606** using, e.g., a blade that extends to push the smearing slide **503** out of the smearing slide magazine **606** or a wheel that turns to push the smearing slide **503** out of the smearing slide magazine **606**.

(34) As the smearing slide **503** leaves the smearing slide magazine **606**, it drops into the slide sled **609** where it slides down until contacting the sample slide **306** located below. A holding bar **612** extending across the distal end of the slide sled **609** holds the smearing slide **503** in the slide sled **609** when the sample slide **306** is moved forward during smearing. The holding bar **612** can include a pivot point that extends toward the bottom of the trough of the slide sled **609** to allow the smearing slide **503** to rock about the center point (side-to-side) when making contact with the sample slide **306**. For example, the holding bar **612** can have a shallow v-shape with the center point providing the pivot point or can include a point or tip that extends downward from the center of the holding bar **612** to provide the pivot point. The pivot point allows the end of smearing slide **503** to self-align with the surface of the sample slide **306**, which aids in the capillary action during smearing. The weight of the smearing slide **503** provides the contact pressure onto the slide **306** with the sample.

(35) A hinged joint between the slide magazine **606** and slide sled **609**, which can be controlled using a servo or stepper motor, allows the contact angle to be adjusted. In the example of FIGS. **6A-6C**, the smearing slide **503** contacts the slide **306** with the sample at an angle of about 45 degrees. A capped pin (e.g., a stud, screw, bolt, etc.) can be located at the proximal end of the slide sled **609** such that it extends upward from the bottom of the trough. When the smearing slide **503** is dispensed, it moves over and past the top of the capped pin as it travels down the trough of the slide sled **609**. When the smearing slide **503** reaches the sample slide **306**, the capped pin can press against the opposite end of the smearing slide **503** to restrict movement of the smearing slide **503** back up the slide sled **609** when the sample slide **306** is retracted during smearing. The cap at the top of the capped pin catches the lip of the smearing slide **503** to prevent it from moving back over the top of the capped pin.

(36) With the smearing slide **503** in position on the sample slide **306**, the slide positioner **203** can advance the slide **306** until the sample contacts the lower edge of the smearing slide **503** and wait momentarily for the capillary action to fully engage the sample with the lower edge and form a meniscus. The sample slide **306** can then be retracted allowing the capillary action to smear the blood along the length of the slide **306**. The slide **306** with the sample continues to retract until the smearing slide **503** drops off the end of the slide **306** and into the bottom of the slide processing unit **100**. The used smearing slide **503** can be cleaned and sterilized for reuse or can be disposed of appropriately. The slide **306** with the smeared sample can then be moved to a desiccation position where the smeared sample is air desiccated for a brief period of time by a small fan in the slide processing unit **100**.

(37) Referring to FIGS. **7A** through **7H**, shown are various views of another example of a slide dispenser unit **615** that can be utilized in the slide processing unit **100**. FIGS. **7A** and **7D** provide front and back views (respectively), FIGS. **7B** and **7C** provide left and right side views (respectively), FIG. **7E** provides a top view, and FIGS. **7F-7H** provide various perspective views of the slide dispenser unit. In this embodiment, the slide dispenser unit **615** includes a smearing slide magazine **618** configured to hold one or more smearing slides **503** and discharge single smearing slides **503** into a slide sled **621** from a side of the smearing slide magazine **618**. The smearing slides **503** are held in position by stacking guides **624** that include a gap **627** at the bottom to allow a single smearing slide **503** to be dispensed from the bottom of a stack.

(38) After a sample slide **306** with a sample is received by the slide clamp **303**, the slide positioner **203** can reposition it for smearing of the sample. A smearing slide **503** can be dispensed from the smearing slide magazine **618** by a blade **630** that extends to push the smearing slide **503** out of the smearing slide magazine **618** and into the slide sled **621** and then retracts back to allow the next

slide in the stack to move into position for dispensing. In the example of FIGS. 7A-7H, the smearing slide **503** drops into the trough of the slide sled **621** and it is guided to the bottom by an end wall **633** and side walls of the slide sled **621**. The bottom of the slide sled **621** is set at a predefined angle (e.g., about 45 degrees) that controls the angle of contact with the sample slide **306**. When the smearing slide **503** reaches the bottom of the trough, the smearing slide **503** moves forward under the bottom of the end wall **633** (as illustrated in FIGS. 7A and 7D) until it reaches the sample slide **306**. With the smearing slide **503** resting on the bottom of the slide sled **621**, the weight of the smearing slide **503** provides the contact pressure onto the sample slide **306**. The slide sled **621** can be placed approximately the same location as the slide sled **609** shown in FIGS. 6A-6C.

