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(54) **SWIMMING POOL MONITORING**

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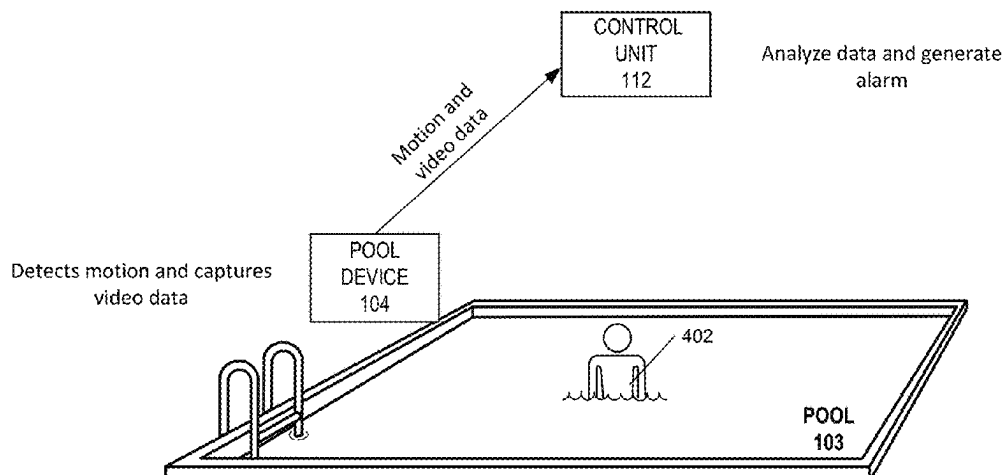
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**ABSTRACT**

A monitor control unit that is configured to receive, from the electronic pool device, the sensor data, compare the sensor data to a threshold, based on comparing the sensor data to a threshold, determine that the sensor data exceeds the threshold, based on determining that the sensor data exceeds the threshold, provide an instruction to initiate the capture of image data by the camera of the electronic pool device, receive, from the camera of the electronic pool device, the image data, analyze the image data, based on analyzing the image data, identify a monitoring system action to perform, and perform the monitoring system action.

**20 Claims, 9 Drawing Sheets**

**400A**



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(51)	<b>Int. Cl.</b> <b>G06F 18/21</b> (2023.01) <b>G06N 3/04</b> (2023.01) <b>G06N 3/08</b> (2023.01) <b>G06V 20/52</b> (2022.01) <b>G06V 40/10</b> (2022.01) <b>G06V 40/20</b> (2022.01) <b>H04N 7/18</b> (2006.01) <b>G01N 33/18</b> (2006.01)	2008/0106422	A1 *	5/2008	Sparks ..... E04H 4/148 340/573.6
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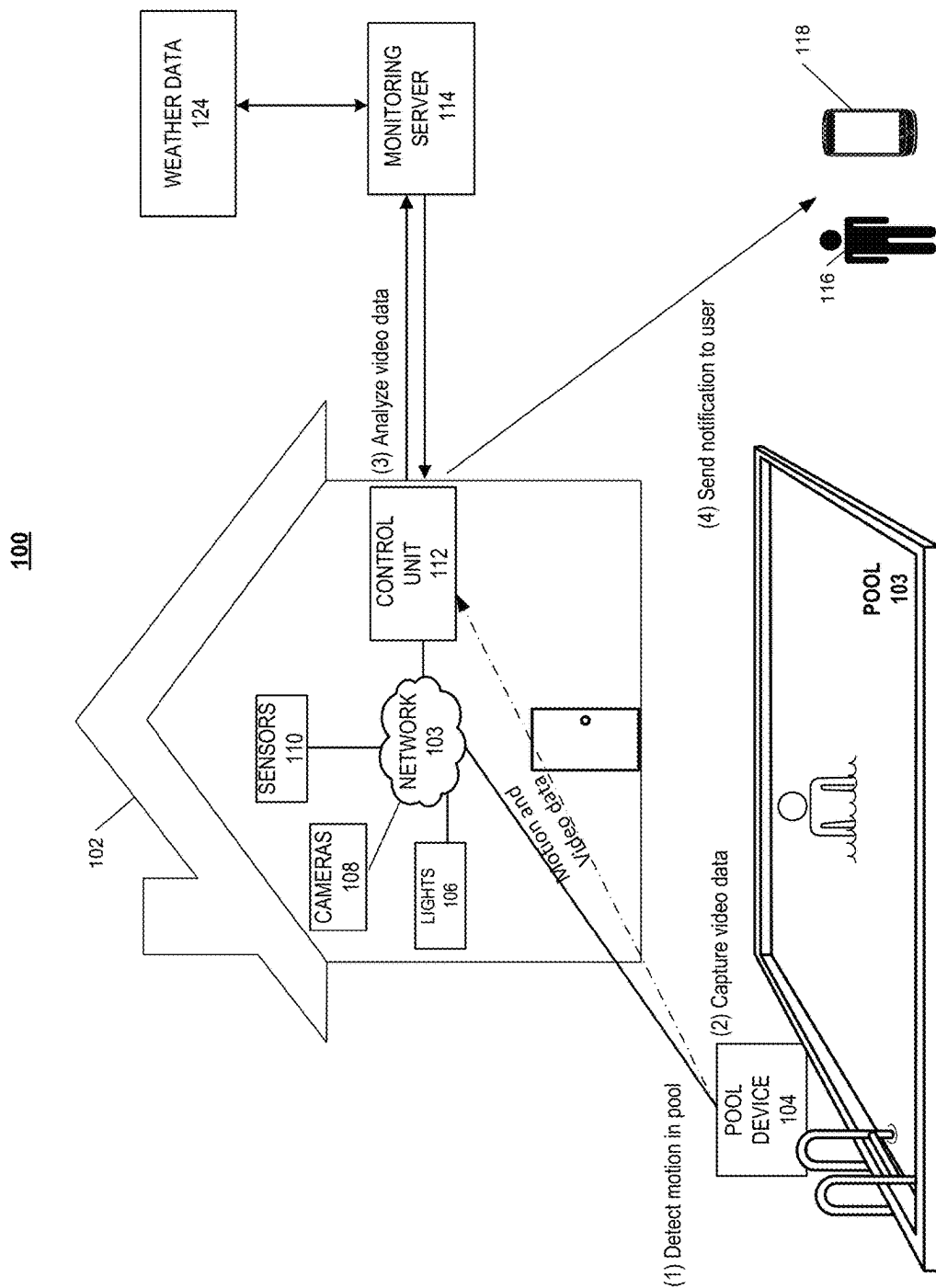


FIG. 1

200

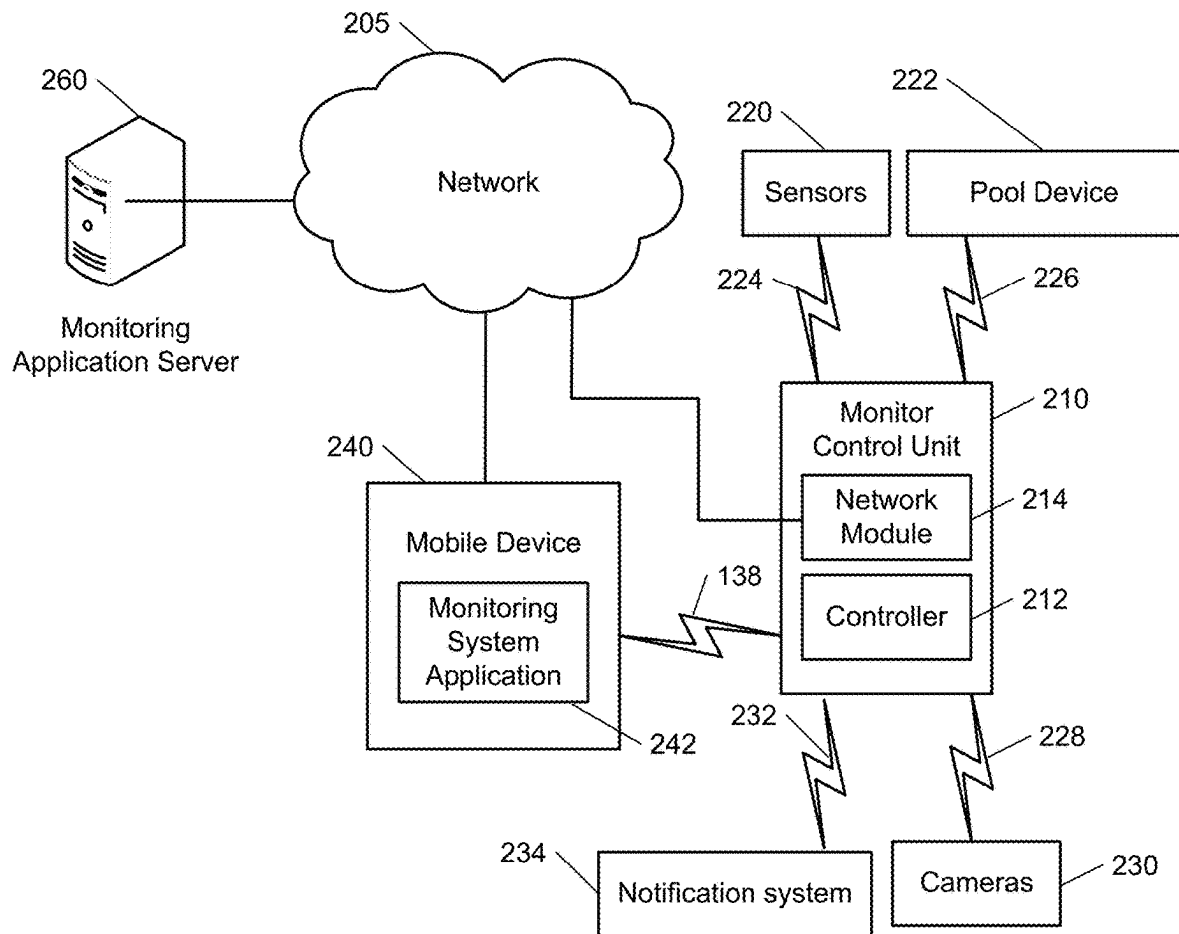


FIG. 2

300

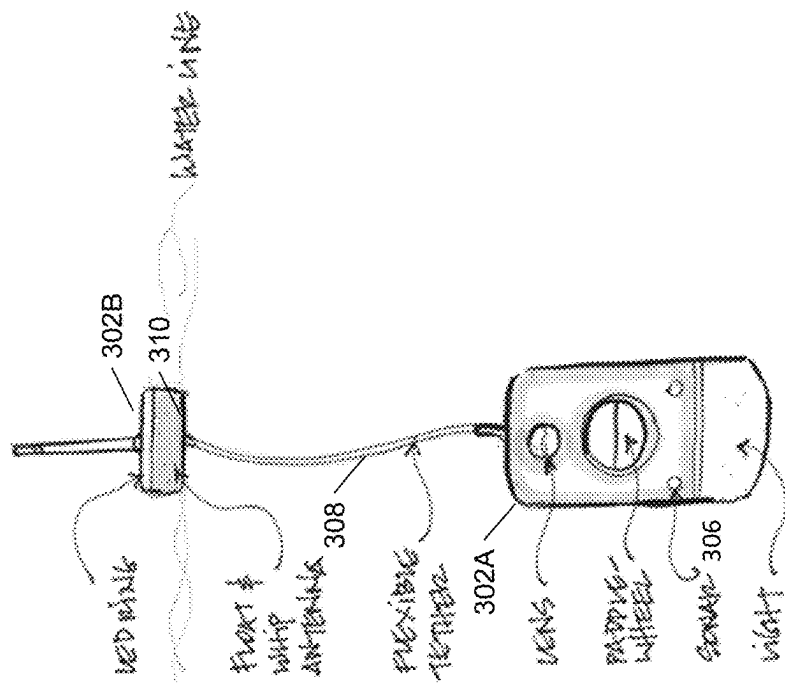
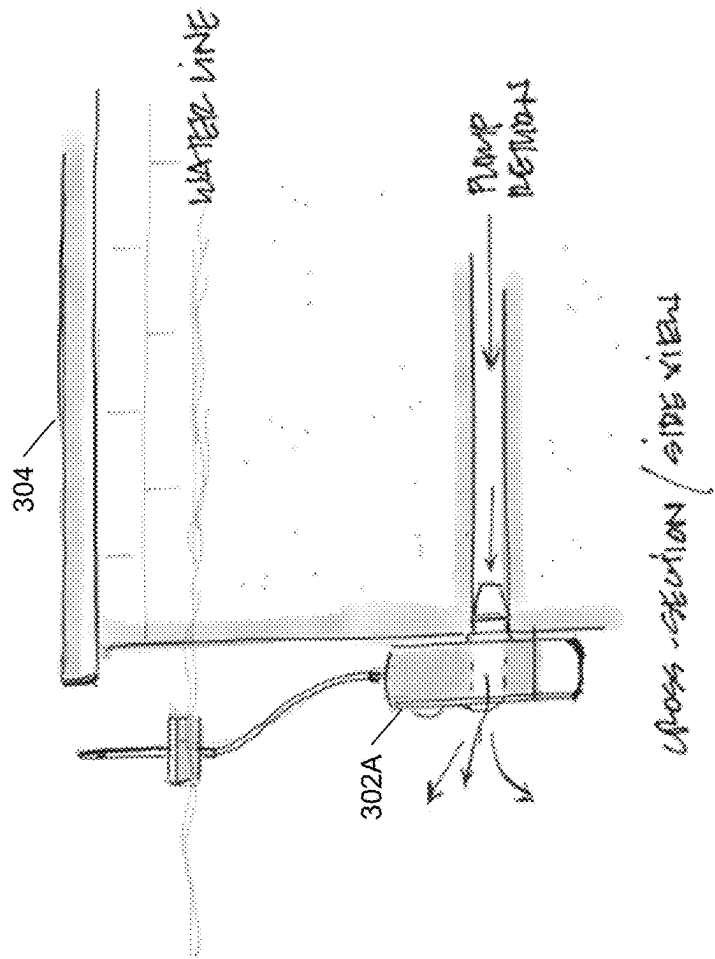


