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(54) **UTILIZATION OF BIOMETRIC DATA**

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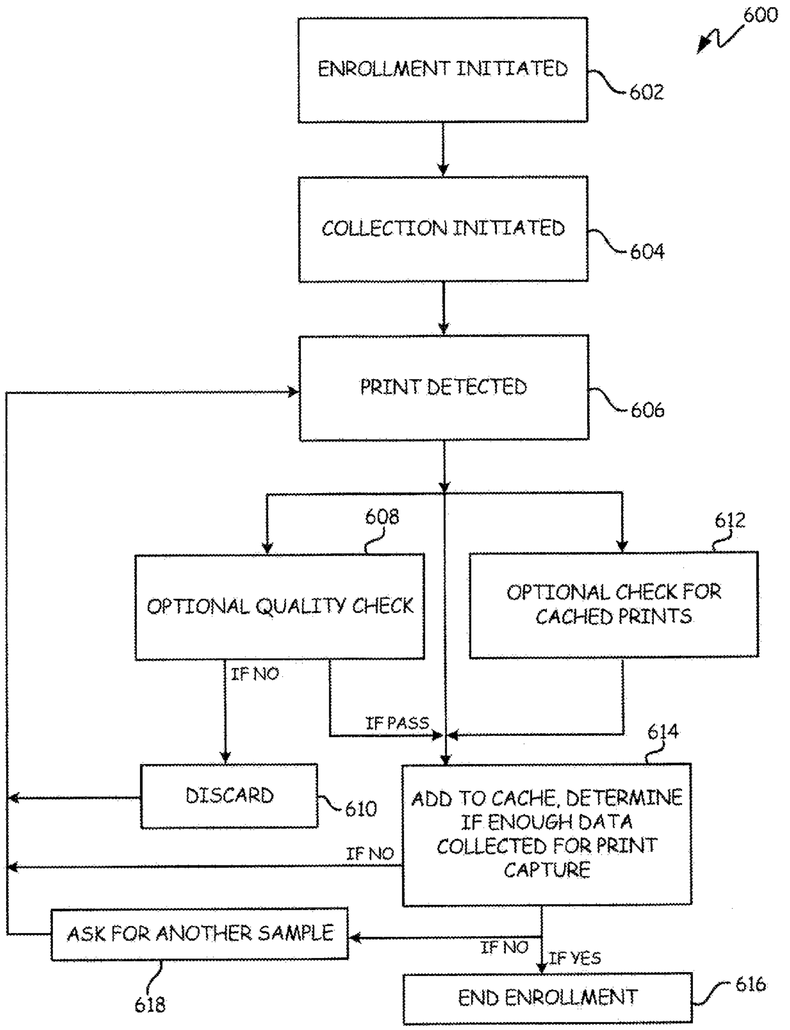
(57) **ABSTRACT**

A method of capturing and storing a plurality of biometric data by a user on a device for a future authentication request is presented. The method includes receiving a first input from a user, through a user input mechanism of the device. The first input comprises a first portion of biometric data. The method also comprises receiving a second input from a user, through the user input mechanism. The second portion comprises a second portion of biometric data. The method also comprises storing the first and second inputs from the user in a biometric data memory portion of a memory of the mobile device. Each input is stored in the memory along with a time stamp assigned by a processor of the device. Each received input is stored such that, upon receiving an authentication request, each input is retrievable by the processor, from the memory based on a recency of the time stamp, such that the most recent input is retrieved first.