(39) The end wall **633** of the slide sled **621** holds the smearing slide **503** in the slide sled **621** when the sample slide **306** is moved forward during smearing. As seen in FIG. 7B, the end wall **633** includes a pivot point **636** that extends toward the centerline of smearing slide **503** to allow the smearing slide **503** to rock about the center point (side-to-side) when making contact with the sample slide **306**. The pivot point **636** allows the end of smearing slide **503** to self-align with the surface of the sample slide **306**, which aids in the capillary action during smearing. A capped pin (e.g., a stud, screw, bolt, etc.) can be located at the upper end of the slide sled **621** such that it extends upward from the bottom of the trough. For example, a small screw or bolt can be secured through a hole or opening **639** in the slide sled **621**. When the smearing slide **503** is dispensed, it moves over and past the top of the capped pin as it travels down the trough of the slide sled **621**. When the smearing slide **503** reaches the sample slide **306**, the capped pin can press against the opposite end of the smearing slide **503** to restrict movement of the smearing slide **503** back up the slide sled **621** when the sample slide **306** is retracted during smearing. The cap at the top of the capped pin catches the lip of the slide **706** to prevent it from moving back over the top of the capped pin.

(40) When the smearing slide **503** is ejected, the blade presses against an edge of the bottom slide of a stack of slides in a slide magazine. An electric motor **642** (or solenoid) rotates a lever arm **645** to push the blade forward against a side of the bottom slide. For example, a rod at the end of the lever arm **645** can move inside a channel or groove to translate the rotational motion of the lever arm **645** into linear motion of the blade **630**. Linear motion of the blade **630** can be ensured using guide pins in a groove. The thickness of the blade **630** is less than the thickness of a smearing slide **503** and the height of the gap **627** is more than the thickness of a smearing slide **503**, but less than twice the thickness of the slides, to avoid dispensing more than one slide at a time.

(41) The pivot point **636** of the slide sled **621** holds the smearing slide **503** in position while the sample slide **306** is moved forward by the slide clamp **303** until the edge of the smearing slide **503** contacts the sample. At that point, capillary action draws the sample across the edge of the smearing slide **503**. The sample slide **306** can then be retracted while the smearing slide **503** pulls the sample along the surface of the sample slide **306**. The capped pin of the slide sled **621** holds the smearing slide **503** in position while the sample slide **306** is moved back by the slide clamp **303**. As the end of the smearing slide **503** passes over the end of the sample slide **306**, the smearing slide **503** drops out of the slide sled **621** into the bottom of the slide processing unit **100** (e.g., the reservoir or a collection drawer). The slide **306** with the smeared sample can then be moved to a desiccation position where the smeared sample is air or vacuum desiccated for a brief period of time. In some embodiments, a vacuum can be used to desiccate the treated sample by drawing air across the sample slide **306** towards a suction tube located adjacent to the slide **306**. In other implementations, forced air can be blown on the sample slide **306** by a small fan in the slide processing unit **100**.

(42) Once desiccated, the sample slide **306** can be positioned under the slide treatment system **703** for staining and/or other chemical treatment of the sample. Referring next to FIGS. 8A through 8F, shown are various views of an example of the slide processing unit **100** including the slide treatment system **703** for staining and/or other chemical treatment of the sample on the slide **306**.