FIG. 3

400A

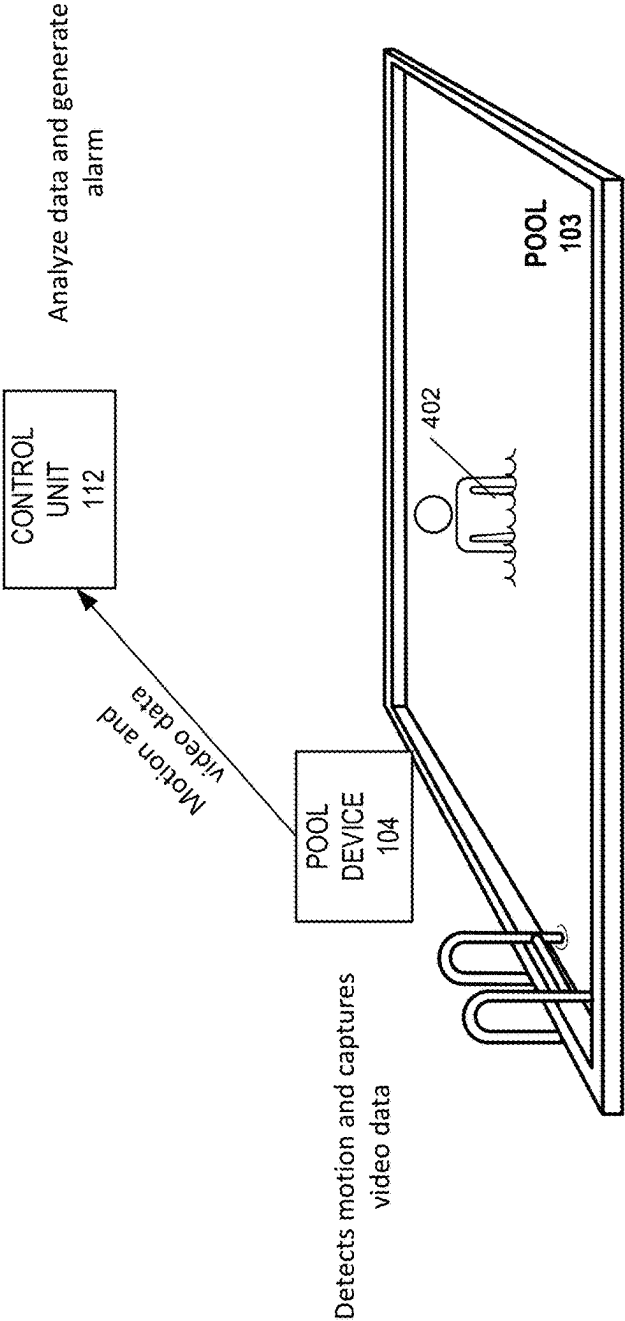
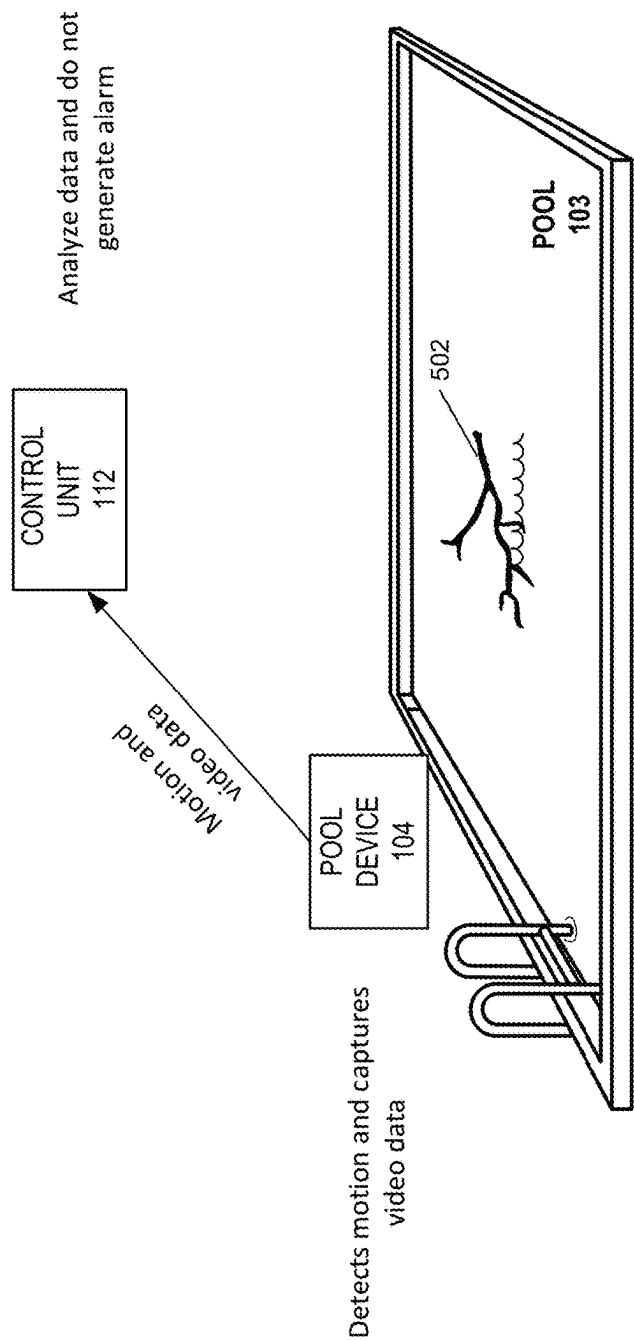
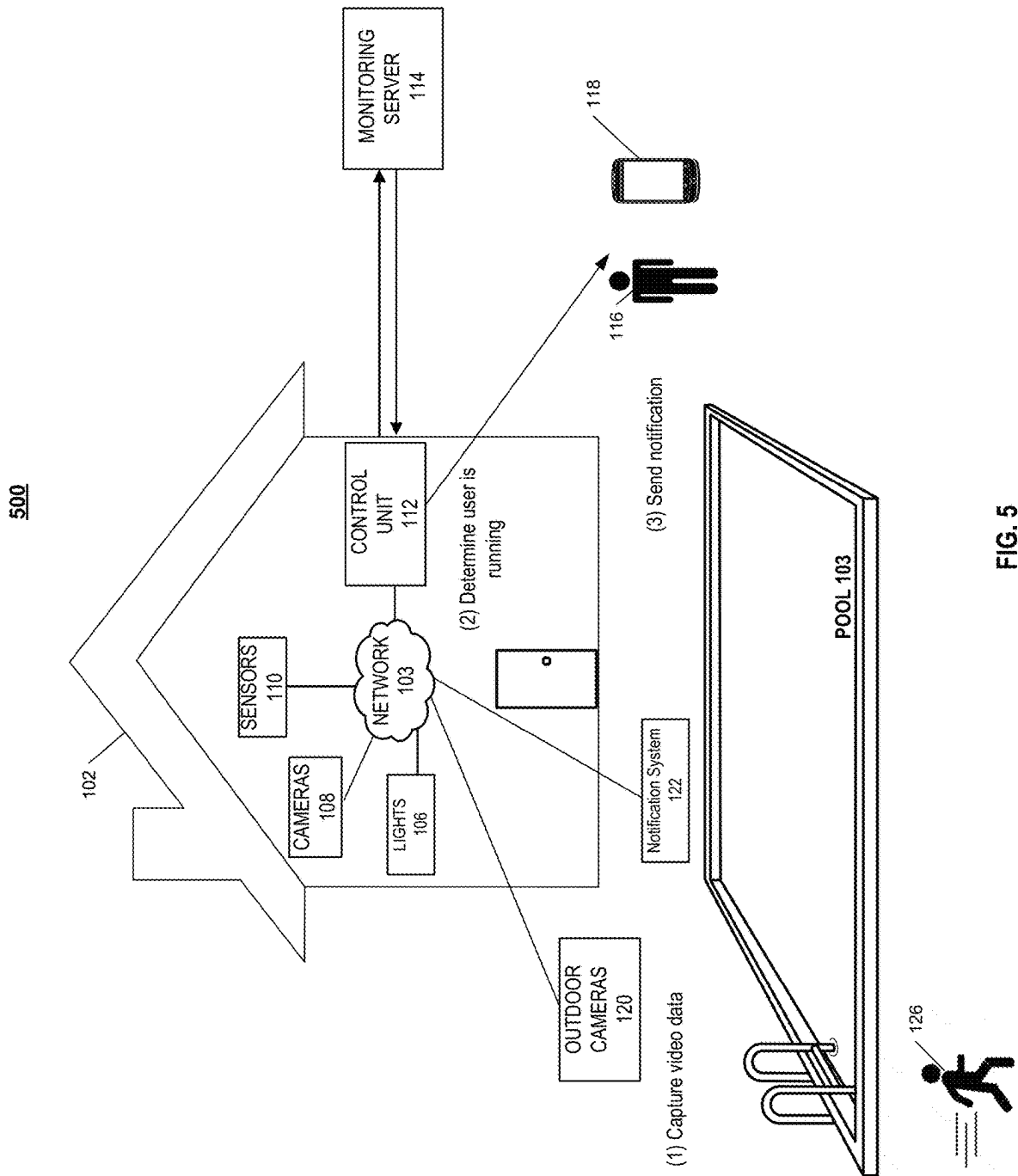