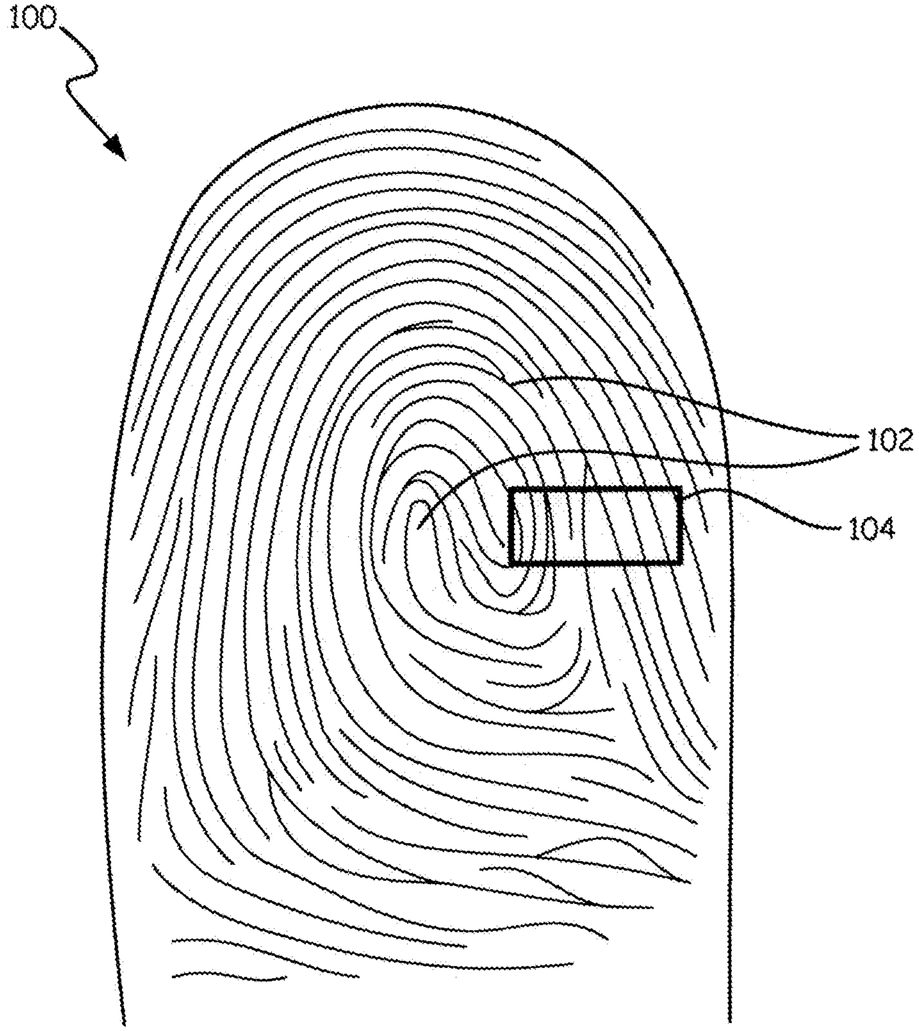


FIG. 1

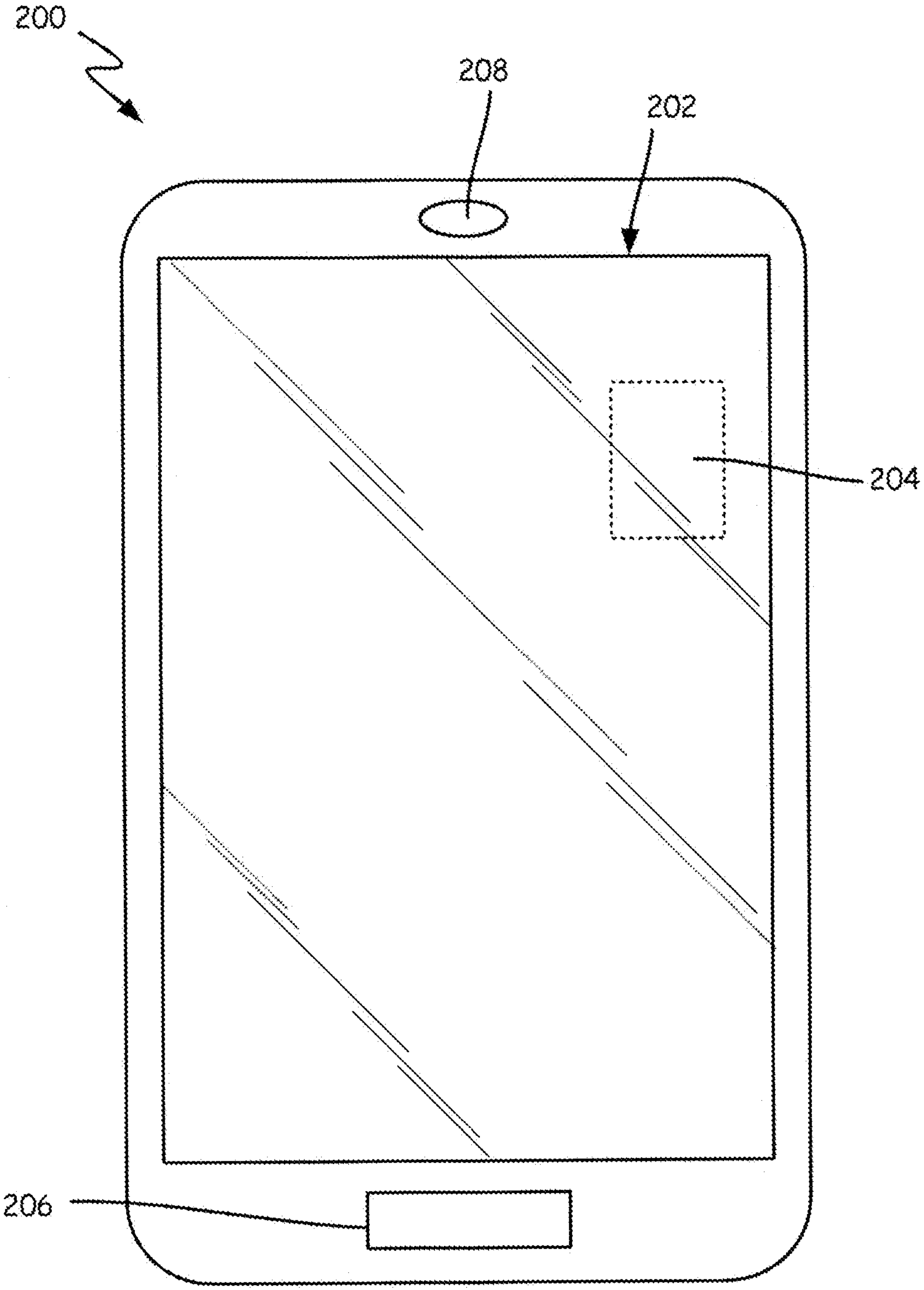


FIG. 2A

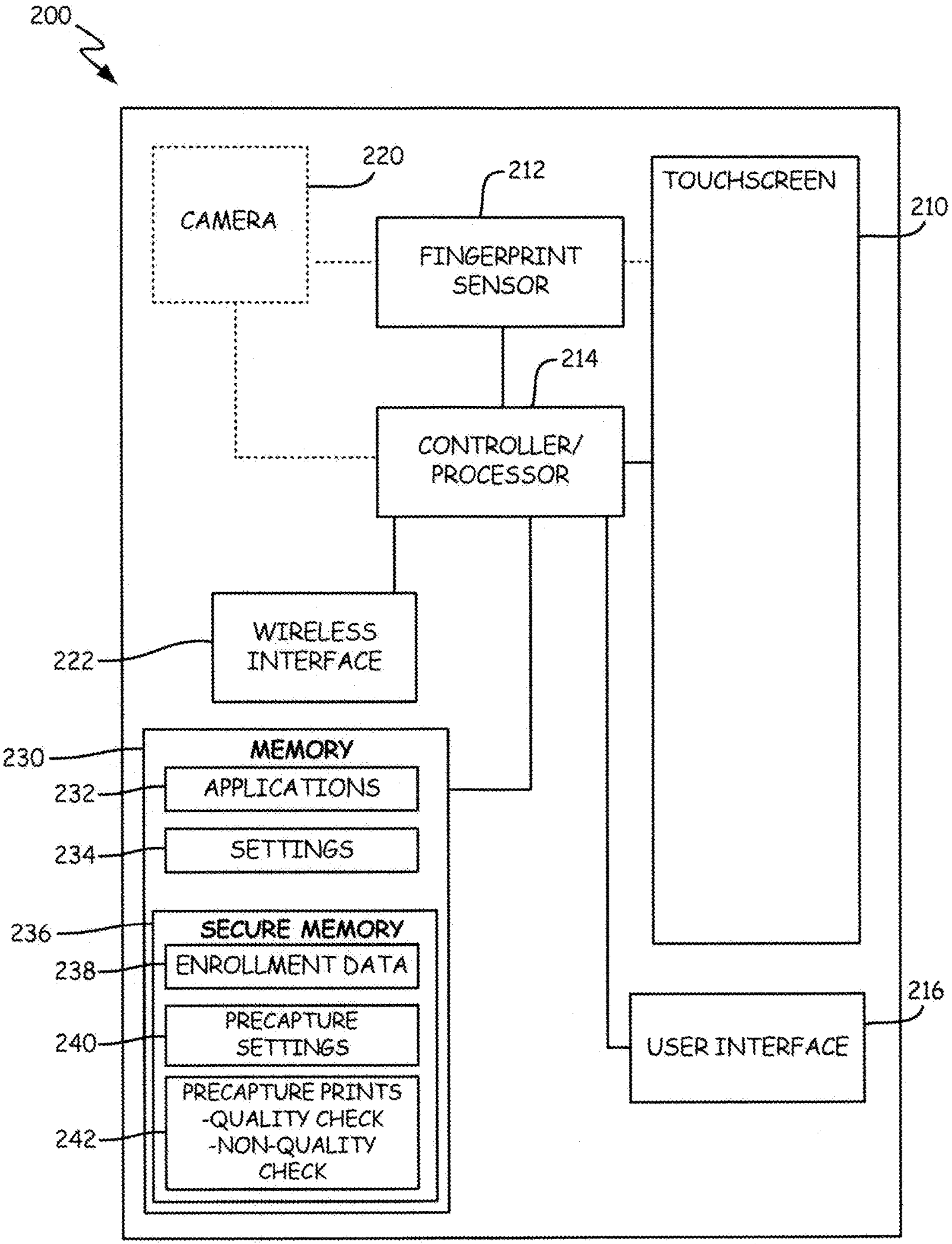

200
CAMERA
220
212
FINGERPRINT SENSOR
TOUCHSCREEN
210
214
CONTROLLER/ PROCESSOR
222
WIRELESS INTERFACE
230
MEMORY
232
APPLICATIONS
234
SETTINGS
236
SECURE MEMORY
238
ENROLLMENT DATA
240
PRECAPTURE SETTINGS
242
PRECAPTURE PRINTS -QUALITY CHECK -NON-QUALITY CHECK
216
USER INTERFACE