The slide treatment system **703** includes one or more jet nozzles **706** for application of a fluid (e.g., stain, water, air, oil or other chemical) to the sample on the slide **306**. The slide treatment system **703** also includes one or more reservoirs **609** for holding the treatment fluids. The fluids can be provided through external supply lines attached to corresponding jet nozzles **706** or from a reservoir **709** that is attached to a jet nozzle **606** through an internal supply line and pressurized using pressure regulated air or other appropriate gas. The slide processing unit **100** can include one or more pressure regulators **712** to ensure that appropriate pressure is applied to the reservoirs **709** for control of the jet sprays. The jet nozzles **706** can be electronically controlled to emit pulsed bursts of fluid for a predefined period of time (e.g., 20 μ sec).

(43) The jet nozzles **706** can be aligned to focus the fluid spray or micro streams at a known or common location on the surface of the slide **306**. By positioning the jet nozzles **706** at a fixed position above the sample slide **306** and controlling the pressure of the applied fluid, a well-defined application area can be provided. FIG. **8A** shows an example of a multi-nozzle arrangement including three jet nozzles **706** that are configured to apply treatment fluids. The jet nozzles **706** can be aligned so that different fluids can be applied to the same location on the sample slide **306** without movement of the slide **306**. For example, four jet nozzles **706** can be arranged and aligned to direct different fluid sprays (e.g., a fixative, a stain, a water wash, and/or an air blast for drying) at a predetermined location. One or more stains and/or fixatives can be stored in individual reservoirs **709**, while the water and air may be supplied from an external source. In other embodiments, some or all of the jet nozzles **706** may be aligned to different locations on the surface of the slide **306**.

(44) The fluids may be applied to the sample on the slide using short pulses while the position of the slide **306** is varied by the slide positioner **203** (or slide manipulation mechanism). In this way, various stains or other chemical treatments can be applied to different portions of the smeared sample on the slide **306**. For instance, a stain may be applied to a defined area of the smeared sample after application of a fixative. A water wash may then be applied to remove excess material and a series of air blasts or vacuum applied to dry the sample. Excess fluids can flow off the slide **306** and into a reservoir in the bottom of the slide processing unit **100** for disposal or draining. As shown in FIGS. **8B** and **8F**, a backsplash **715** can be provided to minimize dispersion of the fluids during treatment of the slide **306**. The slide positioner **203** can position the slide **306** under the jet nozzles **706** and over the backsplash **715** for application of the fluids to the smeared sample. In some implementations, oil may be deposited on the treated sample in order to enhance focusing and imaging.

(45) Referring now to FIGS. **9A** through **9D**, shown in an example of another slide treatment system in accordance with various embodiments of the present disclosure. FIG. **9A** shows a perspective view and FIGS. **9B-9D** show side, front and top internal views (respectively) of the slide processing unit **100**. The slide processing unit **100** includes a slide treatment system having one or more cartridges **718**. The cartridges **718** can hold stains or other chemicals for treatment of the sample on the slide **306**. The stain or other chemical can be applied using deflected micro streams in a manner similar to ink jet printers. By adjusting the position of the sample slide **306** under the nozzles of the cartridges **718**, treatment of the smeared sample can be controlled.

(46) When the slide preparation is completed, the slide positioner **203** can retract and rotate the slide **306** under the digital microscope, as illustrated in FIGS. **3C** and **3D**, utilizing the light source **206**, one or more microscopic lenses **209** and the image capture unit **212** for imaging. As shown in FIG. **5A**, the light source **206** is positioned below the level of the sample slide **306** for illumination during imaging. Sufficient cooling is included to prevent distortion of the captured images by heat from the light source **206**. A plurality of microscopic lenses **209** can be positioned above the level of the sample slide **306**. One of the lenses **209** can be selected for imaging by the image capture unit **212** and linearly adjusted for focus on the sample. As can be seen in FIGS. **5A**, two or more microscopic lenses **209** can be mounted on a common baseplate **806**, which is supported by a pair

of guide rails **809**. By moving the baseplate **806** along the guide rails **809**, the desired lens magnification can be selected. A motor **812** (or solenoid) can be controlled to shift the baseplate **806** to align the appropriate lens **209** with the image capture unit **212**. As depicted in FIG. 5C, linkage **815** can be used to translate the rotational motion of the motor **812** to the linear motion of the baseplate **806**. Sensors and/or mechanical stops can be included to ensure proper alignment of the selected lens with the image capture unit **212**. A dust shield can be provided over the back side of the lenses to avoid accumulation of dust or other dirt on the lenses **209**.