FIG. 4A

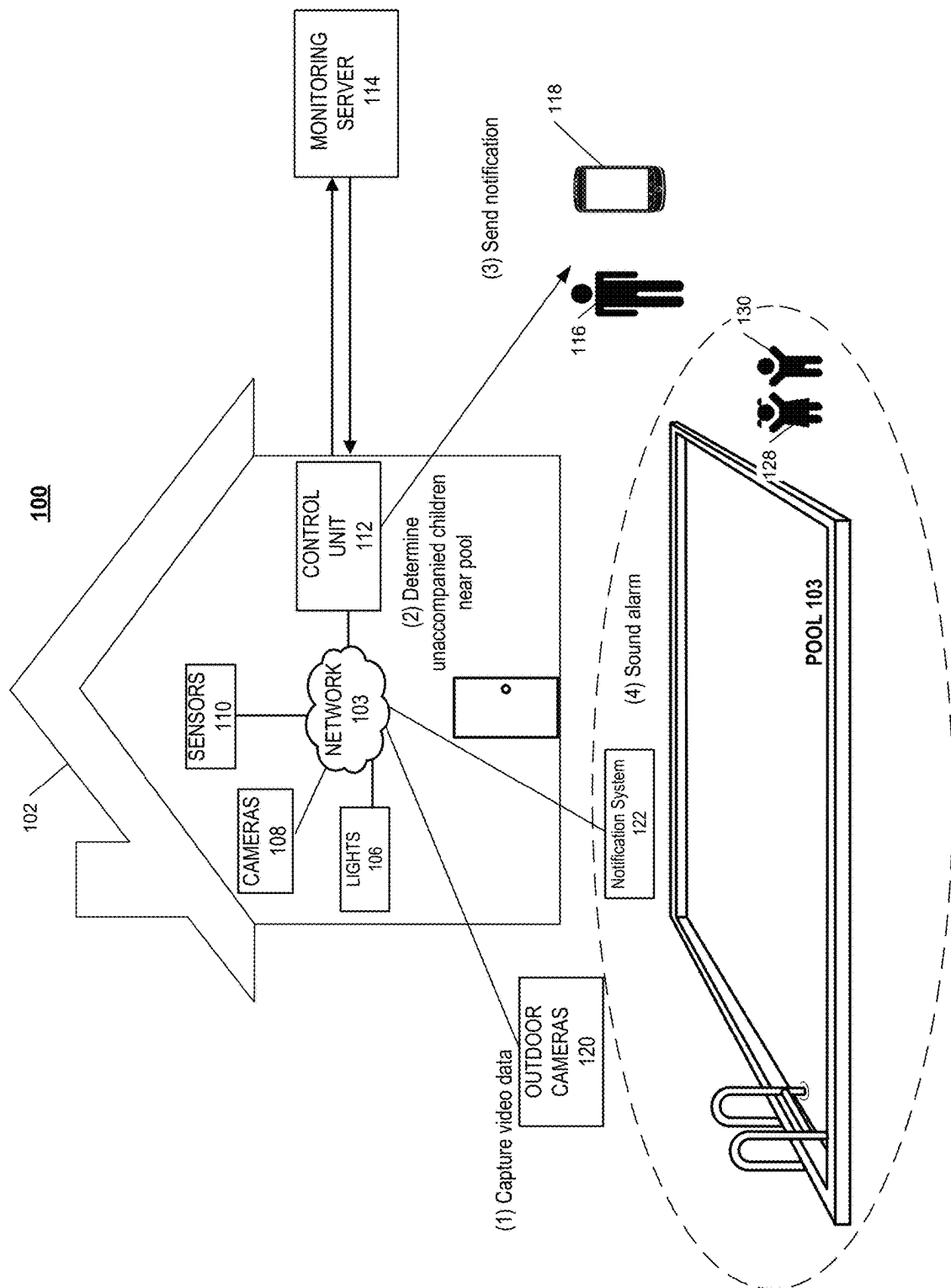
**400B**



**FIG. 4B**

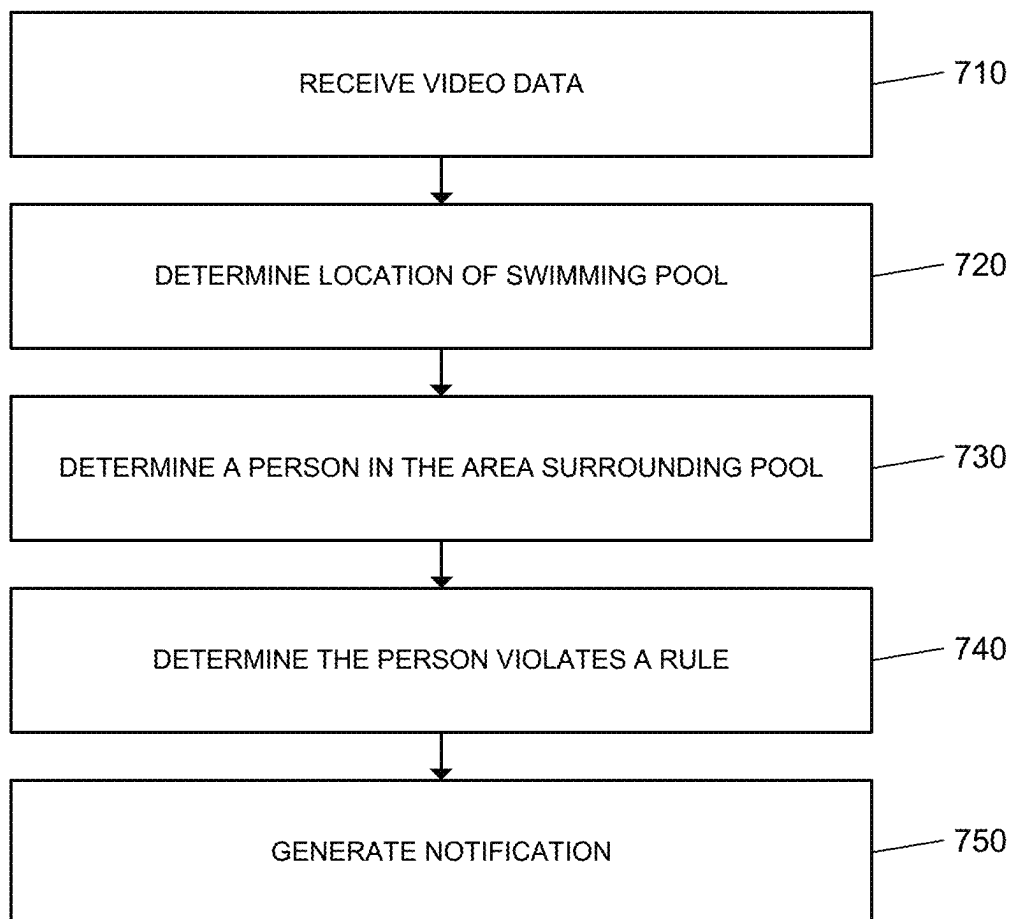




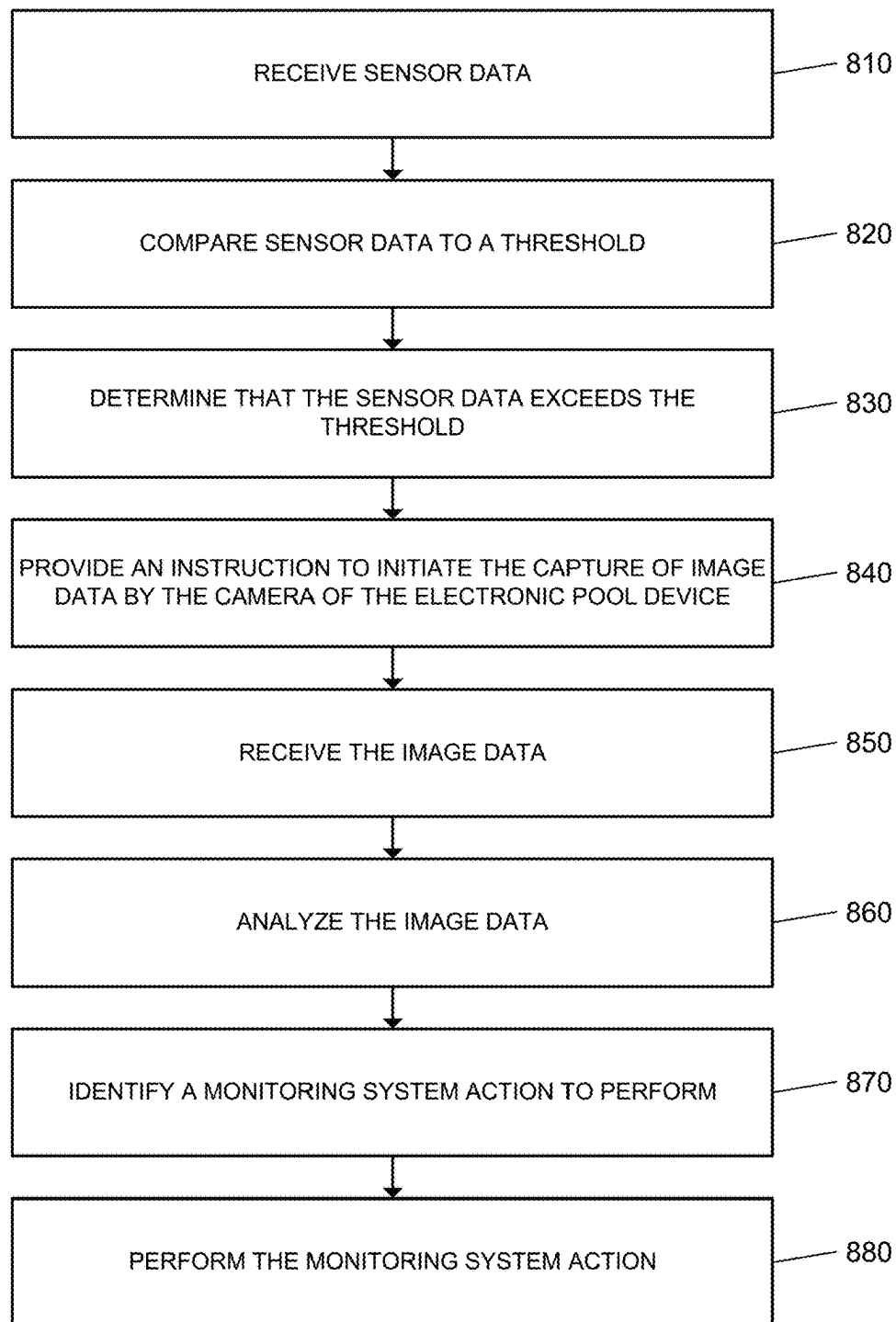


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700



**FIG. 7**

800**FIG. 8**

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**SWIMMING POOL MONITORING****CROSS REFERENCE TO RELATED APPLICATION**

This application is a continuation of U.S. application Ser. No. 16/746,548, filed Jan. 17, 2020, now allowed, which claims benefit of U.S. Provisional Application No. 62/793,568 filed Jan. 17, 2019, and titled "Swimming Pool Monitoring." The disclosure of each of the foregoing applications is incorporated herein by reference.

**TECHNICAL FIELD**

This disclosure relates to property monitoring technology and, for example, using video analytics and other techniques to monitor the activity at a swimming pool.

**BACKGROUND**

Many people equip homes and businesses with monitoring systems to provide increased security for their homes and businesses.

**SUMMARY**

Techniques are described for monitoring technology. For example, techniques are described for using video analytics and other techniques to monitor the area around a swimming pool for prohibited activity.

Implementations of the described techniques may include hardware, a method or process implemented at least partially in hardware, or a computer-readable storage medium encoded with executable instructions that, when executed by a processor, perform operations.

The details of one or more implementations are set forth in the accompanying drawings and the description below. Other features will be apparent from the description and drawings, and from the claims.

**DESCRIPTION OF DRAWINGS**

FIG. 1 illustrates an example of a system for detecting motion in a swimming pool.

FIG. 2 illustrates an example of a monitoring system integrated with an electronic pool device.

FIG. 3 illustrates an example of an electronic pool device.

FIGS. 4A and 4B illustrate examples of a system for detecting motion in a swimming pool.

FIG. 5 illustrates an example of a system for detecting a person running in the area around the swimming pool.

FIG. 6 illustrates an example system for detecting a child at the edge of the swimming pool.

FIG. 7 is a flow chart of an example process for generating an alert.

FIG. 8 is a flow chart of an example process for performing a monitoring system action.

**DETAILED DESCRIPTION**

Pool safety is important regardless of whether a homeowner is at the residence or the residence is vacant. Over the past ten years, there has been an average of over three thousand fatal drownings per year. Many of these drownings were the result of an unattended pool.

Techniques are described for integrating an electronic pool device into a monitoring system to facilitate the moni-

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toring of a swimming pool at a monitored property. The electronic pool device may include a battery powered camera and one or more sensors configured to detect motion in the swimming pool. The electronic pool device may be in communication with a control unit of the monitoring system at the monitored property. The electronic pool device monitors for unexpected activity at the pool. For example, the electronic pool device generates an alert to a user when motion is detected at the pool while the pool is not in use.