FIG. 2B

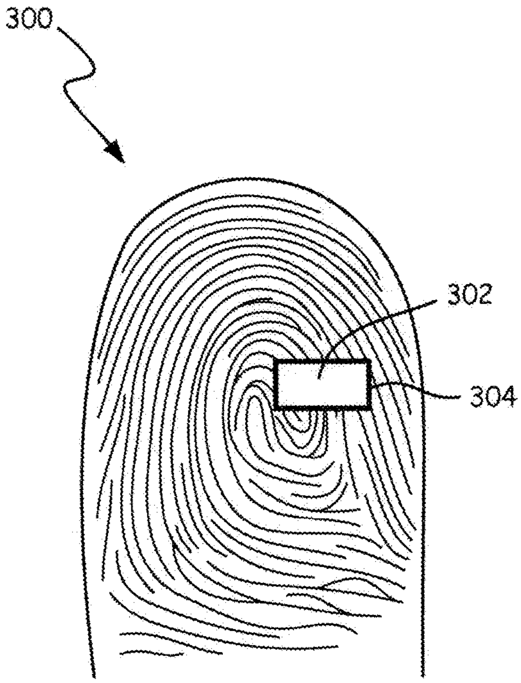


FIG. 3A

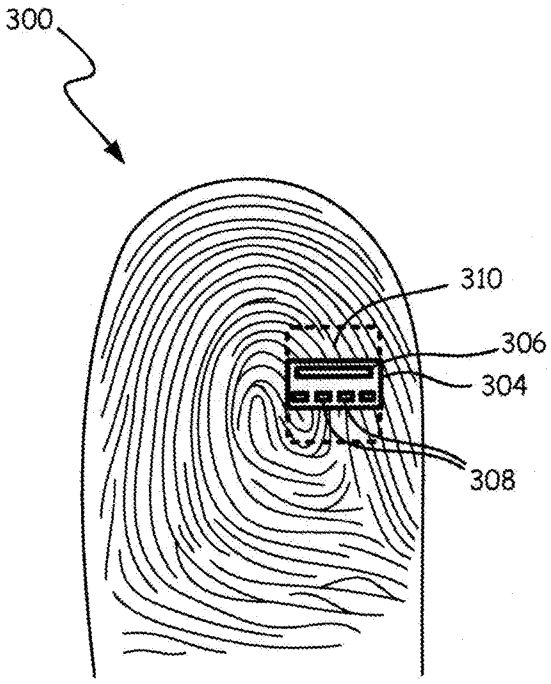


FIG. 3B

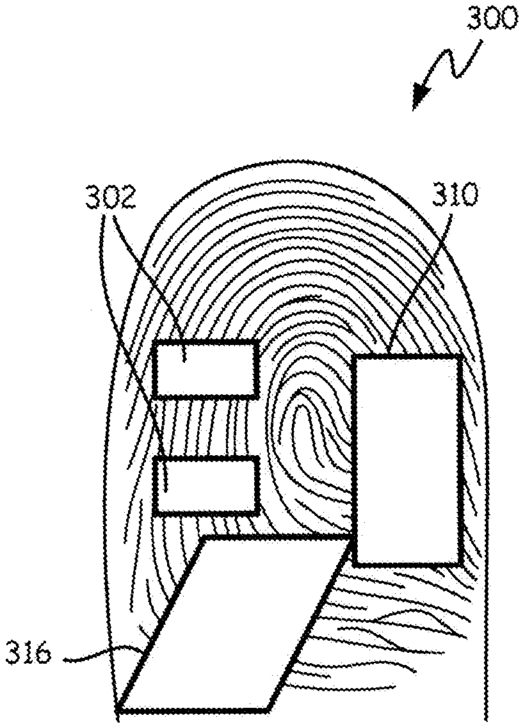


FIG. 3C

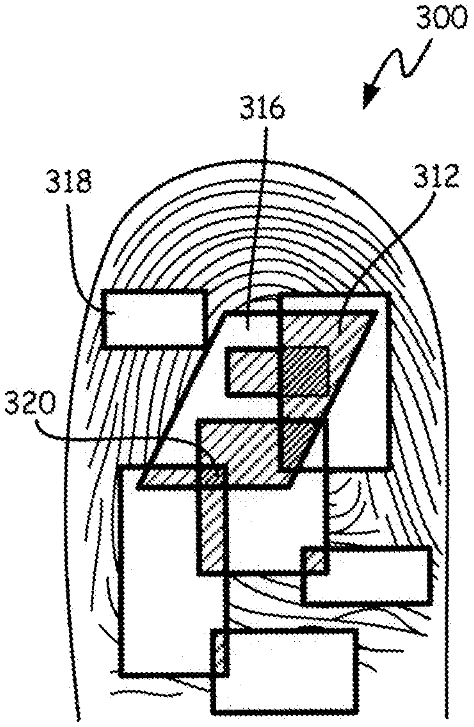


FIG. 3D

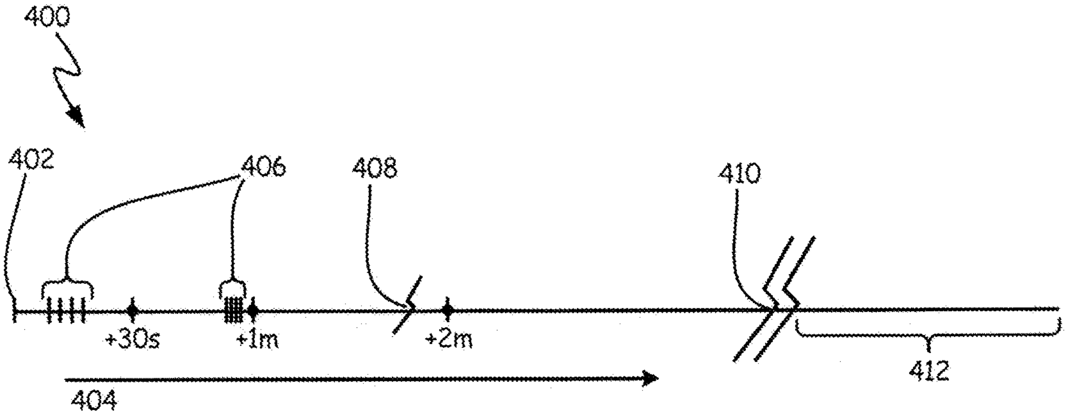

400
402
406
408
410
+30s
+1m
+2m
404
412

FIG. 4A

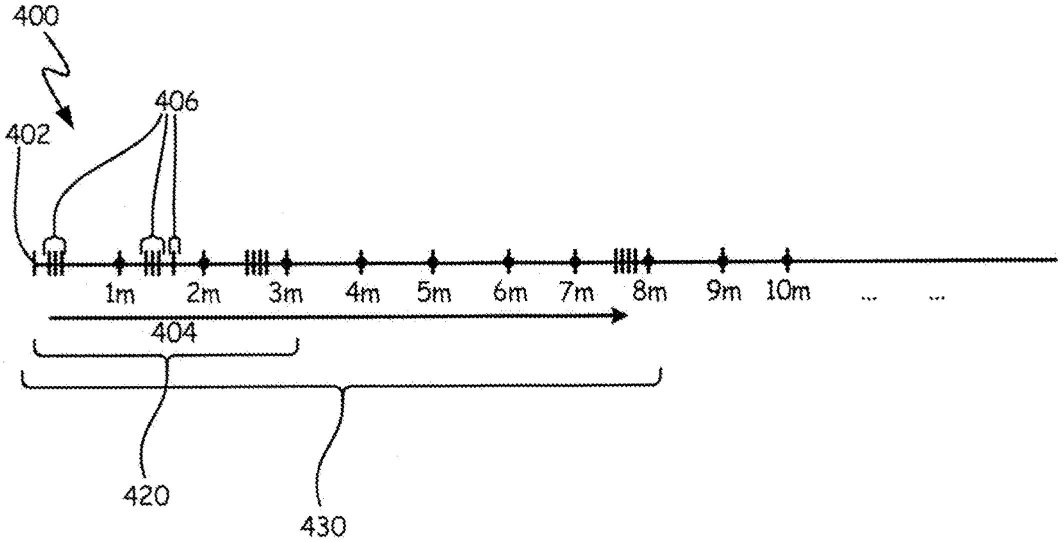

400
402
406
1m
2m
3m
4m
5m
6m
7m
8m
9m
10m
...
...
404
420
430

FIG. 4B

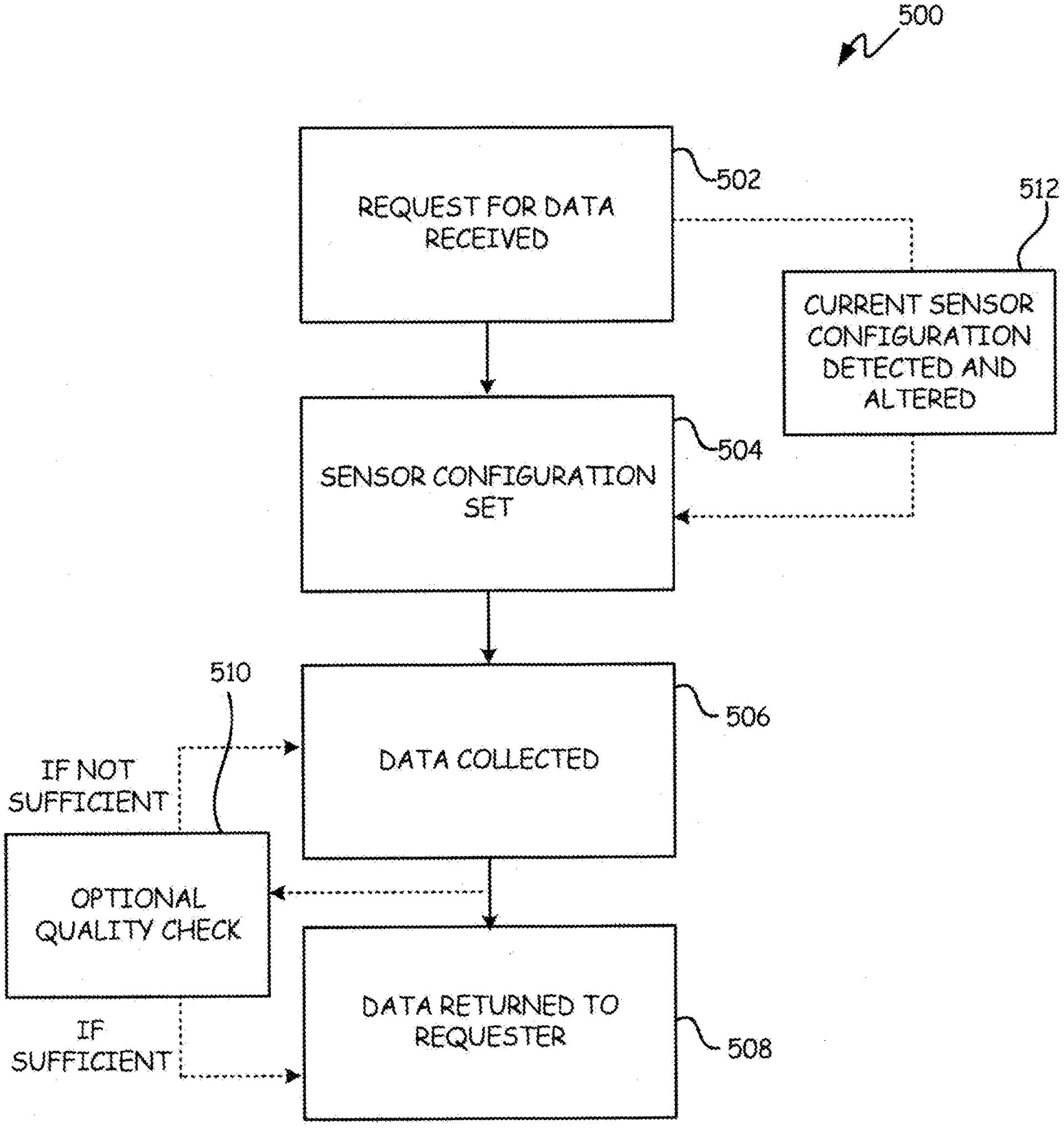

500
REQUEST FOR DATA RECEIVED
502
512
CURRENT SENSOR CONFIGURATION DETECTED AND ALTERED
SENSOR CONFIGURATION SET
504
510
DATA COLLECTED
506
IF NOT SUFFICIENT
OPTIONAL QUALITY CHECK
IF SUFFICIENT
DATA RETURNED TO REQUESTER
508

FIG. 5

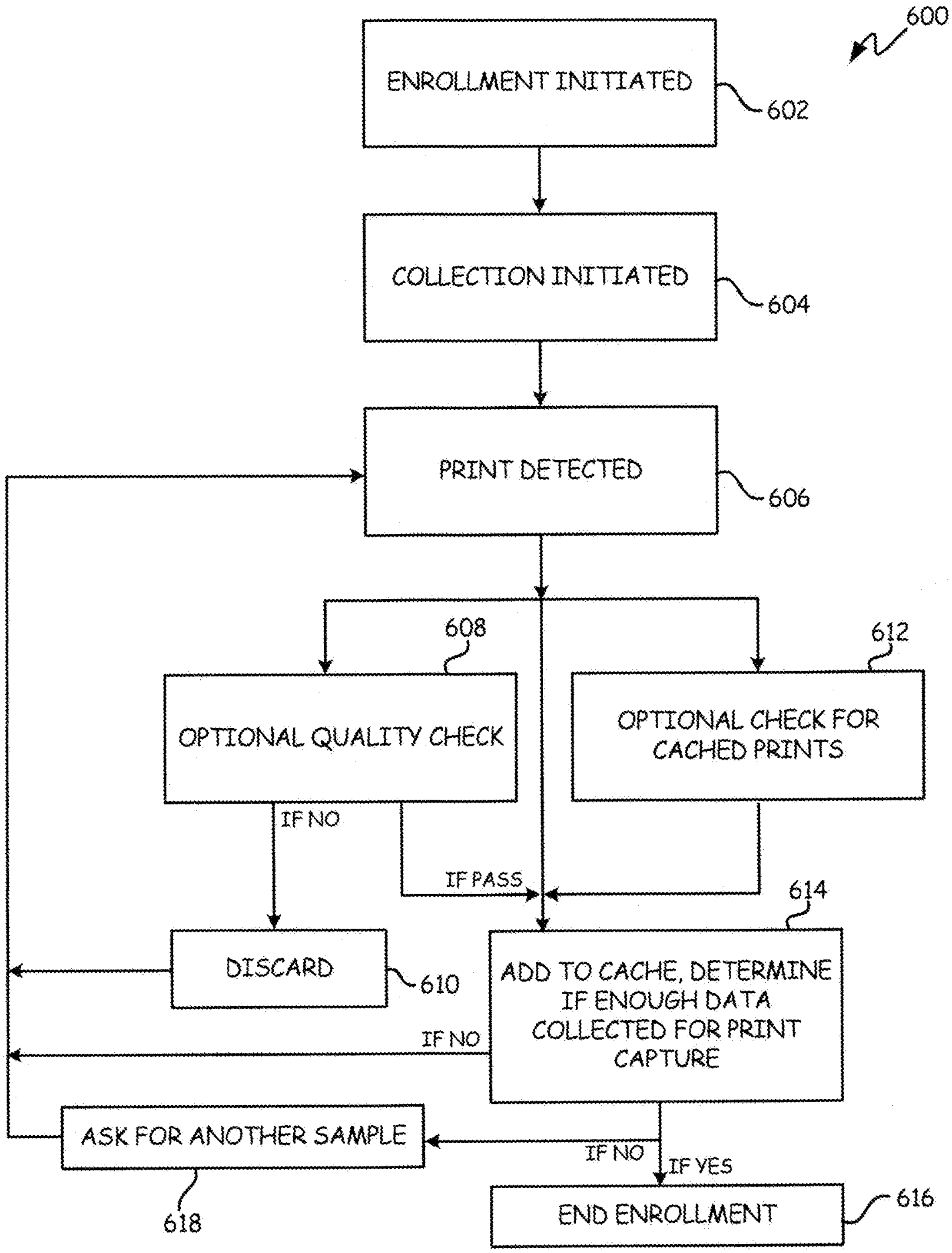

600
ENROLLMENT INITIATED
602
COLLECTION INITIATED
604
PRINT DETECTED
606
608
OPTIONAL QUALITY CHECK
612
OPTIONAL CHECK FOR CACHED PRINTS
IF NO
IF PASS
614
DISCARD
610
ADD TO CACHE, DETERMINE IF ENOUGH DATA COLLECTED FOR PRINT CAPTURE
IF NO
ASK FOR ANOTHER SAMPLE
IF NO
IF YES
618
END ENROLLMENT
616