(47) With the selected microscopic lens **209** in position, the lens **209** and/or light source **206** can be adjusted for examination and imaging of the sample. For example, the selected lens **209** can be adjusted using a stepper or servo motor **818**. Using appropriate gearing or thread pitch allows for very fine adjustment of the lens **209**, which improves the ability to focus the image for capture. The location of the surface of the sample slide **306** can initially be determined by focusing on an etched portion of the slide **306**. Focus of the microscopic lens **209** can then be automatically carried out by the slide processing unit **100** or manually carried out by the user of the slide processing unit **100**. A hard stop can be provided to prevent the lens **206** from striking the sample slide **306** during adjustment.

(48) With the treated sample under the digital microscope, it is possible to automatically identify a monolayer of the smeared sample. As the sample is smeared across the slide **306**, the thickness of the sample on the slide **306** will decrease or be feathered out until the sample smearing is completed. Towards the end of the smearing, there is an area where a monolayer of cells exists (i.e., where the cells are one cell thick, nominally 3-5 microns). In some implementations, the location of the monolayer can be determined by measuring the light passing through the slide. Initially, light can be measured through the glass of the slide **306** on both sides of the sample where no sample exists. This allows the total amount of light coming through clear glass to be determined. The digital microscope can then search for an area where a predefined percentage of the total light is detected passing through the smeared sample. For example, when the light passing through an area of the smeared sample is about 57% of the total light through clear glass, then a monolayer exists in that area. In this way, the location of a monolayer can be determined in the smeared sample.

(49) The slide processing unit **100** can be used to automatically acquire images of treated samples and transmit the images for storage and/or evaluation at a remote location. Images of the sample on the slide **306** can be digitized automatically in a mosaic fashion using the image capture unit **212**, which includes mirrors, lenses, and/or the imaging device **803**. The images may be initially acquired at a high resolution and stored in memory in the slide processing unit **100**. The location (or relative position) of each of the mosaic images, the operating conditions of the light source **206**, lens **209** and/or image capture unit **212**, and/or identification of the sample slide **306** can also be stored in memory. In some implementations, the slide processing unit **100** can also send the acquired images for external storage in a local or remote data store. For example, the images can be transmitted to secure data store in the cloud. The slide processing unit **100** can be configured to send the images for external storage at the time of acquisition or store the images in the memory of the slide processing unit **100** at the time of acquisition and send them for external storage at a later time. For example, the images can be transmitted at a scheduled time (e.g., after normal business hours when usage of the network is low) or when the slide processing unit **100** is idle.

(50) The digitized images can be made visible to either the local operator on the display screen **103** (FIG. 1) and/or transmitted for review by others skilled in the art of pathology. FIG. 10 is a graphical representation illustrating a system for remotely accessing and/or controlling the slide processing unit **100**. For example, communication can be established between the slide processing unit **100** and a user device **903** (e.g., a computer, tablet, smart phone, etc.) via a secure network connection over one or more networks **906** (e.g., an intranet, the Internet and/or a cellular network). As discussed, the slide processing unit **100** can store the image data in local memory (or storage) and/or can store the image data in remote storage **909** for later access. The remote storage may be

representative of one or more data stores as can be appreciated.

(51) In addition, the data can be transmitted to the user device **903** of examination and evaluation. The user device **903** is representative of a plurality of devices that may be coupled to the network **906**. The user device **903** may comprise, for example, a processor-based system such as a computer system. Such a computer system may be embodied in the form of a desktop computer, a laptop computer, personal digital assistants, cellular telephones, smartphones, web pads, tablet computer systems, or other devices with like capability. The user device **903** can include a display such as, for example, a liquid crystal display (LCD) displays, gas plasma-based flat panel displays, organic light emitting diode (OLED) displays, electrophoretic ink (E ink) displays, LCD projectors, or other types of display devices, etc.