In addition, techniques are described for using video analytics to detect when person(s) are performing prohibited activities around the swimming pool. One or more cameras that are time synchronized and spatially calibrated which each other, may be fixed around the swimming pool and may be used to monitor the pool and the surrounding pool side areas for persons performing prohibited actions. For example, the one or more cameras may monitor the area around the pool for persons that are running around the swimming pool. The one or more cameras that are time synchronized and spatially calibrated with each other allows the system to track a person as the person moves through the monitored area and video data of the person is captured by the one or more cameras.

FIG. 1 illustrates an example of a monitoring system **100** integrated with an electronic pool device. As shown in FIG. 1, a property **102** (e.g. a home) of a user **116** is monitored by an in-home monitoring system (e.g. in-home security system) that includes components that are fixed within the property **102**. The in-home monitoring system may include a control unit **112**, one or more sensors **110**, one or more cameras **108**, one or more lights **106**, and an electronic pool device **104**. Each of the one or more sensors **110**, one or more cameras **108**, one or more lights **106**, and the electronic pool device **104** are in communication with the control unit **112** to form the monitoring ecosystem of the monitored property.

The user may integrate the electronic pool device **104** to monitor the conditions of a swimming pool **103** at the monitored property **102**. The swimming pool **103** may be an indoor pool located within the monitored property **102**, or an outdoor pool located on the lawn of the monitored property **102**. In some examples, the electronic pool device **104** may be used to monitor the conditions of a hot tub. In these examples, the electronic pool device **104** may be configured to detect only motion not caused by the bubbles generated in the hot tub. The electronic pool device **104** also monitors the pool for unexpected movement, for example when a child slips into the pool **103**. The electronic pool device **104** may be used to monitor the pool water temperature, the pool water pH levels, and any other suitable status conditions.

The electronic pool device **104** may include a camera portion that is configured to be placed under the surface of the water, and a surface portion that includes an antenna, a microphone and one or more motion detecting sensors. The one or more motion detecting sensors may include an accelerometer, a gyroscope, a mercury switch, or any other appropriate motion detecting sensors. The camera portion and the surface portion of the electronic pool device **104** may each be waterproof. The antenna is configured to allow the electronic pool device **104** to communicate with the control unit **112**. In some implementations, the electronic pool device **104** may communicate with the control unit **112** through Bluetooth, Z-Wave, ZigBee, Wi-Fi, or other suitable form of wireless communication.

The camera portion of the electronic pool device **104** includes a rechargeable battery that is charged by the energy generated from the water flowing through the pool's plumb-

ing system. The camera portion of the electronic pool device **104** may be configured to mount to an existing pool jet, and the battery of the camera portion charges as water flows through the pool jet. In some implementations, the camera portion of the electronic pool device **104** may be in communication with a distinct fitting that is mounted to the pool jet or is in communication with a skimmer, or an irrigation system. As the pool water flows through the fitting or the skimmer, the energy generated is transferred to the battery. In some implementations, the camera portion of the electronic pool device **104** may be charged through a solar panel located on the surface portion of the device **104**. The camera portion of the electronic pool device **104** is connected to the surface portion of the device by a flexible tether. The tether may be configured to allow the surface portion of the device **104** to float on the surface of the water immediately above the camera portion.

For the example illustrated in FIG. 1, the electronic pool device **104** detects motion in the pool. In some implementations, the electronic pool device **104** is placed in the swimming pool **103** when the pool is not being utilized. In these implementations, when the one or more motion sensors of the surface portion of electronic pool device **104** detect motion in the pool, the motion is considered as unexpected motion, and may trigger an alarm or some other form of notification to be generated. For example, the electronic pool device **104** may be placed in the pool **103** when an adult user does not expect any users in the pool **103**.

The one or more motion sensors of the surface portion of the electronic device **104** communicate the motion data to the control unit **112**. The control unit **112** compares the motion data to a motion threshold. The motion threshold may be a threshold determined by the control unit **112** based on the weather conditions at the location of the monitored property **102**. The control unit **112** at the monitored property **102** may receive weather data from a weather data server **124**. In some examples, the weather data server **124** is in direct communication with the control unit **112**. In other examples, the weather data server **124** communicates with a monitoring server **114** which in turn communicates with the control unit **112**. The control unit **112** may adjust the motion threshold based on the weather data indicating windy or rainy conditions.

The control unit **112** may adjust the motion threshold based on the time of the day. For example, the control unit may increase the motion threshold during the weekday between the hours of 8:00 am and 3:00 pm when the residents of the property **102** are away from the home. In these examples, the control unit **112** increases the motion threshold to ensure only motion caused by a person entering the pool triggers an alarm or a notification to be generated. The control unit **112** may decrease the motion threshold during the weekday evening hours and the weekend when the residents of the property **102** are more likely to be at the property. In these examples, the control unit **112** decreases the motion threshold to ensure the any motion detected generates a notification to the resident. The control unit **112** may adjust the motion threshold based on the armed status of the property **102**. For example, when the monitoring system at the monitored property **102** is armed away, the system assumes that the residents of the property are away and the control unit increases the motion threshold. For another example, when the monitoring system is armed stay, the system assumes that the residents of the property are at the property and the control unit decreases the motion threshold.

In some implementations, when the motion detected by the one or more motion detection sensors exceeds the motion threshold, the control unit **112** generates a notification. The user **116** may set one or more rules for the types of notifications generated by the control unit **112**. The user **116** may log into a monitoring system application that runs on the user device **118** and that is managed by the control unit **112**. For example, the user may set preferences to receive a notification on the user device **118** when the pool device **104** detects motion. The user may configure their preferences to receive one or more different notifications based on one or more different thresholds. For example, the user may set their preferences to receive a notification when a first motion threshold is exceeded, and the user may set their preferences to generate an alarm when a second motion threshold is exceeded. In another example, the user **116** may set preferences to generate an alarm at the monitored property **102** when the pool device **104** detects motion.

In another example, the user **116** may set preferences to activate one or more lights in the vicinity of the pool **103** when the pool device detects motion during a specific time of the day. For example, the user may set their preferences to activate one or more lights in the vicinity of the pool **103** when the pool device **104** detects motion after 6:00 PM. In some implementations, the monitoring server **114** manages the monitoring system application. In some examples, when the electronic pool device **104** detects movement after a specific time, the control unit **112** prompts a speaker on the surface portion of the device to generate an audible alert. For example, when the device **104** detects motion after 6:00 PM, the control unit **112** generates an audible alert.

The electronic pool device **104** may also include a pH monitor, and one or more thermometers that monitor the pool conditions. The pH monitor may be located on an under surface of the surface portion of the device **104**, and is configured to measure the pH of the pool water. In some examples, the pH monitor may be located on the camera portion of the electronic device **104**. The user **116** may set one or more preferences for receiving notifications from the control unit **112** based on the measured pH readings. For example, the user **116** may set a preference to receive a notification when the pH exceeds a threshold value. The camera portion of the electronic device **104** includes a thermometer that measures the temperature of the pool water, and the surface portion of the device **104** includes a thermometer that measures the air temperature. The user **116** may set one or more preferences for receiving notifications from the control unit **112** based on the measured temperatures.

The electronic pool device **104** may monitor one or more other pool conditions. For example, the camera of the device **104** may detect debris at the bottom of the pool, and based on detecting the debris at the bottom of the pool, the control unit **112** communicates a notification to the user **116** indicating that maintenance is required. For another example, the camera of the device **104** may detect that the pool water is cloudy, and based on detecting the pool water is cloudy, the control unit **112** communicates a notification to the user **116** indicating that maintenance is required. In some implementations, the control unit **112** may periodically initiate communication with the electronic pool device **104**. In the event that the electronic pool device **104** fails to respond to the communication initiated by the control unit **112**, the control unit **112** may generate an alert to the user notifying the user that the electronic pool device **104** is offline. In some implementations, when the electronic pool device **104** fails to respond to the communication initiated by the

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control unit **112**, the control unit **112** may initiate additional monitoring of the pool area. For example, the one or more cameras that have the pool **103** within their field of view may be powered on, and the captured video data is communicated to and analyzed by the control unit **112**.

In other implementations, the electronic pool device **104** remains in the swimming pool **103** at all times. In these implementations, the camera portion of the electronic pool device **104** may include a sonar detector. The sonar detector is configured to detect objects under the surface of the water of the swimming pool **103**. During a configuration stage, the sonar detector characterizes the underwater portion of the empty swimming pool **103**. The sonar detector emits sound pulses and detects the sound pulses that are reflected off the surfaces of the swimming pool **103**, and back to the sonar detector. The sonar detector generates a signature reflection pattern of the swimming pool **103** based on the data collected during configuration. The sonar detector is configured to detect when there is a change in the reflection pattern of the underwater profile of the pool **103**, based on the reflection data received at the detector. When the sonar detector receives a reflection pattern that is different than the signature reflection pattern collected during configuration, the sonar detector determines an object entered the swimming pool **103**.

The electronic pool device **104** communicates the sonar data to the control unit **112**. The control unit **112** may implement one or more algorithms to determine whether the data detected by the sonar detector was caused by an object and not by other factors such as, weather or a vibration from the pool pump. During configuration, the system may be trained to rule out noise patterns that may cause the sonar detector to detect movement. When the control unit **112** determines the sonar data indicates the motion was caused by an object in the swimming pool **103**, the control unit **112** generates a notification. The notification may be communicated to the user device **118** of the user **116** as an in-app notification.

In some implementations, the notification may include video data collected by the camera of the electronic pool device **104**. When the sonar detector detects an object has entered the swimming pool **103**, the camera may automatically begin to capture video data. The camera portion of the electronic device **104** may be positioned with a 180° field of view. The camera may be positioned so that each side surface of the swimming pool **103** is within the field of view of the camera. In some implementations, the swimming pool **103** may include one or more underwater cameras that are in communication with each other and in communication with the electronic pool device **104**. The electronic pool device **104** may communicate the captured video data to the user device **118** of the user **116**. The user **116** may review the captured data to determine whether the motion was caused by a person or pet in the pool **103**, or whether the motion was caused by an object.

The user may indicate, through the monitoring system application, whether the motion was caused by a person or was caused by an object. For example, the user may review the video data and select a response indicating that the motion was caused by an object. The control unit **112** does not generate an alarm based on receiving data from the user **116** indicating the motion was caused by an object. The control unit may update the one or more motion thresholds based on the data received from the user indicating the motion was caused by an object.

When the user reviews the video data and selects a response indicating that the motion was by a person, the

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control unit **112** may generate an audible alarm at the monitoring property **102**. The control unit **112** may communicate with an external server to dispatch authorities to the property **102** based on determining the user device **118** of the user is outside of a threshold distance from the property **102**. For example, the control unit **112** may communicate directly with authority dispatch server. In other examples the control unit **112** communicates with the monitoring server **114** which in turn communicates with the authority dispatch server.

In some implementations, the surface portion of the electronic pool device **104** may include a switch that allows the user **116** to switch on the camera of the device **104**. In these implementations, the user **116** may switch on the camera of the device **104** when the pool **103** is being utilized. When the pool **103** is being utilized the video data collected by the camera may be communicated to the control unit **112**. The control unit **112** may be trained to identify data indicative of a swimmer in distress. During configuration of the electronic pool device **104**, the control unit **112** may receive labeled data sets that teach the camera to identify a distressed swimmer. The user **116** may provide true or false responses based on reviewing video data of different actions in the captured video data. The user **116** may review the video data and the determinations made by the control unit **112** to respond whether each of the determinations was true or false. For example, the system may determine a person is swimming in the pool **103**, and the user may confirm whether the person was swimming or was in distress.