FIG. 6

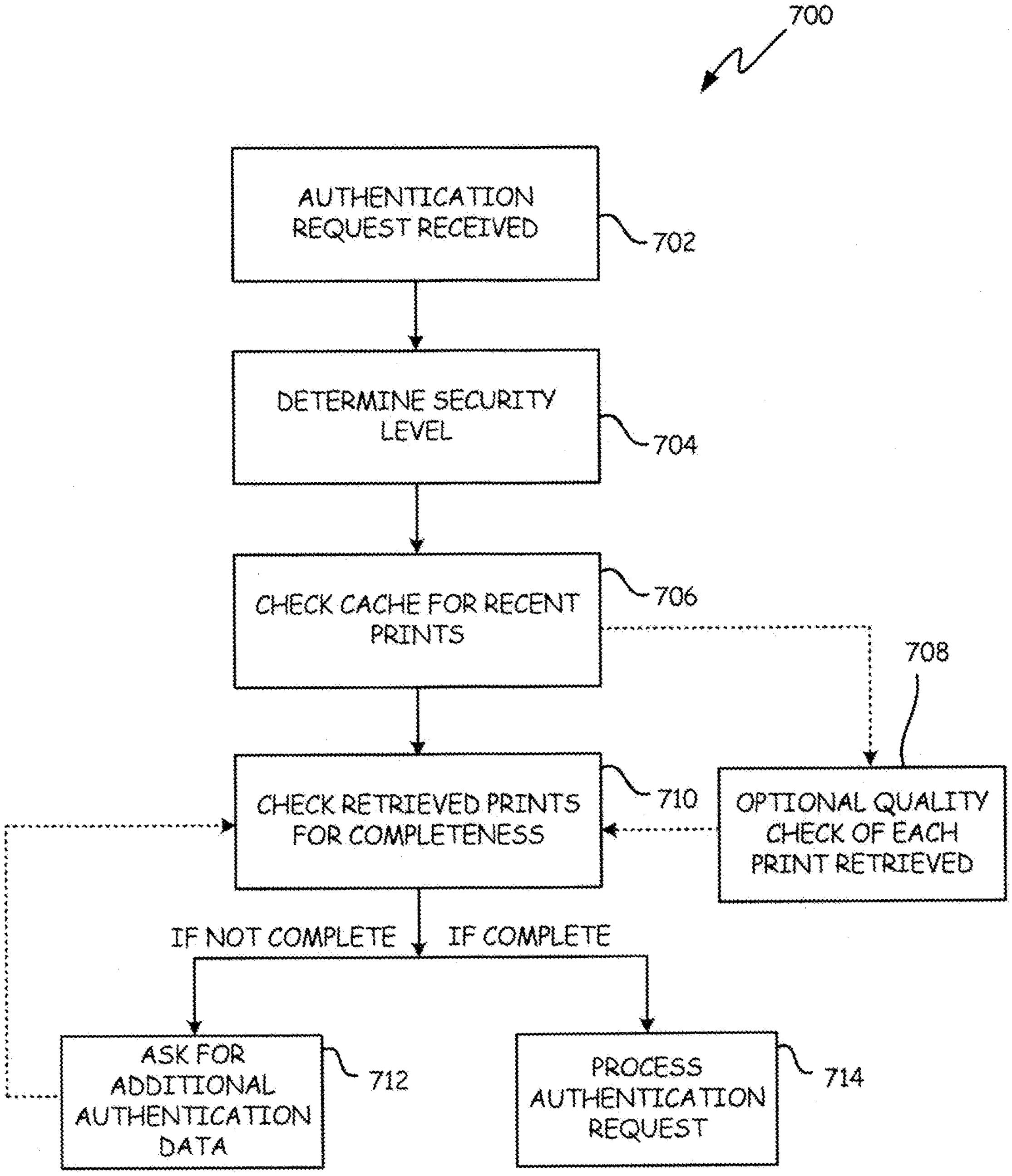

700
AUTHENTICATION REQUEST RECEIVED
702
DETERMINE SECURITY LEVEL
704
CHECK CACHE FOR RECENT PRINTS
706
708
CHECK RETRIEVED PRINTS FOR COMPLETENESS
710
OPTIONAL QUALITY CHECK OF EACH PRINT RETRIEVED
IF NOT COMPLETE
IF COMPLETE
ASK FOR ADDITIONAL AUTHENTICATION DATA
712
PROCESS AUTHENTICATION REQUEST
714

FIG. 7

UTILIZATION OF BIOMETRIC DATA

CROSS REFERENCE TO RELATED APPLICATION

[0001] The present application is a divisional of U.S. Non-Provisional application Ser. No. 15/474,492, which is a continuation of U.S. Non-Provisional application Ser. No. 14/640,336, filed Mar. 6, 2015, which claims the priority of U.S. Provisional Application Ser. No. 61/950,424, filed on Mar. 10, 2014, U.S. Provisional Application Ser. No. 62/041,711, filed Aug. 26, 2014, and U.S. Provisional Application 62/052,820, filed Sep. 19, 2014 the contents of which applications are hereby incorporated by reference in its entirety.

BACKGROUND

[0002] Companies and their customers seek the best of both worlds when it comes to online transactions—convenience and security. With the rise of smart phones and other mobile devices, wearable devices, Internet of Things (IoT) products, vehicles, home automation, robotics and drones, all capable of accessing and completing transactions on the internet, the need for security is growing. However, for most customers, the process of remembering a myriad of passwords for different sites and/or applications presents a burden, especially as these sites increasingly require more complex passwords or other authentication means in an effort to protect customers.

[0003] One solution to the security inconvenience problem is the use of an intermediary, trusted website to authenticate the user. Social media websites are one example of some providers of said third party authentication options. This still requires the user to login, or be logged in, to one of these intermediary sites at the time of the authentication request. While this may lower the number of passwords for the customer to remember, it also heightens the potential risk in case of cellphone or laptop theft, or hacking of one of these intermediary sites where only a password or other set of weak forms of authentication may exist.

[0004] Another solution is the use of biometric data to validate the identity of a user of a device. The advantages of biometric data as an authentication source are clear: the user is not required to remember an alphanumeric sequence or carry a token, the biometric data cannot be easily replicated, and unauthorized access to the user's protected accounts and information is prohibited. The biometric data used for matching may be on the device, or in the cloud. Each offer differing benefits in regard to speed, assurance and accuracy. The embodiments of the invention will be described with respect to fingerprints and fingerprint data, as fingerprints provide a unique and reliable biometric sample for authentication. However, one skilled in the art would understand that other biometric data could also be used with the systems and methods described, for example iris patterns, eye vein patterns, palm prints, face, DNA, etc.

[0005] Each person has a unique set of fingerprints, defined by the unique pattern of friction ridges on the surface of finger. As these friction ridges come together on a fingerprint, they form identifiable patterns that are distinctive between individuals. There is various elements of data used from the fingerprint in authenticating a user, ridge flow, ridge correlation, minutiae points, micro-minutiae points and others. Within these patterns may be a myriad of identifiable features unique to an individual such as a core, a bridge, a crossover, a bifurcation, a rod end, an island, an enclosure, or other feature. Determining whether one fingerprint matches another fingerprint requires comparison of the patterns and features of the enrollment prints to the authentication prints to determine if the user submitting the authentication is the same or different from the enrolled user. However, todays devices are incorporating smaller and smaller fingerprint sensors, which capture only a partial print, determining whether a submitted print matches a previously taken template becomes more difficult, and the chance of error increases. Either the user or service provider must sacrifice security, and accept a higher rate of error, or a user must sacrifice convenience, and provide a series of partial prints.

SUMMARY

[0006] A method of capturing and storing a plurality of biometric data by a user on a device for a future authentication request is presented. The method includes receiving a first input from a user, through a user input mechanism of the device. The first input comprises a first portion of biometric data. The method also comprises receiving a second input from a user, through the user input mechanism. The second portion comprises a second portion of biometric data. The method also comprises storing the first and second inputs from the user in a biometric data memory portion of a memory of the mobile device. Each input is stored in the memory along with a time stamp assigned by a processor of the device. Each received input is stored such that, upon receiving an authentication request, each input is retrievable by the processor, from the memory based on a recency of the time stamp, such that the most recent input is retrieved first.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. **1** is a representation of an exemplary fingerprint.

[0008] FIG. **2**A is a representation of an exemplary device capable of reading fingerprint data.

[0009] FIG. **2**B is a block diagram of an exemplary device capable of reading fingerprint data.

[0010] FIGS. **3**A-**3**D illustrate exemplary fingerprint data representing multiple portions of fingerprint data taken during an exemplary authentication or enrollment process.

[0011] FIGS. **4**A and **4**B illustrate an exemplary cache of fingerprint data taken during a precapture process.

[0012] FIG. **5** illustrates an exemplary method for a single-touch authentication or enrollment of fingerprint data.