(52) To improve the data transmission and reduce latency, the resolution of the acquired images can be reduced and compressed prior to transmission to the user device **903**. For example, the resolution of the acquired image may be reduced by a predefined amount (e.g., 10 to 1), which does not affect the image quality for review by the user, and sent to the user device **903** using an appropriate compression format (e.g., jpeg). If a higher resolution image is requested by the user during evaluation of the images, then the image processing unit **100** can communicate the higher resolution information to the user device **903** for evaluation.

(53) Examination of the sample in the image processing unit **100** can also be actively controlled either locally through the display screen **103** (or other user interface) or remotely via a secure connection with the user device **903**. For example, a pathologist or other user can initially examine the lower resolution images to determine if a condition or problem exists. If there is a question regarding the sample, the higher resolution images can be requested for further examination. In some cases, the higher resolution images of specific areas of the sample can be requested by the pathologist or user to reduce the amount of data being requested. It is also possible for the pathologist or user to actively control the imaging of the sample in real time. This can be especially beneficial if a feature of the sample was captured over multiple images.

(54) In some implementations, the pathologist or user can actively control some of the features of the slide processing unit **100** from a remote location. For example, examination of the treated sample can be remotely controlled in real time over the secure connection with the user device **903**. Images can be transmitted to the user device **903** while commands are sent through an interface on the user device **903** to actively control viewing of the images. The commands can allow the pathologist or user to control the examination of the different areas of the stored image data or, with the sample slide **306** in the image processing unit **100**, to control the active imaging of the sample in the image processing unit **100**. Images that have been stored in the remote storage **909** can also be accessed through the user device **903**.

(55) In some cases, the user can implement real time control of the slide processing unit **100** with real time images being streamed to the user device **930**. Features such as, but not limited to, control of the iris of the light source **206**, remove switching of microscopic lenses (or objectives) **209**, and control of viewing area can be controlled by a remote operator. Linear adjustment of the lens and/or selection of different lenses can also be controlled remotely. For instance, the pathologist or user can pan between different areas or change the resolution (or magnification) of the image(s) to focus the examination as desired. The pathologist or user can also control the image processing unit **100** while images are being captured of the sample in real time. In this way, the pathologist can examine the sample as if the slide **306** were at his or her location.

(56) After imaging and/or examination of the sample is complete, the sample slide **306** can be returned to the carriage **106** by the slide positioner **203**. The user can then remove the sample slide **306** from the slide processing unit **100** for retention or disposal. For example, the user can open the carriage **106** and pull the sample slide **306** out of the grasp of the slide clamp **303**. The processed sample slide **306** can be reinserted into the slide processing unit **100** for subsequent examination using the microscopic lenses **209** and image capture unit **212** (FIG. 3C). The alignment arm **303** of

the slide clamp **303** and the guide shoulder **427**, slide stop **430** and clamp stop **433** of the mounting plate **309** (FIGS. **4A-4F**) allow for consistent positioning of the sample slide **306** during the subsequent imaging. The sample slide **306** can be repositioned by the slide processing unit **100** to return to a location of a previously acquired image for reexamination by a user. In other implementation, the sample slide **306** can be deposited in the bottom of the image processing unit **100** for subsequent removal and disposal. For example, the sample slide **306** may be released and deposited in a receptacle in the bottom of the slide processing unit **100**.

(57) Tissue samples may also be processed by the slide processing unit **100** in a similar fashion. Thin slices of tissue may be placed on a slide **306** and introduced to the slide processing unit **100**. As smearing would not be needed, the sample slide **306** would progress through the staining process described earlier (e.g., desiccation and/or chemical treatment) and positioned under the microscope lens **209** for digitization and/or review. In some implementations, a lump section of tissue may be introduced into the slide processing unit **100** in an appropriate sample jar and frozen section preparation may be automatically accomplished. The lump section can be dehydrated by forced air and/or vacuum desiccation with heat. The tissue can then be sectioned using, e.g., a piezo electrically driven knife (or sharp edge) and the resultant thin sections automatically placed on a slide **306**. The sample slide **306** would then progress through the treatment process (e.g., staining) described earlier and positioned under the microscope lens **209** for digitization and/or review.