In some implementations, when the in-home monitoring system is armed away, the control unit **112** assumes that the occupants of the monitored property **102** are away. The control unit **112** may confirm whether the property **102** is unoccupied by using one or more electronic devices and sensors located throughout the property **102**. For example, the control unit **112** may switch on one or more cameras to scan the one or more rooms of the property to ensure the property is unoccupied. The control unit **112** may contact the authorities in response to detecting motion in the swimming pool of the monitored property **102**. The control unit **112** may contact the authorities when the motion detected in the swimming pool exceeds a high motion threshold. The control unit may determine to contact the police department when the high motion threshold is exceeded when the homeowners are away from the property **102**. In some implementations, when the high motion threshold is exceeded and the homeowners are away from the property **102**, the control unit **112** may prompt the one or more cameras in the pool **103** vicinity to capture video data. The control unit **112** may use one or more video analytic techniques to determine whether the motion is caused by a human or an object. In some implementations, the control unit may be configured to perform facial recognition on the video data to identify the person detected in the swimming pool **103**. In these implementations, the control unit **112** may generate one or more different notifications based on the identity of the person.

In some implementations, the swimming pool may be located at a property that is not monitored by a monitoring system. In these implementations, the pool device may communicate with an external monitoring server via cellular communication. The pool device may monitor for motion and communicate detected motion to the monitoring server.

FIG. 2 illustrates an example of a system **200** configured to monitor a property. The system **200** includes a network **205**, a monitoring system control unit **210**, one or more user devices **240**, and a monitoring application server **260**. The

network **205** facilitates communications between the monitoring system control unit **210**, the one or more user devices **240**, and the monitoring application server **260**. The network **205** is configured to enable exchange of electronic communications between devices connected to the network **205**. For example, the network **205** may be configured to enable exchange of electronic communications between the monitoring system control unit **210**, the one or more user devices **240**, and the monitoring application server **260**. The network **205** may include, for example, one or more of the Internet, Wide Area Networks (WANs), Local Area Networks (LANs), analog or digital wired and wireless telephone networks (e.g., a public switched telephone network (PSTN), Integrated Services Digital Network (ISDN), a cellular network, and Digital Subscriber Line (DSL)), radio, television, cable, satellite, or any other delivery or tunneling mechanism for carrying data. Network **205** may include multiple networks or subnetworks, each of which may include, for example, a wired or wireless data pathway. The network **205** may include a circuit-switched network, a packet-switched data network, or any other network able to carry electronic communications (e.g., data or voice communications). For example, the network **205** may include networks based on the Internet protocol (IP), asynchronous transfer mode (ATM), the PSTN, packet-switched networks based on IP, X.25, or Frame Relay, or other comparable technologies and may support voice using, for example, VoIP, or other comparable protocols used for voice communications. The network **205** may include one or more networks that include wireless data channels and wireless voice channels. The network **205** may be a wireless network, a broadband network, or a combination of networks including a wireless network and a broadband network.

The monitoring system control unit **210** includes a controller **212** and a network module **214**. The controller **212** is configured to control a monitoring system (e.g., a home alarm or security system) that includes the monitor control unit **210**. In some examples, the controller **212** may include a processor or other control circuitry configured to execute instructions of a program that controls operation of an alarm system. In these examples, the controller **212** may be configured to receive input from cameras, sensors, detectors, or other devices included in the alarm system and control operations of devices included in the alarm system or other household devices (e.g., a thermostat, an appliance, lights, etc.). For example, the controller **212** may be configured to control operation of the network module **214** included in the monitoring system control unit **210**.

The network module **214** is a communication device configured to exchange communications over the network **205**. The network module **214** may be a wireless communication module configured to exchange wireless communications over the network **205**. For example, the network module **214** may be a wireless communication device configured to exchange communications over a wireless data channel and a wireless voice channel. In this example, the network module **214** may transmit alarm data over a wireless data channel and establish a two-way voice communication session over a wireless voice channel. The wireless communication device may include one or more of a GSM module, a radio modem, cellular transmission module, or any type of module configured to exchange communications in one of the following formats: LTE, GSM or GPRS, CDMA, EDGE or EGPRS, EV-DO or EVDO, UMTS, or IP.

The network module **214** also may be a wired communication module configured to exchange communications over the network **205** using a wired connection. For

instance, the network module **214** may be a modem, a network interface card, or another type of network interface device. The network module **214** may be an Ethernet network card configured to enable the monitoring control unit **210** to communicate over a local area network and/or the Internet. The network module **214** also may be a voiceband modem configured to enable the alarm panel to communicate over the telephone lines of Plain Old Telephone Systems (POTS).

The monitoring system may include an electronic pool device **222** that is configured to monitor the swimming pool at monitored property. The electronic pool device **222** may be configured to communicate with the monitor control unit **210** through Bluetooth, Z-Wave, ZigBee, Wi-Fi, or other suitable form of wireless communication. The electronic pool device **222** may include a rechargeable battery that is powered by the energy generated by the water flowing through the plumbing system of the swimming pool. In some examples, the electronic device **222** may include a solar panel that is used to power the device.

The monitoring system may include multiple sensors **220**. The sensors **220** may include a contact sensor, a motion sensor, a glass break sensor, or any other type of sensor included in an alarm system or security system. The sensors **220** also may include an environmental sensor, such as a temperature sensor, a water sensor, a rain sensor, a wind sensor, a light sensor, a smoke detector, a carbon monoxide detector, an air quality sensor, etc. The sensors **220** further may include a health monitoring sensor, such as a prescription bottle sensor that monitors taking of prescriptions, a blood pressure sensor, a blood sugar sensor, a bed mat configured to sense presence of liquid (e.g., bodily fluids) on the bed mat, etc. In some examples, the sensors **220** may include a radio-frequency identification (RFID) sensor that identifies a particular article that includes a pre-assigned RFID tag.

The one or more cameras **230** may be a video/photographic camera or other type of optical sensing device configured to capture images. For instance, the one or more cameras **230** may be configured to capture images of an area within a building monitored by the monitor control unit **210**. The one or more cameras **230** may be configured to capture single, static images of the area and also video images of the area in which multiple images of the area are captured at a relatively high frequency (e.g., thirty images per second). The one or more cameras **230** may be controlled based on commands received from the monitor control unit **210**. The one or more outdoor cameras may be video/photographic cameras that are mounted outside of the monitored property. The one or more outdoor cameras may be arranged to ensure that the entire pool and the area surrounding the swimming pool is within the field of view of at least one of the outdoor cameras. Each of the one or more outdoor cameras may be time synchronized and spatially calibrated with respect to each other.

The sensors **220**, the pool device **222**, and the cameras **230** communicate with the controller **212** over communication links **224**, **226**, and **228**. The communication links **224**, **226**, and **228** may be a wired or wireless data pathway configured to transmit signals from the sensors **220**, the pool device **222**, and the cameras **230** to the controller **212**. The communication link **224**, **226**, and **228** may include a local network, such as, 802.11 “Wi-Fi” wireless Ethernet (e.g., using low-power Wi-Fi chipsets), Z-Wave, Power Over Ethernet (POE), Zigbee, Bluetooth, “HomePlug” or other

Powerline networks that operate over AC wiring, and a Category 5 (CAT5) or Category 6 (CAT6) wired Ethernet network.

The monitoring application server **260** is an electronic device configured to provide monitoring services by exchanging electronic communications with the monitor control unit **210**, and the one or more user devices **240**, over the network **205**. For example, the monitoring application server **260** may be configured to monitor events (e.g., alarm events) generated by the monitor control unit **210**. In this example, the monitoring application server **260** may exchange electronic communications with the network module **214** included in the monitoring system control unit **210** to receive information regarding events (e.g., alarm events) detected by the monitoring system control unit **210**. The monitoring application server **260** also may receive information regarding events (e.g., alarm events) from the one or more user devices **240**.

The one or more user devices **240** are devices that host and display user interfaces. The user device **240** may be a cellular phone or a non-cellular locally networked device with a display. The user device **240** may include a cell phone, a smart phone, a tablet PC, a personal digital assistant ("PDA"), or any other portable device configured to communicate over a network and display information. For example, implementations may also include Blackberry-type devices (e.g., as provided by Research in Motion), electronic organizers, iPhone-type devices (e.g., as provided by Apple), iPod devices (e.g., as provided by Apple) or other portable music players, other communication devices, and handheld or portable electronic devices for gaming, communications, and/or data organization. The user device **240** may perform functions unrelated to the monitoring system, such as placing personal telephone calls, playing music, playing video, displaying pictures, browsing the Internet, maintaining an electronic calendar, etc.

The user device **240** includes a monitoring system application **242**. The monitoring system application **242** refers to a software/firmware program running on the corresponding mobile device that enables the user interface and features described throughout. The user device **240** may load or install the monitoring system application **242** based on data received over a network or data received from local media. The monitoring system application **242** runs on mobile devices platforms, such as iPhone, iPod touch, Blackberry, Google Android, Windows Mobile, etc. The monitoring system application **242** enables the user device **140** to receive and process image and sensor data from the monitoring system.

In some implementations, the one or more user devices **240** communicate with and receive monitoring system data from the monitor control unit **210** using the communication link **238**. For instance, the one or more user devices **240** may communicate with the monitor control unit **210** using various local wireless protocols such as Wi-Fi, Bolt, Lora, Bluetooth, Z-Wave, ZigBee, "HomePlug," or other Powerline networks that operate over AC wiring, or Power over Ethernet (POE), or wired protocols such as Ethernet and USB, to connect the one or more user devices **240** to local security and automation equipment. The one or more user devices **240** may connect locally to the monitoring system and its sensors and other devices. The local connection may improve the speed of status and control communications because communicating through the network **205** with a remote server (e.g., the monitoring application server **260**) may be significantly slower.

Although the one or more user devices **240** are shown as communicating with the monitor control unit **210**, the one or more user devices **240** may communicate directly with the sensors and other devices controlled by the monitor control unit **210**. In some implementations, the one or more user devices **240** replace the monitoring system control unit **210** and perform the functions of the monitoring system control unit **210** for local monitoring and long range/offsite communication.

FIG. 3 illustrates an example of an electronic pool device. For the implementation illustrated in FIG. 3, the electronic pool device may include a camera portion **302A** and a surface portion **302B**. The camera portion **302A** is configured to be placed under the surface of the water, and may be mounted to an inlet of a pool jet. The pool water that flows through the pool jet may be used to power the battery of the camera portion **302A** of the pool device **104**. When the battery of the camera portion **302A** of the pool device **104** is running low, the pool pump may increase the flow rate of the water through the one or more pool jets to increase the power supplied to the battery. In some implementations, the surface portion **302B** may include a solar panel that converts solar energy to power the battery. The surface portion **302B** of the electronic pool device is configured to float on the surface of the water of the pool **304**. In some implementations, when the pool is in use and a swimmer contacts the surface portion of the pool device **104**, the camera initiates the capture of video data.

The surface portion **302B** may be attached to the camera portion **302A** of the device by a flexible tether **308**. In some examples, the tether may be configured to disconnect from the camera portion of the pool device **104** when the tether is under physical stress. The user may receive a notification through the monitoring system application when the control unit receives data from the pool device indicating that the tether disconnected. The surface portion **302B** of the device may include an antenna **310** and one or more sensors. The antenna **310** is configured to allow the electronic pool device to communicate with the control unit **112** of the monitored property **102**. The surface portion **302B** may also include one or more sensors for detecting motion. The one or more motion detecting sensors may include an accelerometer, a gyroscope, a mercury switch, or any other appropriate motion detecting sensors. The surface portion **302B** may also include may include a pH sensor, a thermometer, and a microphone.

The microphone on the surface portion **302B** of the pool device **104** is a high-sensitivity microphone that is configured to detect an object that causes the pool water to thrash or splash sound when an object enters the pool. When the high-sensitivity microphone detects a splashing sound, the camera may switch on automatically to capture video data. In some implementations, the camera portion **302A** of the pool device **104** may include the high sensitivity microphone.

FIGS. 4A and 4B illustrate an example of a system for detecting motion in a swimming pool **103**. As illustrated in FIGS. 4A and 4B, the pool device **104** detects motion in the pool **103**, and communicates the motion data to the control unit **112**. In the implementations where the electronic pool device **104** is placed in the swimming pool **103** when the pool is not being utilized, the one or more motion sensors of the surface portion of the pool device **104** detects motion in the pool **103** and communicates the motion data to the control unit **112**. The control unit **112** compares the received motion data to a motion threshold, and based on the motion data exceeding the motion threshold, the control unit **112**



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communicates a notification to the user device of a resident of the monitored property. The control unit **112** simultaneously commands the camera of the pool device **104** to capture video data.