[0013] FIG. **6** illustrates an exemplary method for gathering initial fingerprint data for enrollment of a fingerprint template.

[0014] FIG. **7** illustrates an exemplary method for gathering fingerprint data for authentication against the fingerprint template.

DETAILED DESCRIPTION

[0015] Any authentication mechanism using fingerprint data needs to be convenient for consumers, yet secure enough to protect their data. If a user is able to enter an entire fingerprint for an authentication on a mobile device, the process of accurately determining whether a later print matched or did not match is a more accurate one, and merely requires comparison of the two prints for identifying fingerprint features.

[0016] However, as users more frequently access sensitive data through devices with smaller and smaller fingerprint sensors, namely mobile phones and tablets for. As the sensors that read biometric data shrink, the data captured is reduced, and so is the ability to differentiate. For example, in smartphones the sensor area available to capture touch input from a fingerprint may measure as small as ⅙ by ⅙ inch. This is in contrast to an average fingerprint which measures ½ by 1 inch.

[0017] FIG. **1** shows such an exemplary fingerprint **100**. Fingerprints are identifiable and separate individual users from each other by specific features **102**. These features **102**, when considered across the entire finger print, clearly identify one user from another. However, the identification process is different when the sensor is too small to capture an entire finger print. For example, as shown in FIG. **1**, exemplary capture area **104** does not happen to contain any identifying features **102**. Therefore, identifying a user by this capture area **104** presents a difficult security challenge as many users may exhibit a very similar partial print on a portion of one finger. One set of lines looks remarkably similar to another set of lines.

[0018] Because of the small sensor area available, obtaining a complete print for authentication may require, in one embodiment, a user to enter a series of fingerprint data by touching or swiping across the sensor area during a capture time period. However, this may not be a solution that meets the needs of the customer regarding convenience. In fact, many device manufacturers are limiting the number of touch prints deemed acceptable to authenticate a user, with their customers in mind. This limits the maximum level of security that can be obtained.

[0019] FIG. **2**A is a representation of an exemplary device capable of reading fingerprint data. The device **200** may, for example, be a cellular phone with a touch screen, a laptop with a fingerprint sensor, a tablet, or any other electric device capable of receiving fingerprint data. In another embodiment, the device **200** may be a camera, or other electronic device. The device **200** may have a screen **202**. Many devices today can accept biometric inputs, for example, fingerprint input, through a variety of different mechanisms. In one embodiment, the fingerprint or portion of a fingerprint may be taken by device **200** through a screen sensor element **204**, where the screen sensor element may be in a dedicated portion of the screen or may be built into the entirety of the screen **202**. In another embodiment, the sensor may be built into a button element **206**. Further, in yet another embodiment, the biometric data may be taken through a camera element **208**, wherein a user may hold their finger above the camera element **208** such that a picture is taken of their finger and the fingerprint data is collected in this manner.

[0020] FIG. **2**B is a representation of an exemplary device **200** capable of reading fingerprint data. Device **200** comprises, in one embodiment, a controller or processor **214**. Device **200** also comprises, in one embodiment, a fingerprint sensor **212**. Device **200** may comprise, in one embodiment, a screen **210**, which may be a touchscreen. Fingerprint sensor **212** may be incorporated into screen **210**, or a camera **220**, or may otherwise be accessible through the device **200**. The controller **214** may communicate, in one embodiment, with a wireless interface such that a user of the device **200** may access the internet or an intranet, or otherwise communicate with another device. The device **200** may also comprise, in one embodiment, a memory **230**. The memory **230** may comprise, in one embodiment, an applications memory **232**. The memory **230** may also comprise, in one embodiment, a settings memory **234**.

[0021] The memory **230** may also comprise, in one embodiment, a secure memory **236**. Fingerprint data captured by the fingerprint sensor **212** may be stored, in one embodiment, in the secure memory **236**. Secure memory **236** may also comprise, in one embodiment, enrollment data **238**. Enrollment data **238** may comprise fingerprint data taken during an initial enrollment of a user on the device **200**, as described in further detail below. Secure memory **236** may further comprise precapture settings **240**, where precapture settings **240** refers to the settings governing a method of capturing fingerprint data prior to a request for authentication, as described in detail below. Secure memory **236** may also comprise a cache **242** containing fingerprint data captured during a precapture period, as described in detail below. The fingerprint data in the cache **242** may be separated, in one embodiment, into data that has undergone a quality check from data that has not. In another embodiment, none of the fingerprint data in the cache **242** undergoes a quality check until the authentication request is received.

[0022] One concern with collecting and storing biometric on a portable device is that the information is potentially available if the device is stolen, and it may be vulnerable to hacking. One common feature of devices, primarily mobile devices, is the ARM processor manufactured by many manufacturers for example, NXP, ATMEL, Qualcoom, Snapdragon, or ST Microelectrics. The ARM processor may also have a TrustZone feature which, in one embodiment, provides for higher security level of stored data and processing capability. Processor **214** may also contain, in one embodiment, a Trusted Execution element, for example, that provided by Intel. In one embodiment, the Trusted Execution Element, is where the biometric samples are housed during the precapture period prior to authentication. In one embodiment, secure memory **236** is associated with such an ARM processor.

[0023] Biometric data authentication works well on many physical platforms, with sensors easily accommodated into the hardware of a device, for example, device **200**, in a position convenient for the user. In one embodiment, fingerprint sensor **212** is a radio-frequency (RF) sensor, for example an RF capacitive fingerprint sensor such as that produced by AuthenTec Trueprint Technology. In another embodiment, sensor **212** is an optics-based sensor. In another embodiment, the sensor **212** could be a complementary metal oxide semiconductor (CMOS) based sensor. In yet another embodiment, the sensor **212** could be ultrasonic based. These and other appropriate sensors could be incorporated into the hardware or software of a mobile device **200**, or other hardware like a tablet, Internet of Things (IoT) device, vehicle, home automation or many others, for example, through screen sensor element **204**, button element **206**, in a bezel on the back of device **200** (not shown), or camera element **208**. In an alternate embodiment, sensors **212** can be incorporated into non-screen portions of the device **200**, for example, on the back, sides, or other non-screen portions of the device **200**. In an alternate embodiment, sensors **212** can be incorporated directly within the screen component **210** of the device, such as screen sensor element **204**, either in a dedicated portion of the touchscreen component **210** or throughout the entirety of the touchscreen component **210** such that any portion of the screen can collect biometric information. In another embodiment sensor **212** may receive data through camera **220** or other touchless capture technology capable of receiving visible, infrared or other wavelengths of light or even forms of ultrasonic or radio wave technology.

Single Touch and Swipe Capture of Fingerprint Data

[0024] Biometric sensors can be configured to collect biometric data such as fingerprint data from a large area or a small area of screen sensor element **204**. The advantage of covering a large area is that more biometric data can be captured more efficiently. For example, a one inch square area could capture an entire fingerprint. However, an area that large may not be available. For example, in an embodiment where the sensor **212** comprises a portion of the home or a power on/off button, the area may be too small to capture an entire fingerprint, or even the majority of a fingerprint.

[0025] FIGS. **3**A and **3**B show different mechanisms for capturing a single portion of fingerprint data from a user. In one embodiment, a portion of fingerprint **300** is taken as touch data **302** through sensor area **304**. Sensor area **304** may be configured to accept either touch data **302** as shown in FIG. **3**A or swipe data **310** as shown in FIG. **3**B. In one embodiment, where the sensor area **304** is configured to accept touch data **302**, a user simply has to touch their finger to the sensor area **304** and touch data **302** is captured throughout by at least a portion of the sensor area **304**. In one embodiment, the sensor area is configured to capture a series of images as the finger is swiped over it. The series of images is then either assembled, or not assembled and provides for a larger amount of data to match for better accuracy or higher reliability. In another embodiment where the sensor area **304** is configured to accept swipe data **310**, only a portion of the sensor area **304** is active, represented by active sensor **306** that extends across a majority of the sensor area **304**. In addition to sensor area **306** one or more speed detectors **308** are used to determine the speed at which a finger is swiped across the sensor area **304**. In one embodiment, the active sensor **306** is engaged by a user's finger prior to the speed detectors **308** being engaged. In another embodiment, the user's finger first engages the speed detectors **308** and then passes over the active sensor **306**. While FIGS. **3**A and **3**B show two different sensor area configurations, in another embodiment, the same sensor area **304** is able to accept either touch data **302** or swipe data **310** depending on which type of data is input into the sensor area **304** by the user.

[0026] In one embodiment, the sensor area **304** can switch between the touch sensor configuration of FIG. **3**A and the swipe sensor of FIG. **3**B, based on an indication from the entity requesting a biometric sample. For example, a financial institution may only require a single touch data **302** to allow a user to log into a financial application, but may require a swipe data **310** in order to approve a financial transaction. Further, an online store, for example the Google Play store or the Amazon.com retail site, may also allow a single touch data **302** for a user to log into their website, but may require a swipe data **310** in order to use a stored credit card to complete a purchase.

[0027] In one embodiment, the sensor area **304** may automatically switch between the sensor area **304** and **310**, but may provide an indication to a user that a different input method is requested. For example, device **200** may provide a pop-up indication on a screen presented to the user indicating that the user needs to either touch or swipe sensor area **304** in order to compete their desired action in the application or website.

[0028] The advantage of combining both a touch and a swipe capture system is such that it allows the device **200** to capture more information from a single interaction with the user. As shown in FIG. **3**B the swipe data **310** is the same width as the touch data **302** but extends longer, allowing for greater fingerprint data to be captured without the user being required to use multiple touches. This is desired by many device and application manufacturers such that it allows a user to rapidly authenticate themselves, while maintaining security, in an efficient manner. In another embodiment, the device **200** may receive an indication from an application that a user is most-likely going to be entering touch data **302** or swipe data **310**. Further, the ability to switch back and forth between a sensor accepting touch data **302** and swipe data **310**, is that it allows application manufacturers, website owners, and device manufacturers to provide the convenience of accepting touch input **302** for lower security transactions, but also have the option to capture the greater amount of data from a swipe input for situations requiring higher security.