(58) With reference now to FIG. **11**, shown is a schematic block diagram of an example of processing circuitry that may be used to control the operation of the image processing unit **100** in accordance with various embodiments of the present disclosure. The processing circuitry includes at least one processor circuit, for example, having a processor **1003** and a memory **1006**, both of which are coupled to a local interface **1009**. To this end, the processing circuitry **1000** may be implemented using one or more circuits, one or more microprocessors, microcontrollers, application specific integrated circuits, dedicated hardware, digital signal processors, microcomputers, central processing units, field programmable gate arrays, programmable logic devices, state machines, or any combination thereof. The local interface **1009** may comprise, for example, a data bus with an accompanying address/control bus or other bus structure as can be appreciated. The processing circuitry **1000** can include a display screen **103** for rendering of generated graphics such as, e.g., a user interface and/or receive inputs from a user.

(59) The processing circuitry **1000** can also include an input/output interface **1012** through which user input can be received from a user interface unit **1015** such, e.g., a keypad, mouse or touch screen and/or output from the image processing unit **100** can be sent to an external display for rendering. In addition, the processing circuitry **1000** can include one or more communication interfaces **1018** that allow the processing circuitry **1000** to communicatively couple with other communication devices or networks. The communication interfaces may include one or more wireless connection(s) such as, e.g., Bluetooth®, WiFi (e.g., 802.11) or other radio frequency (RF) connection and/or one or more wired connection(s). The processing circuitry **1000** can also include one or more control interface(s) **1021** in communication with motors (e.g., stepper or servo motors **321** and **330**), solenoids, or other controllable devices used to control operation of the image processing unit **100**.

(60) Stored in the memory **1006** are both data and several components that are executable by the processor **1003**. In particular, stored in the memory **1006** and executable by the processor **1003** are IPU (image processing unit) system application(s) **1024**, an operating system **1027**, and/or other applications **1030**. IPU system applications **1024** can include applications that support, e.g., control of the operation of the image processing unit **100**. For example, the IPU system applications **1024** can be configured to automatically process and acquire images of a sample on a slide **306** and provide capabilities for locally and remotely controlling the operation of the image processing unit **100** as has been described. It is understood that there may be other applications that are stored in the memory **1006** and are executable by the processor **1003** as can be appreciated. Where any

component discussed herein is implemented in the form of software, any one of a number of programming languages may be employed such as, for example, C, C++, C#, Objective C, Java®, JavaScript®, Perl, PHP, Visual Basic®, Python®, Ruby, Delphi®, Flash®, LabVIEW® or other programming languages. A data store **1033** and other data such as image data captured by the image capture unit **212** can also be stored in the memory **1006**.

(61) A number of software components are stored in the memory **1006** and are executable by the processor **1003**. In this respect, the term “executable” means a program file that is in a form that can ultimately be run by the processor **1003**. Examples of executable programs may be, for example, a compiled program that can be translated into machine code in a format that can be loaded into a random access portion of the memory **1006** and run by the processor **1003**, source code that may be expressed in proper format such as object code that is capable of being loaded into a random access portion of the memory **1006** and executed by the processor **1003**, or source code that may be interpreted by another executable program to generate instructions in a random access portion of the memory **1006** to be executed by the processor **1003**, etc. An executable program may be stored in any portion or component of the memory **1006** including, for example, random access memory (RAM), read-only memory (ROM), hard drive, solid-state drive, USB flash drive, memory card, optical disc such as compact disc (CD) or digital versatile disc (DVD), floppy disk, magnetic tape, or other memory components.

(62) The memory **1006** is defined herein as including both volatile and nonvolatile memory and data storage components. Volatile components are those that do not retain data values upon loss of power. Nonvolatile components are those that retain data upon a loss of power. Thus, the memory **1006** may comprise, for example, random access memory (RAM), read-only memory (ROM), hard disk drives, solid-state drives, USB flash drives, memory cards accessed via a memory card reader, floppy disks accessed via an associated floppy disk drive, optical discs accessed via an optical disc drive, magnetic tapes accessed via an appropriate tape drive, and/or other memory components, or a combination of any two or more of these memory components. In addition, the RAM may comprise, for example, static random access memory (SRAM), dynamic random access memory (DRAM), or magnetic random access memory (MRAM) and other such devices. The ROM may comprise, for example, a programmable read-only memory (PROM), an erasable programmable read-only memory (EPROM), an electrically erasable programmable read-only memory (EEPROM), or other like memory device.