In the implementations where the electronic pool device **104** remains in the swimming pool **103** at all times, the camera portion of the pool device **104** includes a sonar detector. The sonar detector is configured to detect objects by detecting a change in the reflection pattern of the underwater profile of the swimming pool **103**. When the sonar detector receives a reflection pattern that is different than the signature reflection pattern collected during configuration, the sonar detector determines an object entered the swimming pool **103**. The pool device **104** communicates the sonar data to the control unit **112**, and simultaneously begins to capture video data.

The video data captured by the pool device **104** is communicated to the control unit **112**, and the control unit **112** analyzes the video data. The control unit **112** may be configured to use one or more techniques to analyze the video data. The control unit may analyze the data to determine whether the motion was caused by a person or by an object. In some implementations, the control unit may be configured to identify a swimmer in distress.

As illustrated in FIG. 4 A, the control unit **112** analyzes the video data and determines that the motion is caused by a user **402**. The control unit **112** may send a notification to a user device of a resident of the property, and the notification may include the video data captured by the control unit. The resident of the property may review the video data received. In some implementations, the control unit may be configured to perform facial recognition on the video data to identify the person detected in the swimming pool **103**. The user may select an option to have the control unit generate an alarm based on determining that the user **402** in the swimming pool **103** seems to be a trespasser. In some implementations, the control unit **112** may automatically generate an audible alarm at the monitored property based on determining that the user **402** is an unknown user and the monitoring system at the property being armed away.

As illustrated in FIG. 4B, the control unit **112** analyzes the video data and determines that the motion is caused by a tree branch **502**. The control unit **112** may send a notification to the user device of the resident of the property indicating that the motion was caused by an object. In these implementations, the control unit **112** does not generate an alarm.

FIG. 5 illustrates an example of a monitoring system **500** that includes one or more outdoor cameras **120** that are configured to monitor the activity around the swimming pool **103**. As shown in FIG. 5, the property **102** (e.g. a home) of a user **116** is monitored by an in-home monitoring system (e.g. in-home security system) that includes components that are fixed within the property **102**. The in-home monitoring system may include a monitor control unit **112**, one or more sensors **110**, one or more cameras **108**, one or more lights **106**, one or more outdoor cameras **120**, and a notification system **122**. In some examples, the in-home monitoring system may also include a pool device **104**, for example, as illustrated in FIG. 1.

The user **116** may integrate one or more outdoor cameras **120** to monitor the activity around the swimming pool **103**. The one or more outdoor cameras **120** utilize video analytics and other techniques to detect when a user is performing a prohibited action in the area surrounding the swimming pool **103**. For example, video analytics may be used to detect when children are present around the pool **103** unsupervised by an adult.

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The user **116**, a resident of the property **102** may set one or more rules associated with the activity in the area around the swimming pool **103**. The user **116** may log into a monitoring application that runs on the user device **118** to set the one or more rules and the applicable one or more zones around the swimming pool **103**. The user **116** may have the ability to customize and continuously update the one or more applicable rules. The user **116** may set time schedules for applying the one or more rules. The user **116** may also set the corresponding notification that is generated when a rule is violated by a user. For example, the user **116** may set up rules indicating that no children are allowed around the pool unless accompanied by an adult, and the user may set up a rule that indicates that there should not be any running near the swimming pool. The user **116** may set up one or more different rules for different zones around the swimming pool **103**. For example, the user **116** may set up a rule that indicates that diving is not allowed in a first zone at one end of the pool, but diving is allowed in a second zone at the other end of the pool. The user **116** may set up a rule that indicates that eating and drinking is only allowed in a third zone. The notification system **122** may be used to notify a resident or a lifeguard on duty at the swimming pool **103** when the system detects that a user set rule has been violated. For example, a speaker of the notification system may output a whistle sound when a user is detected to be running in the area around the swimming pool **103**.

As illustrated in FIG. 5, the one or more outdoor cameras **120** capture video data of the area surrounding the swimming pool **103**. The one or more outdoor cameras **120** may be configured to detect when a person moves into the area surrounding the swimming pool **103**, and may begin to capture video data when a person is detected. In some implementations, the one or more outdoor cameras **120** may be configured to continuously capture video data. The one or more outdoor cameras **120** may be time-synchronized and spatially calibrated with each other and the spatial dimensions of the swimming pool **103**. The one or more cameras **120** may track a user as the user moves around in the area surrounding the swimming pool **103**. The one or more cameras may use facial analysis and other techniques to track one or more different users as the one or more users move around in the area surrounding the swimming pool **103**. The one or more cameras **120** may use identifiers to tag the one or more users as the users navigate within the monitored area.

The one or more outdoor cameras **120** may communicate the captured video data to a control unit **112**. In some implementations, the monitor control unit **112** may include a processing module that is configured to process the video data received from the one or more outdoor cameras **120**. In other implementations, each of the one or more outdoor cameras **120** are configured to include a processing module that processes the captured video data. The monitor control unit **112** may use one or more video analytics techniques to detect the activity of the user **126**. For example, the monitor control unit **112** utilizes one or more deep learning techniques and or three-dimensional sensing technologies to determine the location of a user with respect to the swimming pool **103**, and to determine the activity of the user while in the monitored area.

The monitor control unit **112** may determine the speed of the user **126** detected in the area surrounding the pool **103**. For example, the monitor control unit **112** may use machine-learning learning techniques to analyze the gait of the user **126** to determine whether the user **126** is running. The monitor control unit **112** may determine the speed of the user

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126 when the user 126 is determined to be within a monitored area around the pool 103. In some implementations, the monitor control unit 112 determines the speed of each of a one or more users that enter the monitored area around the swimming pool 103, and does not determine the speed of a user until the user enters the monitored area. In some implementations, the monitoring control unit 112 may determine the speed of movement of users based on gauging how fast the user moves from a frame of one camera to a frame of a second camera. Based on the one or more cameras being spatially calibrated, the monitor control unit 112 may determine the user's speed. In some implementations, the monitor control unit 112 may compare the determined speed of the user 126 to a speed threshold to determine whether the user 126 was walking or running. When the user's speed exceeds the speed threshold, the monitor control unit determines that the user 126 is running in the area surrounding the swimming pool 103.

The monitor control unit 112 sends a command to the notification system 122 to generate a notification based on determining that the user 126 violated the no running rule. The notification system 122 may be an electronic notification board that is located outdoor near the swimming pool 103. The notification system 122 may be used to provide audible and visual notifications to a resident user 116 at the property 102. As illustrated in FIG. 5, a speaker of the notification system 122 outputs an automated whistle sound, that simulates a lifeguard's whistle, to notify the user 126 to stop running. The resident 116 may configure the notification system to generate one or more different notifications based on the rule that is violated. For example, the notification system may generate a voice command based on detecting a user eating in a prohibited area near the pool 103. In another example, the notification system may generate an audible alarm based on determining that a child is in the area of the pool 103 without an adult. The notifications generated by the notification system may be different based on the severity of the violation. In the example illustrated in FIG. 5, the monitor control unit 112 may simultaneously communicate an electronic notification to the user device 118 of the user 116. The notification may indicate that a user is running in the area surrounding the pool 103.

In some implementations, the swimming pool 103 may be a large swimming pool that is open for public use. For example, a community center swimming pool. In these implementations, the one or more cameras may not be integrated with an in-home security system. Instead, the one or more cameras that are configured to monitor the area surrounding the swimming pool 103, may be in communication with a cloud processor. The cloud processor may be in communication with the notification system which is located at an area near the swimming pool 103. In these implementations, the notification system may be located at an area near a lifeguard booth. The notification system may indicate to the lifeguard the one or more zones of the surrounding pool area where user activity violates a pool rule. The notification system may include a user interface that list the rules associated with the usage of the public pool. For example, the notification system may include an LCD screen that lists the one or more rules. The one or more rules may include no eating, no diving into the shallow end of the pool, and no unattended children near the edge of the pool, and any other user set rule.

As illustrated in FIG. 6, the one or more outdoor cameras 120 capture video data of the area surrounding the swimming pool 103. The one or more outdoor cameras 120 may be configured to detect when a person moves into the area

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surrounding the swimming pool 103, and may begin to capture video data when a person is detected. In some implementations, the one or more outdoor cameras 120 may be configured to continuously capture video data. The one or more outdoor cameras 120 communicate the video data to the monitor control unit 112. The monitor control unit 112 analyzes the video data to detect the activity of the one or more users in the area surrounding the swimming pool 103. The monitor control unit 112 may utilize one or more data processing techniques to determine the activity of the one or more users in the area surrounding the pool 103. The monitor control unit 112 may determine whether the user 124 is a child or an adult. For example, the user 116 may set a rule indicating that children should not be in the area surrounding the swimming pool 103 without being accompanied by an adult. Based on the user implementing this rule, the monitor control unit 112 may use one or more techniques to analyze the height and other physical characteristics of persons that enter the monitored area to determine whether the person is likely a child or an adult. In some implementations, the monitor control unit 112 may utilize a trained convolutional neural network (CNN) to classify users into an age class.

The resident user 116 may set a rule that no child should be unaccompanied by an adult when in a zone near the edge of the pool 103. Based on the user set rule, the monitor control unit 112 determines that each of the one or more users 128 and 130 detected near the edge of the pool 103 are children, and based on determining that each of the users around the pool 103 are children, communicates to the notification system to generate an alarm. The notification system may generate an audible alarm or a visual alarm to notify the residents of the property 102 that unaccompanied children are near the pool 103. The monitor control unit 112 simultaneously communicates an electronic notification to the user device 118 of an adult user 116 at the monitored property 102. In some implementations, the electronic notification may include one or more images of the children detected at the swimming pool 103. The user 116 may have the option to review the one or more images, and elect to end the alarm after reviewing the images. For example, the user 116 may end the alarm based on the children playing safely on the side of the pool 103.

FIG. 7 illustrates an example process 700 for generating a notification based on determining that a user violated a rule. The monitor control unit 112 receives video data (710). For example, the monitor control unit 112 receives video data from one or more cameras that monitor the swimming pool 103 and the surrounding area. The one or more cameras may be arranged so that the swimming pool 103 and the surrounding area are within the field of view of at least one of the camera. In some examples, the one or more cameras may be pan or tilt cameras that move to adjust their field of view. Each of the one or more cameras are time synchronized with each other and spatially calibrated against each other and the swimming pool 103. In some implementations, the one or more cameras that are configured to monitor the pool constantly capture video data and communicate the data to the monitor control unit 112. In other implementations, the one or more cameras initiate video data capture when a motion sensor detects motion.

The monitor control unit 112 determines the spatial location of the swimming pool (720). For example, the monitor control unit 112 analyzes the video data received from the one or more cameras to determine the spatial location of the swimming pool 103. The monitor control unit 112 may use one or more three-dimensional sensing technologies to iden-

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tify the location of the swimming pool. The monitor control unit 112 may use one or more three-dimensional sensing technologies to identify the areas surrounding the swimming pool 103.

In some implementations, the one or more outdoor cameras may communicate the spatial characteristics sensed by the cameras to the monitor control unit 112, or may communicate the spatial characteristics sensed by the cameras to the one or more underwater pool sensors to improve the performance of the pool sensors. For example, the outdoor cameras may determine that the pool is a given size and shape, and this size and shape data may be used to create a rough model or set of parameters that may predict how sonar from the underwater sensor should behave.

The one or more outdoor cameras and the one or more underwater pool sensors are synchronization and spatial calibrated with each other. The synchronization and spatial calibration between the outdoor cameras and the underwater devices may be used to continuously track people and objects as they enter and exit the pool water. This association can provide gapless coverage of each person, ensuring that, for example, a child is always accounted for. Additionally, data about the person or object that might be easily determined by the outdoor cameras can be transferred to the underwater device or vice versa. For example, if someone jumps into the pool, the disturbance in the water might make it difficult for an underwater device to immediately determine if it is a person or an object. However, the outdoor camera has already been tracking the person as they approached the pool, and has already identified them as a person (perhaps even a specific person), and may communicate this data, as well as the location and trajectory that they are expected to enter the water, to the underwater camera. This data can then remain associated with the person or object as it is tracked by the underwater device and used to increase accuracy of that tracking. For example, an adult swimmer might be expected to move in different ways than a child, or a pool toy would.