[0029] In one embodiment, the sensor or sensors **212** are integrated into a device **200** such that they are configured to anticipate the type of touch data **302** or swipe data **310** interaction the user will have with the device **200**, and operates either as a touch or swipe input receiver. This may be accomplished, in one embodiment, by internal sensors within the device **200**, such as accelerometers or other motion detection sensors.

[0030] In a further embodiment, the sensor **212** detects the type of touch independent from indications given by an application, but instead by detecting an indication of a touch or swipe input. For example, in one embodiment, the sensor **212** detects that the user's finger is in motion and converts to a swipe sensor configuration in response to such detection. In another example, the sensor **212** detects the user's finger is stationary and converts to a touch sensor configuration.

[0031] In an embodiment where the device **200** can switch between accepting touch data **302** and swipe data **310**, the change may be triggered by an indication from the entity requesting the data. This may be, for example, the device **200** itself as part of an authentication or enrollment. The device may require a touch data **302**, in one embodiment, as part of the process of allowing a user to turn off the device **200**, or access a home screen from a sleep mode. The device **200** may require a swipe data **310**, in one embodiment, as part of allowing a user access to their e-mail, or access to certain setting options. The entity requesting the data could also be an application choosing from a lower security authentication model (touch data **302**) or higher security authentication model (swipe data **310**). Further, the requesting entity could also be a website accessed on the device **200**. Additionally, any requesting entity may request touch data **302** or swipe data **310** as part of an enrollment or authentication procedure.

[0032] In one embodiment, upon receiving an indication that a request for fingerprint data has been made, the controller **214** may communicate that request to the sensor **212**. The sensor **212** may then retrieve the requested data, either as touch data **302** or swipe data **304**. This data may be retrieved passively as a user interacts with the sensor **212**, for example as the user interacts with an application prior to the requested authentication. Alternatively, the data may be retrieved actively by the controller **214** providing an indication to a user of the device **200**, for example as a pop-up or other indication, requesting data be provided. The indication may specify that touch data **302** is requested, or that swipe data **310** is requested, or that either touch data **302** or swipe **310** is acceptable. Upon the sensor **212** retrieving the data from a user, the controller then, in one embodiment, sends the requested data back to the requested entity.

[0033] In one embodiment, the single item of fingerprint data obtained as part of the transaction with the requesting entity is discarded once used, and not saved in memory **230** or secure memory **236**. In another embodiment, the single item of fingerprint data obtained is saved in the precapture prints portion **242** of secure memory **236**.

Multiple Touch and Swipe Capture of Fingerprint Data

[0034] While the use of a sensor area **304** capable of switching between accepting touch data **302** and swipe data **310** is useful in a situation requiring a single touch enrollment or authentication from a user, it is also a useful feature of a system that stores a plurality of prints, as described below in further detail with respect to the precapture process. A further security precaution, in addition to the availability of switching from a touch to a swipe configuration may, in one embodiment, concern the position of the data captured on the fingerprint specimen. As discussed above, often the sensor area **304** is too small to capture an entire fingerprint specimen. Therefore, several different specimens may be required to obtain the requisite amount of data in order to be sure that a sample taken for authentication matches a previously-captured enrollment template. FIGS. **3**C and **3**D show two different sets of fingerprint data taken in an exemplary authentication process. In FIG. **3**C, several touch data **302** and swipe data **310** have been captured from a fingerprint **300**. Also shown in FIG. **3**C is a nonlinear swipe data sample **316**. Such a nonlinear swipe data sample **316** may result from a user moving their finger across the sensor shown in FIG. **3**B such that it is moving in an atypical up and down fashion.

[0035] None of the samples in FIG. **3**C have any overlap with any other segment. Overlap between collected data samples ensures that two different samples come from the same user. For example, many people are in the habit of allowing other individuals to use their devices, for example, to make a phone call. Or, in another example, a parent may allow a child to play a game on their tablet. However, the parent user of said tablet would not want a precapture system to keep the data collected from the child's touching of the screen for later authentication. In such a situation the parent may choose to require authentication through the precapture process to only use prints that either exhibit single overlap data **312** or multiple overlap data **320**. This data may be used in conjunction with non-verified data **316**. Additionally, the use of overlapping print data may be mandated by the device manufacturer, website owner or application developer in order to ensure security. Therefore, an increased security measure may be to discard all non-verified data **316**.

[0036] In this way the precapture process for a device **200** owned by an exemplary parent user would ensure that all data kept is relevant to the main user of the tablet, and that data collected relevant to other users is discarded. However, in another embodiment, the user may choose to keep all touch data and, in such an embodiment, non-verified data **316** would be kept in the system. This may be advantageous as, in one embodiment, non-verified data **316** may later become verified if a later-captured print exhibits an overlap area.

Precapture Storage of Fingerprint Data

[0037] Without a full print, it may be difficult to authenticate the identity of a user above a certain accuracy threshold. This problem can be remedied, however, by taking multiple samples of biometric data. One solution previously mentioned to the problem of the small area of sensor **212** is to passively capture biometric data from the user during a time period prior to a request for authentication. For example, if a user has purchased a new phone, they may take several minutes to complete the startup process prior to the need to enter an authentication: for example, logging into an email account for the first time. During this initial startup process, the user may, for example, touch the screen or other sensor element **212** enough times that a composite print is achieved, or only requires a few additional touches to get the required amount of data for an initial enrollment, or authentication fingerprint sample. This ability to passively collect and store biometric data information allows for the generation of a composite biometric sample that serves as the required enrollment template or authentication sample.

[0038] Both of the touch data **302** and swipe data **310** could be used in combination with a precapture process, which may, in one embodiment, passively capture the touch data **302** and swipe data **310** any time the user interacts with the sensor **212**. For example, if the sensor **212** is in a button element **206**, each time the user presses button element **206**, a touch data sample **302** may be passively captured as part of the precapture process. In one embodiment, the sensor **212** may capture, and the device may store both touch and swipe data in a memory cache, for example secure memory **236**. In one embodiment, any touch data **302** or swipe data **310** is tagged with a time stamp, such that the device is able to know how far away in time that data was acquired. In one embodiment, the time stamp is a relative time stamp such that the device is only aware that such a fingerprint sample was taken, for example, five seconds or five minutes or five days prior to a present authentication request. In another embodiment, the time stamp is tagged with an absolute date stamp, for example, that the information was captured on Thursday, Feb. 2, 2015 at 4:17 PM. FIGS. **4**A and B show examples of such a relative time stamp.

[0039] This precapture process, in one embodiment, captures a plurality of data samples, in one embodiment as shown, for example, in FIGS. **3**C and **3**D, using an adaptive authentication template that continuously adds information to a stored biometric sample as the information is captured by the biometric sensor, or sensors **212**. As shown in FIGS. **3**C and **3**D, each portion of an input by a user, represented by each of the touch data **302** or swipe data **310**, is added to the stored biometric sample as they are received by the device **200**, increasing the amount of data available for a secure authentication. This allows the device **200** to obtain enough biometric data to, in one embodiment, log the user in automatically in response to a request for authentication. In another embodiment, the precapture system provides a supplemental source of biometric data such that, instead of the typical 15-20 touches required, only a few touches are required to complete an authentication process.

[0040] FIGS. **4**A and **4**B illustrate an exemplary cache of fingerprint data taken during a precapture process. In one embodiment, as shown in FIG. **4**A, data samples **406** are received by the device **200** through sensors **212** as a user interacts with the device **200**. Authentication request **402** occurs at a relative time **0**, and the device **200** then retrieves a plurality of data samples **406** from the memory **230**, or the secured memory **236**. Each of the plurality of data samples **406** has a timestamp indicating how far away in time from the authentication request **402** each of the data samples **406** were taken. The timestamp is assigned based on the reverse time axis **404**, relative to the authentication request **402**. For example, as shown in FIG. **4**A, a plurality of samples **406** were captured within 30 seconds of the authentication request **402**, and another plurality were captured within a minute of the authentication requests **402**. In one embodiment, the device pulls all available data at once to create a composite print for authentication, such as print **300** shown in FIG. **3**D. In another embodiment, upon receiving a request for authentication, the device pulls data samples **406** in order of recency with respect to the authentication request **402**. In one embodiment, the prints pulled in response to an authentication request **402** are part of the authentication period. The authentication period may be set by the device **200**, or by the requesting entity.

[0041] In another embodiment, in order to ensure that all samples are from a single user, the trusted storage portion is periodically purged of all samples. Some triggers for a purge may, in one embodiment, include the shutdown or startup of the device, a preset inactivity period, or a dynamic inactivity depending on user activity. Additionally, the trigger may be a device determined trigger, such that the period of inactivity required for a specific device to power down its screen, a detection of a movement by GPS, a detection of hacking or break-in, a removal of a back cover, or a clear button/indicator is pressed, or a detection that the device **200** has been rotated past a certain trigger angle, for example more than 90 degrees. In this way, a user may be able to trigger a purge by holding their device **200** and moving their hand such that the device **200** detects this motion through internal accelerometers and trigger a purge.

[0042] In one embodiment, the purge is also triggered by a successful authentication, such that a user can now use the same print for two successful authentications without providing new samples through the precapture process described previously. As shown in FIG. **4**A, an indicia of user change **408** was detected almost 2 minutes prior to authentication. The indicia **408** may be a turning of the device **200**, for example, 90 or 180 degrees. The indicia **408** may automatically trigger a purge of all data or it may flag data occurring prior to the trigger as potentially compromised. In this way, the next authentication request **402** may trigger a purge of this data depending on the security necessary. In another embodiment, the device may detect that the indicia **408** was a turning of the device **200** in line with the confines of an application, namely switching the screen view from landscape to portrait. In such an embodiment, where the indicia **408** is not likely to indicate a switch between users, the indicia **408** may be disregarded by the device **200**, and the data occurring prior to indicia **408** may not be purged. However, in an embodiment where overlap data **308** or **320** is required for an authentication sample, the flagged data may be rejected as non-verified data **316**. FIG. **4**A also shows a period of purged data **412** that occurred prior to a purge trigger **410**. For example, the purge trigger may have been the device **200** turning off and then back on.