(63) Also, the processor **1003** may represent multiple processors **1003** and the memory **1006** may represent multiple memories **1006** that operate in parallel processing circuits, respectively. In such a case, the local interface **1009** may be an appropriate network that facilitates communication between any two of the multiple processors **1003**, between any processor **1003** and any of the memories **1006**, or between any two of the memories **1006**, etc. The local interface **1009** may comprise additional systems designed to coordinate this communication, including, for example, performing load balancing. The processor **1003** may be of electrical or of some other available construction.

(64) Although the IPU system application(s) **1024**, the operating system **1027**, application(s) **1030**, and other various systems described herein may be embodied in software or code executed by general purpose hardware as discussed above, as an alternative the same may also be embodied in dedicated hardware or a combination of software/general purpose hardware and dedicated hardware. If embodied in dedicated hardware, each can be implemented as a circuit or state machine that employs any one of or a combination of a number of technologies. These technologies may include, but are not limited to, discrete logic circuits having logic gates for implementing various logic functions upon an application of one or more data signals, application specific integrated circuits having appropriate logic gates, or other components, etc. Such technologies are generally well known by those skilled in the art and, consequently, are not described in detail herein.

(65) Also, any logic or application described herein, including the IPU system application(s) **1024** and/or application(s) **1030**, that comprises software or code can be embodied in any non-transitory computer-readable medium for use by or in connection with an instruction execution system such as, for example, a processor **1003** in a computer system or other system. In this sense, the logic may comprise, for example, statements including instructions and declarations that can be fetched from the computer-readable medium and executed by the instruction execution system. In the context of the present disclosure, a “computer-readable medium” can be any medium that can contain, store, or maintain the logic or application described herein for use by or in connection with the instruction execution system. The computer-readable medium can comprise any one of many physical media such as, for example, magnetic, optical, or semiconductor media. More specific examples of a suitable computer-readable medium would include, but are not limited to, magnetic tapes, magnetic floppy diskettes, magnetic hard drives, memory cards, solid-state drives, USB flash drives, or optical discs. Also, the computer-readable medium may be a random access memory (RAM) including, for example, static random access memory (SRAM) and dynamic random access memory (DRAM), or magnetic random access memory (MRAM). In addition, the computer-readable medium may be a read-only memory (ROM), a programmable read-only memory (PROM), an erasable programmable read-only memory (EPROM), an electrically erasable programmable read-only memory (EEPROM), or other type of memory device.

(66) It should be emphasized that the above-described embodiments of the present disclosure are merely possible examples of implementations set forth for a clear understanding of the principles of the disclosure. Many variations and modifications may be made to the above-described embodiment(s) without departing substantially from the spirit and principles of the disclosure. All such modifications and variations are intended to be included herein within the scope of this disclosure and protected by the following claims.

(67) It should be noted that ratios, concentrations, amounts, and other numerical data may be expressed herein in a range format. It is to be understood that such a range format is used for convenience and brevity, and thus, should be interpreted in a flexible manner to include not only the numerical values explicitly recited as the limits of the range, but also to include all the individual numerical values or sub-ranges encompassed within that range as if each numerical value and sub-range is explicitly recited. To illustrate, a concentration range of “about 0.1% to about 5%” should be interpreted to include not only the explicitly recited concentration of about 0.1 wt % to about 5 wt %, but also include individual concentrations (e.g., 1%, 2%, 3%, and 4%) and the sub-ranges (e.g., 0.5%, 1.1%, 2.2%, 3.3%, and 4.4%) within the indicated range. The term “about” can include traditional rounding according to significant figures of numerical values. In addition, the phrase “about ‘x’ to ‘y’” includes “about ‘x’ to about ‘y’”.