The monitor control unit 112 determines that a person is in an area surrounding the swimming pool (730). For example, the monitor control unit determines that a person is in a first zone around the pool. The monitor control unit 112 analyzes the received video data to determine whether the video data includes video of a person, and determines which of a one or more user defined zones, the person is located. The user 116 may log into the monitoring application during the initial configuration to identify the one or more zones of the enforcement area. For example, the user 116 may identify one end of the pool as zone one, the middle portion as zone two, and the other end as zone three. In some examples, the user 116 may identify the zones based on the distance from the pool's edge. For example, zone one includes the area within two feet from the pool, zone two includes the area within four three to six feet from the pool.

The monitor control unit 112 may use facial analysis to detect the identity of the detected person. In examples where the swimming pool 103 is located at a monitored residence, the user 116 may register the one or more residents of the property during the configuration of the system. For example, the user 116 may provide one or more images of resident A, resident B, and child resident C through the monitoring application. When at least one camera detects a person around the swimming pool 103, the monitoring control unit 112 utilizes one or more facial analysis algorithms to determine whether the person is one of residents. For example, based on facial analysis the monitor control unit 112 determines that the person is resident A. The system

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tracks the resident A as the resident moves throughout the area surrounding the swimming pool 103. The system is configured to track each of the one or more users that enter the area surrounding the pool 113. The monitor control unit 112 may associate each user that enters the area surrounding the swimming pool 113 with a unique identifier. When the monitor control unit 112 analyzes additional video data, and determines that a user detected in the additional video data matches a known user, the monitor control unit 112 may track the activity or movements of the known user throughout the monitored area.

In examples where the swimming pool 103 is open to the public, the one or more cameras communicate the video data to a processor, the processor may use facial analysis to track the one or more users as they move through the monitored area around the swimming pool 103. For example, the processor determines an identity of a person and appends an identifier to the person, based on the identifier, the processor can track the one or more persons that are in the area surrounding the pool 103.

The monitor control unit 112 determines that the person within the area surrounding the pool violates a rule (740). For example, the monitoring control unit 112 determines that a person in zone three is eating. The monitor control unit 112 may utilize one or more deep learning techniques to identify the actions of the one or more persons within the monitored area. The monitoring control unit 112 may use a trained convolutional neural network (CNN) to analyze the captured video data to determine the actions of the person in the captured video. The convolutional neural network may be trained to identify human actions such as, eating, drinking, running, and diving into the pool. In some examples, the convolutional neural network may be trained to classify a person into an age class, this classification may be used to determine whether the person is an adult or is a child. The convolutional neural network may be trained to identify objects such as food and drink, or to identify harmful objects such as a knife, scissors, or a weapon. A deep neural network (DNN) The convolutional neural network may be trained to identify when a user is about to dive into the swimming pool 103.

The monitor control unit 112 determines the action of the person and determines whether the action violates a rule based on comparing to the one or more user set rules. For example, the monitor control unit 112 determines that a person is drinking in a zone where drinking is prohibited. In examples where the person is identified as a child resident of the property, the monitor control unit 112 may determine that a rule is violated when the child is detected in the area surrounding the swimming pool 103, and the video data does not indicate the presence of another adult in the area surrounding the pool 103. In some examples, the user 116 may set a rule that prohibits running in a first zone closest to the pool 103, but allows running in a second zone. In such an example, when a person is determined to be running in the second zone, and moves into the first zone, the monitor control unit 112 determines that the person violated a rule.

The user may set a rule that users may not be engaged in boisterous play or roughhousing in the area surrounding the pool 103. The monitor control unit 112 may be configured to detect the behavior of the users in the monitored area based on heuristics of their motion. The user may set a rule that there can be no climbing in particular areas around the swimming pool 103. The monitor control unit 112 may be configured to use human tracking techniques to detect when a user is climbing in a zone that restricts users from climbing.

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In some implementations, the monitor control unit **112** may be configured to detect pets and other animals that enter the monitored area around the swimming pool **103**. For example, the resident user may set a rule that indicates that pets are not allowed within the monitored area around the pool. In some implementations the user may set a rule that items such as knives, or other dangerous items should not be brought into the monitored area. In these implementations, the user may set a list of prohibited items, and the monitor control unit **112** may be trained to identify the one or more prohibited items.

The notification system generates a notification (**750**). For example, the notification system **122** may generate an audible alarm when a child is detected close to the edge of the swimming pool **103**. The user **116** may specify the type of notification that is generated based on the user set rule that is violated. For example, the user **116** may specify that the notification system generate a whistle sound when a person is detected as running in the area surrounding the pool **103**. On the other hand, the user **116** may specify that the notification system generate a flashing light visual alarm and send a notification to the user device **118** of the user **116** when the system determines that a person is likely attempting to dive into a shallow end of the pool **103**. The user **116** may specify that the notifications are escalated when the person detected of violating a rule is a repeat offender, or does not cease their behavior.

In some examples, the notification system **122** may be used to remind each of a one or more tracked users to perform one or more actions. For example, the notification system may be used to send a notification to the user device of a user A, when the system determines that user A has not been detected as applying sunblock in the past hour. For another example, the notification system may be used to send a notification to the user device of a user B, when the system determines that user B consumed more than three beers and should not enter the swimming pool. In some examples, the notification system may generate a voice warning to indicate to the adult user that they have consumed their limit of beers. For another example, the notification system may be used to send a notification to a user when the system determines that the user has been at the pool for over three hours.

In some implementations, where the swimming pool is a public pool, the notification system **122** may serve as an aid to a lifeguard. In these implementations, the notification system may be an LCD user interface that identifies the zone where the violation occurred. The user interface may include the violation information overlaid on an actual or synthesized video feed of the pool area, or an abstract graphical representation of the pool as an overhead plan or other perspective. The display could be optimized for a handheld device, lifeguard tower mounted display, publicly visible monitor. Based on the information received from the notification system **122**, the lifeguard may turn his or her attention to the area where the violation occurred. In some implementations, the notification system may output voice commands that indicate the current weather conditions, such as temperature, to the one or more users at the swimming pool **103**. In some implementations, the system may automate pool or walkway lighting, blinking or changing colors to indicate the location and/or severity of the violation.

FIG. 8 illustrates an example process **800** for performing an action. The process **800** may be performed by a monitoring system at a property **102** with an electronic pool device **104** that is configured to monitor a swimming pool **103** at the property **102**. For example, the process **800** may

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be performed by the control unit **112** that is in communication with the electronic pool device **104** and one or more other sensors located throughout the monitored property **102**.

The process **800** includes receiving sensor data (**810**). For example, the control unit **112** may receive motion sensor data from a motion sensor on the camera portion of an electronic pool device **104**. The electronic pool device **104** is configured to monitor the conditions of the swimming pool at the property **102**.

In some implementations, the camera portion of the electronic pool device is waterproof and is located under a surface of water in the swimming pool **1003** and the surface portion of the electronic pool device **104** is located above the surface of water in the swimming pool **103**, and is configured to include an antenna and a microphone, where the one or more sensors included in the surface portion of the electronic pool device **104** include one or more motion detecting sensors. For example, the electronic pool device **104** includes a camera portion that is configured to be placed under the surface of the water, and a surface portion that includes one or more motion detecting sensors.

The one or more motion detecting sensors may include an accelerometer, a gyroscope, a mercury switch, or any other appropriate motion detecting sensors. The one or more motion sensors are configured to detect motion caused when an object enters the swimming pool, that is, the motion caused when an object breaks the surface of the water in the swimming pool **103**.

In some implementations, the camera portion of the electronic pool device **104** includes a pH monitor that is configured to measure the pH of the water in the swimming pool **103**. In these implementations, the control unit **112** may receive pH sensor data from the pH monitor of the electronic pool device **104**. The camera portion of the electronic pool device **104** may include a thermometer that is configured to measure the temperature of the swimming pool water. In these implementations, a resident of the property **102** may set one or more preferences for receiving notifications from the control unit **112** based on the measured pH readings and the measured water temperature.

The process **800** includes comparing the sensor data to a threshold (**820**). For example, the control unit **112** compares the motion sensor data to a motion sensor threshold. In some implementations, the process includes receiving, from the electronic pool device **104**, the sensor data by receiving, from a motion sensor in the surface portion of the electronic pool device **104**, motion sensor data, receiving, from an external server, weather data, and based on receiving the weather data, determining a motion threshold. For example, the motion threshold may be a motion threshold that is determined by the control unit **112** based on the local weather conditions at the monitored property **102**.

In some implementations, the control unit **112** at the monitored property **102** may receive weather data from a weather data server **124**. The weather data server **124** may be in direct communication with the control unit **112**, or the weather data server **124** may communicate with a monitoring server **114** which in turn communicates with the control unit **112**. The control unit **112** may adjust the motion threshold based on the weather data indicating windy or rainy conditions.

In some implementations, the control unit **112** may adjust the motion threshold based on the armed status of the monitoring system at the property **102**. For example, when the monitoring system at the monitored property **102** is armed away, the system assumes that the residents of the

property 102 are away from the property 102, and the control unit 112 increases the motion threshold. For another example, when the monitoring system is armed stay, the system assumes that the residents of the property are at the property, and the control unit 112 decreases the motion

threshold. The process 800 involves determining that the sensor data exceeds the threshold based on comparing the sensor data to a threshold (830). For example, the control unit 112 determines that the motion sensor data exceeds the motion

threshold. For another example, the control unit 112 determines that the pH sensor data exceeds the pH threshold. The process 800 involves providing an instruction to initiate the capture of image data by the camera of the electronic pool device (840). For example, the control unit 112 prompts the camera of the electronic pool device 104 to capture image data. In some implementations, the electronic pool device 104 is placed in the swimming pool 103 when the pool is not being utilized. In these implementations, any motion that is detected by the one or more motion sensors in the surface portion of the electronic pool device 104 may be considered unexpected motion. When the control unit 112 detects unexpected motion that exceeds the motion threshold, the control unit 112 sends a command to the camera of the electronic pool device 104 to capture image data to

determine the cause of the unexpected motion. The process 800 involves receiving the image data from the camera of the electronic pool device (850). For example, the control unit 112 receives the captured image data via Bluetooth, Z-Wave, ZigBee, Wi-Fi, or other suitable form of wireless communication, from the electronic pool device.

The process 800 involves analyzing the image data received from the camera of the electronic pool device (860). For example, the control unit 112 utilizes one or more image analytic techniques to analyze the received images to determine whether the motion was caused by a person or an object. In some implementations, when the control unit 112 determines that the motion was caused by a person, the control unit 112 may perform facial recognition on the image data to identify the person detected in the swimming pool 103. The resident user may select an option to have the control unit 112 generate an alarm based on determining that the motion was caused by a person that is determined to be a trespasser.

The process 800 involves identifying a monitoring system action to perform based on analyzing the image data (870). For example, the control unit 112 determines to generate an audible alarm at the monitored property 102 based on determining that the motion in the swimming pool 103 was caused by a person when the swimming pool 103 should not be in use. In some implementations, when the electronic pool device 104 is placed in the swimming pool 103 when the pool 103 is not in use, the control unit 112 determines that any motion in the swimming pool 103 is unexpected motion. When the unexpected motion is detected in the swimming pool 103, the control unit 112 analyzes the received image data to determine whether the motion was caused by a person or an object. The control unit 112 may determine to generate an audible alarm at the monitored property 102 based on determining that the motion in the swimming pool 103 was caused by a person.

In some examples, the control unit 112 may determine to switch on one or more lights in the vicinity of the swimming pool 103 based on determining that the motion in the swimming pool 103 was caused by person. In other examples, the control unit 112 may determine to generate at audible alarm at the property 102 based on determining that

the motion in the swimming pool 103 was caused by a person. In yet another example, the control unit 112 may determine not to generate a notification based on determining that the motion in the swimming pool 103 was caused by an object. For example, when the control unit 112 analyzes the image data to determine that the motion in the swimming pool 103 was caused by a tree branch, the control unit 112 determines that a notification does not need to be communicated to the user device of the resident of the property 102.