[0043] FIG. **4**B shows a longer timeline **400** with more available data samples **406** for authentication, depending on the security required for authentication request **402**. If the authentication requires a high level of security, for example a financial application, then only data samples occurring within a secured period **420** may be used, in one embodiment. If, on the other hand, a lower level of security is needed, for example a social media application, then a normal authentication period **430** may be used. In one embodiment, a normal authentication period **430** may extend back minutes, hours or even days depending on whether or not a dynamic or preset trigger **410** is received and a purge triggered.

[0044] Both the initial enrollment and all later authentication can be accomplished using a passive biometric data capture system as described above with respect to both the touch data **302** and swipe data **310**. In one embodiment, biometric data is passively captured from a user during a time period when they are touching the touchpad or other biometric sensor **212**. This may occur while they are completing a task generally unrelated to enrollment or authentication. For example, if a user has purchased a new phone, they may take several minutes to complete the startup process prior to the need to enter an initial authentication, or the required initial enrollment—for example, logging into an email account for the first time or setting the initial settings on the device. During this initial startup process the user may for example, touch the screen enough times that a composite print is achieved with no or only a few additional touches to get the required data for a verifiable print. The ability to passively collect and store biometric data information allows for the generation of a more complete biometric sample that serves as the required enrollment or authentication, without requiring a user to enter touch or swipe date 15 to 20 times to achieve the print.

[0045] This process of passive collection of biometric information, in one embodiment, fingerprint data is referred to collectively as the precapture process as described previously, or the capture process outside of an authentication task or operation. This precapture collection occurs during a period before the user of a device, e.g. device **200** encounters an authentication requirement, defined as the period ending with the authentication and extending back in time for a specified length. The specified length of time depends both on the type of activity engaged in prior to authentication and the security level of the authentication. These time periods can be set by the device's user, device manufacturer, website the user seeks to enter, or the biometric data collection software provider. Additionally, the type of activity is considered—if the user is consistently tapping the screen in response to, for example, gaming stimuli, that may be considered more reliable than periodic clicks over a longer period of time. Or, if the device's user indicates through a saved setting that they use the device with multiple users, data **406** captured during a gaming application may be considered less reliable.

[0046] In the case where a greater level of security is needed than the biometric data cached during the precapture period, or where a website requires a secondary authentication period (for example, to complete a monetary transfer), a secondary security procedure may be implemented in addition to the biometric data collected during the precapture period. The precapture process is, thus, customizable based on preferences of the company whose content is accessed by a user. In one embodiment, the company is a website owner. In another embodiment, the company is an application developer. In another embodiment the company is a corporation working with its employees, partners, and customers for access to facilities, data or services.

[0047] In one embodiment, the company is presented with a user interface that allows them to set the thresholds for access. For example, the company may set a minimum number of data samples **406** that must be obtained during the precapture period in order to accept the authentication. In another embodiment, the company may require a certain number of single overlap data **308** or multiple overlap data **320** in order to ensure that the required security has been met. Since the adaptive authentication template continuously collects biometric samples provided by the user, the precapture process can accommodate the different threshold levels set by a company. In another embodiment, the company may only allow data collected during a set period of time, for example, the last five minutes. Additionally, the company may choose, in another embodiment, to require a second security authentication format. This customizability by the company allows the company to ensure that their customer's data is secure, with convenient access. The second security authentication format may be an alphanumeric password, or selection of a correct photo from a photo array or another verification mechanism.

[0048] Additionally, in one embodiment, the user of the precapture process can also customize their settings. This customization may occur, in one embodiment, on the device **200** through an application interface. It could also occur, in another embodiment, at the initial startup of the device **200** upon purchase. Further, in another embodiment, the settings are changeable by the user at a later point. Customization may also take place, in another embodiment, on a website later accessible and changed by the user. This provides an additional safety feature in that if a user does lose their device **200**, they are able to ensure that data samples **406** are no longer accessible or usable by someone who later finds or has stolen the device **200**, by making changes through a website interface.

[0049] The user may, in one embodiment, adjust the requisite tolerance levels for logging into different websites or applications, and may also set a preferred secondary security measure of website that requires a secondary security measure. For example, the user may set a password to accompany the use of their biometric information.

[0050] Additionally, the user may set precapture settings around automatic addition and purging of data samples **406** to and from the secured memory cache **236**. The user may indicate, through the user interface, in one embodiment, that they wish for the precapture process to happen automatically in the background while they use the device **200**. Alternatively, the user may indicate, in one embodiment, that the system request permission to add samples to the secured memory cache **236** when certain activities are taking place. For example, the user may request a permission screen to appear when games are played on a specific device, but give automatic authorization to add samples when the user's email or calendar is open. This allows the user the functionality to allow a friend or child to use the device in order play said games without the risk of their biometric information being confused with the user's.

[0051] Additionally, the user may, in one embodiment, configure settings around using their biometric samples in the secure memory cache **236**. For example, the user may indicate that their device **200** is to automatically use the adaptive authentication template as a login mechanism, in one embodiment. Alternatively, the user may indicate, in another embodiment, that the user must ask permission before each authentication to use the stored precapture prints **242**. These, and other settings may be saved in the general settings **234**, or in the secured precapture settings **240**. Once set up, the secured precapture settings **240** may not be accessible, in one embodiment, without a successful authentication. The user may also, in one embodiment, enter settings around quality checking data samples **406**, either as they are received by the device **200**, or when the authentication request **402** is received. Constantly checking the quality of data samples **406** may require considerable processor power and, consequently, may result in a shorter battery life. Instead, the user may choose to not have the data samples **406** checked for quality (e.g. resolution, size of print, overlap with earlier prints, etc.) until the authentication request **402** is received. In another embodiment, the device **200** may only check the quality of data samples **406** automatically when the device **200** is plugged in and charging.

[0052] The user may, in one embodiment, also configure settings around the storage of the biometric samples in the secure memory cache **236**. For example, the user may indicate that their device **200** is to automatically use the adaptive authentication template as a login mechanism in one embodiment. Alternatively, the user may indicate in another embodiment, that the device **200** must ask permission before each authentication to use stored precapture prints **242**.

[0053] The user may, in one embodiment, also configure settings around the storage of the data samples **406**. The user may, in one embodiment, set an indication to keep or change settings on a time-based interval, for example, once monthly or annually. The user may also, in one embodiment, set an indication to keep or change settings on a device-based interval, for example, at startup or shutdown of a device **200**. Additionally, the user may, in one embodiment, set indications around when the secured memory **206** should purge the precapture prints **242**. For example, the user may, in one embodiment, set a purge every time the device **200** is shutdown or, in another embodiment, set a purge each time the user opens a specific application. The user may also set times when a new enrollment should be taken, replacing the enrollment data **238** stored within the secure memory **236**. In another embodiment, the enrollment data **238** can only be purged through access of a website of the biometric software provider.

Enrollment and Authentication Methods

[0054] There are a number of different reasons that a device manufacturer or application manufacturer would require a fingerprint sample from a user. In one example, a device manufacturer may take an initial enrollment print from a user during the first time that a user uses the device **200**. For example, this enrollment process may be initiated when a user first opens a device **200** and takes it out of the box. However, in an alternate embodiment, the enrollment period may be triggered by the user at a later time. For example, if a user is having their device **200** setup by the manufacturer, for example, a new phone setup at the phone service provider, the enrollment period may be activated such that print data taken by an employee of the manufacturer is not accepted as part of the initial enrollment print.

[0055] Another reason that biometric data may be required would be for an authentication procedure, where the device **200** or an application running on the device **200** seeks an authentication sample from a user and compares it back to that original enrollment print(s) in order to determine that the user is the owner of the device **200**. While many device manufacturers allow the user to provide 15 to 20 touches during an enrollment period, the amount of time that it would take for a user to provide this many touches during an authentication period is often not acceptable from a convenience standpoint.

[0056] In the single-touch embodiment described above, the method of enrolling a user upon receiving a request for enrollment, and the method of authenticating a user upon receiving a request for authentication follow that shown in FIG. **5**.

[0057] The single-input method, which may be either an enrollment or an authentication of a user, **500** starts in block **502** when the system detects a request for fingerprint data. As discussed above, the request may come from an outside entity, for example a website or an application, or from the device **200** itself, for example as part of a turn on/turn off procedure or to access the home screen from a locked or sleeping mode.

[0058] After receiving the request for data in block **502**, the system then determines the appropriate sensor configuration in block **504**, namely either a touch input configuration or a swipe input configuration. In one embodiment, the requesting entity may require the sensor **212** be configured to receive specifically touch data **302** or swipe data **310**. This could be for required for security considerations, or other reasons. Optionally, the system may detect a current sensor configuration and switch to the desired sensor configuration, in block **512**. In an embodiment where the device **200** has multiple sensor inputs, for example both a button sensor element and a screen sensor element, this may require switching from a touch input through the button to a swipe input on the screen, for example, or it may require switching a single sensor element from a touch input configuration to a swipe input configuration, as shown in FIGS. **3A-3B** with sensor area **304**. In another embodiment, the system anticipates the appropriate input configuration based on prior user actions (for example, multiple touches or swipes as part of a gaming application) or based on previous user interactions with the requesting entity. For example, a user may typically swipe across the screen to open an e-mail application. Therefore, in block **504**, when an authentication requests comes from an e-mail application, the system may anticipate that the user will input a swipe data portion **310**. Additionally, the device **200** may anticipate the type of input in another appropriate manner.

[0059] In block **506**, after the sensor configuration is set, the sensor **212** receives data from the user. This may be the requested touch input **302** or swipe input **310**, in one embodiment. The data may then go through an optional quality check in block **510**. In one embodiment, the quality check is not done by the system performing method **500**, but by the requesting entity once the data is returned, in block **508**. The method ends, in one embodiment, in block **508** with the collected data being returned to the requesting entity.