Claims

1. A system for processing microscope slides, comprising: a carriage having a movable surface for supporting a slide; a slide positioner comprising a slide clamp configured to receive and move a slide, the slide positioner configured to obtain a first slide and adjust positioning of the first slide, including from a first position at the carriage to a second position under a sled; a slide dispenser unit comprising the sled, configured to dispense a second slide down the sled to contact an upper surface of the first slide to smear a sample on the first slide; an image capture unit configured to capture a digital image of the first slide via a lens when the slide positioner positions the first slide between the lens and a light source; and wherein the slide positioner is located in a housing comprising a plurality of walls configured to enclose the slide positioner, slide dispenser unit, and image capture unit, and the carriage is configured to move the first slide into the housing to be received by the slide positioner; and wherein the sled includes a pivot point configured to extend towards a centerline of the second slide to cause the second slide to rock about a center point

thereof when the second slide is in contact with the first slide.

2. The system of claim 1, wherein the sled is configured to cause the second slide to move under the pivot point.

3. The system of claim 1, further comprising processing circuitry configured to enable remote control of the system, and configured to communicate digital images captured by the image capture unit to a user computing device in real time.

4. The system of claim 3, wherein at least one selected from the group of the light source and the lens is configured to be remotely controlled by the user computing device.

5. The system of claim 4, wherein the processing circuitry is configured to communicate the digital images during adjustment of at least one selected from the group of the light source and the lens.

6. The system of claim 1, wherein the weight of the second slide provides contact pressure on the first slide for smearing the sample.

7. The system of claim 2, wherein the pivot point is positioned at an end wall located above the second slide when the second slide is in contact with the first slide, and the sled further comprises an aperture configured to allow a pin to be positioned below the second slide to further regulate motion of the second slide.

8. The system of claim 1, wherein the second position is under the sled, and the slide positioner is configured to reposition the first slide from the second position to a third position between the lens and the light source.

9. The system of claim 8, wherein the slide clamp is configured to obtain the first slide by gripping a proximal end of the first slide while the first slide is positioned within the carriage, and is configured to linearly extract the first slide from the carriage.

10. The system of claim 9, wherein the sled is configured to cause the second slide to contact the first slide in the second position and smear the sample on the first slide.

11. The system of claim 8, wherein the slide positioner is configured to reposition the first slide away from under the sled to an intermediate position under a fluid applicator configured to apply a treatment fluid to the first slide.

12. The system of claim 1, further comprising processing circuitry configured to capture the digital image at a first resolution, and configured to transmit the digital image to a user computing device at a second resolution.

13. The system of claim 12, wherein the second resolution is lower than the first resolution.

14. The system of claim 12, wherein the user computing device is configured to permit a user to request the digital image be transmitted to the user computing device at the first resolution.

15. The system of claim 1, further comprising a user computing device configured to store the digital image.

16. The system of claim 1, wherein digital images captured by the image capture unit are stored in a remote data store via a secure connection.

17. The system of claim 16, wherein a user computing device is configured to permit user access to the digital images stored in the remote data store.

18. The system of claim 17, wherein the user computing device is configured to display one or more of the digital images, and is configured to permit a user to control area, resolution, or both of the one or more digital images displayed by the user computing device.

19. A system for processing microscope slides, comprising: a carriage having a movable surface for supporting a slide; a slide positioner comprising a slide clamp configured to receive and move a slide, the slide positioner configured to obtain a first slide and adjust positioning of the first slide, including from a first position at the carriage to a second position under a sled; a slide dispenser unit comprising the sled, configured to dispense a second slide down the sled to contact an upper surface of the first slide to smear a sample on the first slide; an image capture unit configured to capture a digital image of the first slide via a lens when the slide positioner positions the first slide between the lens and a light source; and wherein the slide positioner is located in a housing

comprising a plurality of walls configured to enclose the slide positioner, slide dispenser unit, and image capture unit, and the carriage is configured to move the first slide into the housing to be received by the slide positioner; and wherein the sled includes a pivot point positioned at an end wall located above the second slide when the second slide is in contact with the first slide.

20. The system of claim 19, wherein the pivot point is positioned at a lower corner of the end wall.