[0060] In one embodiment, the device **200** then discards the collected data and does not retain a copy. This may be useful, for example, in the embodiment where multiple users use a single device **200**. A user may choose to only allow the device **200** to use a single-input enrollment/authentication method such as method **500** because retaining fingerprint data, for example, may result in conflicting data inputs in the secure memory **236**. In another embodiment, while the device **200** may use a single-input method, such as method **500**, for a given authentication or enrollment, it may also store the collected data as one input. In one embodiment, a successful single-input authentication may be the basis for accepting or rejecting other prints as overlapping data **320**, as discussed above with respect to FIGS. **3C** and **3D**.

[0061] FIG. **6** illustrates an exemplary method for gathering initial fingerprint data for enrollment of a fingerprint template. As set forth above, the enrollment template may be periodically purged based on user or manufacturer settings, in one embodiment. In another embodiment, the enrollment template may be stored within the secure memory **236** as enrollment data **238** and not purged without a trigger from the user or device manufacturer.

[0062] The enrollment method **600** starts in block **602**, with an enrollment initiation. As described previously, this initiation may occur upon the device being taken out of a box for the first time, or it may occur at a later date. For example, in one embodiment, a popup may appear on the device **200** for the first time asking if the current user of the device **200** is the owner of the device **200**. In such an embodiment, if the device **200** is being setup by a manufacturer or other service provider, the touch data **302** and swipe data **310** provided by the service provider will not be used as part of the enrollment template. In such an exemplary embodiment, the employee of the manufacturer or the service provider may be able to initiate enrollment at a later time. The enrollment initiation in block **602** may also take place, for example, when the user sets up or uses a trusted application for a first time, for example their email or a social media application.

[0063] Once the enrollment is initiated in block **602**, the method then progresses to block **604** where the collection is initiated. This may take place immediately upon the user providing an indication that the device **200** is theirs, or it may occur several seconds later, for example, if the manufacturer's employee indicates that the device is being turned over to a user (for example, the device **200** detecting a 90 or 180 degree turn, or the employee affirmatively indicating a transfer), then the earliest set of data samples **406** may be discarded. In another embodiment, the first set of data samples is always discarded until the device owner takes active steps to initiate passive capture of data samples **406** for enrollment, for example, by changing settings within the device **200**.

[0064] In another embodiment, the collection may be initiated by a first print being detected in block **606**. Once the print is detected it may go through an optional quality check process as shown in block **608**. This may result in a processor of the device **200** checking the quality of the print to ensure that sufficient features **102** are detected to identify the print detection in block **606** as having sufficient resolution to be used for a later authentication. If the print detected in block **606** fails the optional quality check in **608** as shown in block **610**, the print is discarded and the process goes back to detecting the next touch or swipe input.

[0065] Additionally, when the print is detected it may also trigger the device **200** to optionally check for other cached prints in secure memory cache **236**, as indicated in block **612**. For example, in the embodiment where the enrollment is initiated upon detecting a user logging into an e-mail for the first time, for example, the device **200** may note that there was no interruption between that selection of initiating the enrollment period during the opening of the email and a prior period where a user was interacting with the screen, for example in setting up a social media account. This may be sufficient for the device to determine that cached prints in relation to that earlier action, for example those collected while setting up the social media application, are sufficient to be used as part of the enrollment process and this is done in block **612**.

[0066] In the event that a new print is detected, the device **200** then adds the current print to the secure memory cache **236** and determines if there is enough data collected for an initial enrollment print to be captured, as indicated in block **614**. If there is enough data the process ends. If there is not enough data the method goes back to block **606** to detect another print. Additionally, this may involve an optional popup or other indication to a user that more data is needed, as indicated in block **618**. If enough data is collected for an enrollment print to be captured and stored in the enrollment data portion **238** of secure memory cache **236** the process ends at block **616**. In one embodiment, the enrollment period may be initiated periodically, for example, annually to update the enrollment data **238**.

[0067] FIG. **7** illustrates an exemplary method for gathering fingerprint data for authentication against the fingerprint template. The fingerprint template may be, for example, taken through method **600**. However, the exemplary method of FIG. **7** could be used to authenticate a print against an enrollment template taken through a different method. In one embodiment, the authentication method **700** starts when an authentication request, such as authentication request **402**, is received in block **702**. This authentication request may come, for example, from an application installed on the device **200**, or from a website, or from a settings requirement within the device **200** itself.

[0068] Once the authentication request is received in block **702** the method then moves onto block **704** where a security level is determined for the authentication request. The security level may depend, for example, on the sensitivity of the transaction request by the authentication, for example, a financial transaction may have a higher security level then logging into or making a post on a social media website. Once a security level is determined in block **704** the device **200** may then determine, based on the security level, a time period acceptable for pulling recent touch data **302** and swipe data **310** from the memory cache. A higher security level may only allow for cached prints to be used from a period of up to a minute, for example, whereas a low security threshold may allow prints from the last time the device was turned on, which could, for example, be up to a period of days depending on the habits of a user. In one embodiment, upon determining an appropriate authentication period, the device checks the cache for recent prints in block **706**.

[0069] In one embodiment, the prints in the cache go through an optional quality check in block **708**. In one embodiment, the optional quality check is done every time the device takes a touch data **302** or a swipe data **310**. However, constantly using the CPU of a device to check the quality of every touch data **302** and swipe data **310** requires a considerable amount of battery and most users will not want this as part of their experience using device **200**. Therefore, to compensate for the fact that touch data **302** and swipe data **310** are not checked for quality when they are originally taken the authentication method may add this additional quality check in block **708**. However, this quality check in block **708** is not necessary in the embodiment where touch data **302** and swipe data **310** are checked when taken. For example, in one embodiment, touch data **302** and swipe data **310** may be checked automatically when a user opens up an application or logs into a website for a transaction. The indication of high security required by the user logging into a financial institution application on a device **200**, in one embodiment, may be sufficient to trigger the device to begin checking later touch data **302** and swipe data **310** taken between the time that the user logs into the financial institution application such that when the user goes to authenticate a transaction within such a high security application, additional option **708** is not necessary in another embodiment.

[0070] Once recent prints within an acceptable time period are determined and compiled, there is an additional step in block **710** to check the quantity of the collected prints and the quantity prints to determine whether or not there is a sufficient composite print detected in order to fully compare the authentication with the enrollment print previously taken. If there is a sufficient quantity and quality of collected fingerprint data the process then moves on to block **714** wherein the authentication request is processed. If instead a sufficient quantity or quality is not detected the process moves to block **712** where the user is presented with the request for additional authentication data and the method goes back to block **710** to then check the quality of the additional fingerprint data gathered. In this manner, the user may completely bypass the need to enter either a password or fingerprint data if there is enough data in the precapture store **242**. This sufficiently decreases the number of times that a user has to input fingerprint data in order to authenticate securely.

[0071] Some examples of additional security measures may include a controlled response where the user enters a predefined keyword, or an answer to the question that only the user would know, for example, who the user's third grade teacher was. Another secondary measure would be multiple types of sensors used in conjunction—for example, the RF sensors in the phone in conjunction with an NFC sensor in the user's car or on the user's keychain. Further, the device could also use the user's location as a secondary security measure: in one embodiment, the device could sense that the user is in a trusted location such as home, office, or a commonly frequented coffee shop and use that as a secondary authentication means. Additionally, in another embodiment, the secondary authentication measure may be a camera on the device **200** that takes a picture. Any of these secondary security means may be used in conjunction with precaptured biometric information to provide a more secure authentication process.

[0072] Although the present invention has been described with reference to preferred embodiments, workers skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the invention. For example, while embodiments of the present invention have been described with respect to fingerprints, as fingerprints provide a unique and reliable biometric sample for authentication, one skilled in the art would understand that other biometric data could also be used with the systems and methods described, for example iris patterns, DNA, etc.

What is claimed is:

1. A method of capturing and storing a plurality of biometric data by a user on a device for a future authentication request, the method comprising:

receiving a first input from a user, through a user input mechanism of the device, wherein the first input comprises a first portion of biometric data;

receiving a second input from a user, through the user input mechanism, wherein the second portion comprises a second portion of biometric data;

storing the first and second inputs from the user in a biometric data memory portion of a memory of the mobile device, wherein each input is stored in the memory along with a time stamp assigned by a processor of the device, and wherein, each received input is stored such that, upon receiving an authentication request, each input is retrievable by the processor, from the memory based on a recency of the time stamp, such that the most recent input is retrieved first.

2. The method of claim **1**, and further comprising:

comparing, prior to entering each input into the memory, the first portion of biometric data to the second portion of biometric data and, upon finding a partial match between the first and second portions of biometric data, storing the second input in the biometric data memory portion.

3. The method of claim **1**, wherein the time stamp is a relative time stamp, referring to an elapsed time between a capture and the future authentication request.

4. The method of claim **1**, wherein the time stamp is an absolute time stamp.

5. The method of claim **1**, wherein the biometric data memory portion of the device is a secured memory.

6. The method of claim **1**, wherein the biometric data memory portion is periodically purged of all biometric data.

7. The method of claim **1**, wherein the biometric data memory portion is purged when an on/off status of the device changes.

8. The method of claim **1**, wherein the biometric data memory portion is purged based on a detected trigger.

9. A mobile device with a touchscreen configured to provide automatic biometric authentication, the device comprising:

a fingerprint sensor built into the touchscreen, the fingerprint sensor configured to passively capture a plurality of fingerprint portions associated with a user of the mobile device;

a memory configured to store the captured plurality of fingerprint portions, wherein each captured plurality of print is stored with a time stamp; and

a processor configured to, upon receiving an authentication request from a source, automatically assemble a set of fingerprint portions sufficient to meet a security requirement associated with the authentication request.

10. The mobile device of claim **9**, wherein the memory also comprises an enrollment template, and wherein, before storage, each of the captured plurality of fingerprint portions is compared to the enrollment template, and a matching fingerprint portion is stored.

11. The mobile device of claim **9**, wherein the security requirement comprises a number of fingerprint portions with an overlap portions captured within a secured time period.

12. The mobile device of claim **9**, wherein the plurality of fingerprint portions comprises a combination of captured touch fingerprint portions and captured swipe fingerprint portions.

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