The process 800 involves performing the monitoring system action (880). For example, the control unit 112 performs a monitoring system action by communicating a notification to a user device of a resident of the property 102 indicating that the motion in the swimming pool 103 was caused by a person.

In some implementations, the electronic pool device 104 includes a sonar detector. In these implementations, the camera portion of the electronic pool device 104 may include a sonar detector that is configured to detect objects under the surface of the water in the swimming pool 103. In these implementations, the electronic pool device 104 may be configured to remain in the swimming pool 103 at all times.

The sonar detector is configured to characterize the underwater portion of the empty swimming pool 103 during the configuration of the electronic pool device 104. The sonar detector is configured to emit sound pulses and to detect the sound pulses that are reflected off the side surfaces of the swimming pool 103, and back to the sonar detector. Based on this, the sonar detector generates a signature reflection pattern of the swimming pool 103.

The sonar detector is configured to detect when there is a change in the reflection pattern of the underwater profile of the pool 103, based on the reflection data received at the detector. When the sonar detector receives a reflection pattern that is different than the signature reflection pattern collected during configuration, the sonar detector determines an object entered the swimming pool 103. The electronic pool device 104 communicates the sonar data to the control unit 112. The control unit 112 may implement one or more algorithms to determine whether the data detected by the sonar detector was caused by an object and not by other factors such as, weather or a vibration from the pool pump.

The control unit 112 may be configured to receive image data from the camera of the electronic pool device 104 and from the one or more cameras located in the vicinity of the swimming pool 103. In some implementations, the control unit 112 may be configured to receive image data from one or more underwater cameras that are in communicating with each other and in communication with the electronic pool device 104. In these implementations, the control unit 112 may be configured to monitor the activity around the swimming pool 103. The monitor control unit 112 may utilize video analytics and other techniques to determine when a user is performing a prohibited action in the area surrounding the swimming pool 103. In these implementations, the resident user 116, may set one or more rules that are applicable to one or more user zones around the swimming pool 103 through a monitoring application on the user device.

As describes above with reference to FIG. 5, the user 116 may customize the rules and the notifications generated when a user violates the rules. For example, the resident user 116 may input a rule that the control unit sounds an audible alarm at the property 102 when a child enters the swimming pool 103 without being supervised by an adult. The control unit 112 may determine whether a person by the swimming

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pool **103** is a child or an adult by using one or more techniques to analyze the height and other physical characteristics of persons that enter the monitored area.

In some implementations, the monitor control unit **112** may utilize a trained convolutional neural network (CNN) to classify users into an age class. When the control unit **112** determines that a user in the vicinity of the pool **103** is a child, and subsequently determines that the user entered the swimming pool **103**, and is not supervised by an adult, the control unit sounds an audible alarm at the monitored property **102**. In some examples, the control unit **112** may communicate a notification to the user device of the resident of the property **102** indicating that an unsupervised child entered the swimming pool **103**. In some examples, the notification may include the captured image data. In these examples, the resident user may have the option to review the one or more images, and elect to end the alarm after reviewing the images. For example, the user **116** may end the alarm based on determining that the child is wearing a floatation device.

The one or more outdoor cameras **120** may be time-synchronized and spatially calibrated with each other and the spatial dimensions of the swimming pool **103**. The one or more cameras **120** may be configured to track a user as the user moves around in the area surrounding the swimming pool **103**. The one or more cameras may use facial analysis and other techniques to track one or more different users as the one or more users move around in the area surrounding the swimming pool **103**. The one or more cameras **120** may use identifiers to tag the one or more users as the users navigate within the monitored area. The monitor control unit **112** may use one or more video analytics techniques to detect the activity of the user **126**. For example, the monitor control unit **112** utilizes one or more deep learning techniques and or three-dimensional sensing technologies to determine the location of a user with respect to the swimming pool **103**, and to determine the activity of the user while in the monitored area.

In some implementations, the monitoring system includes one or more cameras located in a vicinity of the pool, where each of the one or more cameras are configured to capture image data of an area surrounding the pool. The monitor control unit **112** may be configured to receive, from a user, a condition and an action to perform based on the condition being met. For example, the user may be an administrative user at a public swimming pool, and the administrative user may identify one or more rules that indicate actions that are prohibited in the vicinity of the swimming pool.

The monitor control unit **112** may receive, from the one or more cameras located in the vicinity of the pool, additional image data, and may be configured to analyze the additional image data using one or more image analytic techniques. For example, the monitor control unit **112** may be configured to use one or more deep learning techniques to identify a person in the image data, and to determine an action of the person in the identified image data. For another example, the monitor control unit **112** may be configured to use a trained convolutional neural network (CNN) to analyze the additional image data.

The monitor control unit **112** may be configured to determine that a condition has been met based on analyzing the additional image data using the one or more image analytic techniques. The monitor control unit **112** may be configured to perform the action based on determining that a condition has been met. For example, the monitor control unit **112** may be configured to generate an audible output to notify a person that alcoholic beverages are not allowed in

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the vicinity of the pool. For another example, the monitor control unit **112** may be configured to generate a whistle sound that mimics the whistle sound of a lifeguard based on determining that a person is running in the vicinity of pool. For another example, the monitor control unit **112** may be configured to generate an audible alarm based on determining that a pet is in the vicinity of the pool.

The described systems, methods, and techniques may be implemented in digital electronic circuitry, computer hardware, firmware, software, or in combinations of these elements. Apparatus implementing these techniques may include appropriate input and output devices, a computer processor, and a computer program product tangibly embodied in a machine-readable storage device for execution by a programmable processor. A process implementing these techniques may be performed by a programmable processor executing a program of instructions to perform desired functions by operating on input data and generating appropriate output. The techniques may be implemented in one or more computer programs that are executable on a programmable system including at least one programmable processor coupled to receive data and instructions from, and to transmit data and instructions to, a data storage system, at least one input device, and at least one output device. Each computer program may be implemented in a high-level procedural or object-oriented programming language, or in assembly or machine language if desired; and in any case, the language may be a compiled or interpreted language. Suitable processors include, by way of example, both general and special purpose microprocessors. Generally, a processor will receive instructions and data from a read-only memory and/or a random access memory. Storage devices suitable for tangibly embodying computer program instructions and data include all forms of non-volatile memory, including by way of example semiconductor memory devices, such as Erasable Programmable Read-Only Memory (EPROM), Electrically Erasable Programmable Read-Only Memory (EEPROM), and flash memory devices; magnetic disks such as internal hard disks and removable disks; magneto-optical disks; and Compact Disc Read-Only Memory (CD-ROM). Any of the foregoing may be supplemented by, or incorporated in, specially-designed ASICs (application-specific integrated circuits).

It will be understood that various modifications may be made. For example, other useful implementations could be achieved if steps of the disclosed techniques were performed in a different order and/or if components in the disclosed systems were combined in a different manner and/or replaced or supplemented by other components. Accordingly, other implementations are within the scope of the disclosure.

The invention claimed is:

1. A monitoring system comprising one or more computers and one or more storage devices on which are stored instructions that are operable, when executed by the one or more computers, to cause the one or more computers to perform operations comprising:

- receiving, from a sonar detector that monitors a swimming pool located at a property, sonar data;
- using a result of analyzing the sonar data, determining that an object entered the swimming pool; and
- in response to and after determining that the object entered the swimming pool using the result of the analysis of the sonar data, performing a monitoring system action that includes initiating the capture of image data by a camera of one or more cameras located in a vicinity of the swimming pool.

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2. The system of claim 1, wherein the sonar detector is configured to:
  - transmit sound pulses and detect the sound pulses reflected off surfaces of the swimming pool.
3. The system of claim 1, the operations comprising:
  - maintaining, prior to receiving the sonar data, a configuration reflection signature of baseline sonar data that represents an underwater portion of the swimming pool when no person is in the swimming pool and that was generated using reflected sonar sound pulses transmitted during a sonar configuration process when no person is in the swimming pool;
  - wherein analyzing the sonar data and determining that the object entered the swimming pool comprises:
    - computing a difference between the sonar data and the configuration reflection signature; and
    - determining, using the difference between the sonar data and the configuration reflection signature, that the object entered the swimming pool.
4. The system of claim 1, wherein:
  - analyzing the sonar data comprises:
    - comparing a previously generated configuration reflection signature of the swimming pool when no person is in the swimming pool with a newly generated reflection signature generated using the sonar data, and
    - determining that the object entered the swimming pool uses the comparison of the previously generated configuration reflection signature with the newly generated reflection signature.
5. The system of claim 4, wherein:
  - determining that the object entered the swimming pool using the comparison comprises:
    - determining, using a result of the comparison of the previously generated configuration reflection signature with the newly generated reflection signature based on the sonar data, a difference between the previously generated configuration reflection signature and the newly generated reflection signature; and
    - determining, using the difference, that the object entered the swimming pool; and
    - performing the monitoring system action is responsive to determining that the object entered the swimming pool using the difference between the previously generated configuration reflection signature and the newly generated reflection signature.
6. The system of claim 4, wherein the previously generated configuration reflection signature includes an indication of a weather condition during a configuration process a) used to generate the previously generated configuration reflection signature and b) that occurred when no person is in the swimming pool.
7. The system of claim 4, wherein the previously generated configuration reflection signature includes an indication of an element of the swimming pool operating during configuration.
8. The system of claim 7, wherein the element of the swimming pool operating during the configuration is a pump system.
9. The system of claim 1, wherein performing the monitoring system action includes:
  - generating a notification indicating the object entered the swimming pool; and
  - transmitting the notification to a user device.
10. The system of claim 1, wherein the operations comprise:

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- receiving, from the camera of the one or more cameras located in the vicinity of the swimming pool, the image data.
11. The system of claim 10, wherein the camera is positioned with a field of view that includes each side surface of the swimming pool.
  12. The system of claim 10, wherein the camera is located under a water line of the swimming pool.
  13. The system of claim 10, wherein the operations comprise:
    - transmitting the image data to a user device.
  14. The system of claim 13, wherein the operations comprise:
    - receiving response data from the user device after transmitting the image data to the user device.
  15. The system of claim 1, wherein the monitoring system action includes sounding an audible alarm at the property.
  16. The system of claim 1, wherein the operations comprise:
    - determining whether a user of the property is outside of a threshold distance from the property; and
    - in response to determining that user of the property is outside of the threshold distance, performing the monitoring system action, at least in part, by transmitting data to an external server to request dispatch of authorities to the property.
  17. A method comprising:
    - receiving, from a sonar detector at a property, sonar data of an area at the property;
    - using a result of analyzing the sonar data, determining whether an event occurred in the area; and
    - in response to and after determining that the event occurred in the area using the result of the analysis of the sonar data, performing a monitoring system action that includes initiating the capture of image data by a camera of one or more cameras that captures images of the area at the property.
  18. The method of claim 17, the method comprising:
    - maintaining, prior to receiving the sonar data, a configuration reflection signature of baseline sonar data that represents a portion of the area at the property when no person is in the area and that was generated using reflected sonar sound pulses transmitted during a sonar configuration process when no person is in the area, wherein analyzing the sonar data and determining whether the event occurred in the area comprises:
      - computing a difference between the sonar data and the configuration reflection signature of the baseline sonar data; and
      - determining, using the difference between the sonar data and the configuration reflection signature of the baseline sonar data, whether the event occurred in the area.
  19. The method of claim 17, wherein analyzing the sonar data comprises:
    - comparing a previously generated configuration reflection signature with a newly generated reflection signature generated using the sonar data.
  20. One or more non-transitory computer storage media encoded with instructions that, when executed by one or more computers, cause the one or more computers to perform operations comprising:
    - maintaining a configuration reflection signature of baseline sonar data that represents an underwater portion of a swimming pool when no person is in the swimming pool and that was generated using reflected sonar sound

pulses transmitted during a sonar configuration process  
when no person is in the swimming pool;  
receiving, from a sonar detector that monitors the swim-  
ming pool located at a property, sonar data;  
computing a difference between the sonar data and the 5  
configuration reflection signature;  
determining, using the difference between the sonar data  
and the configuration reflection signature, that an object  
entered the swimming pool; and  
in response to and after determining that the object 10  
entered the swimming pool using the difference  
between the sonar data and the configuration reflection  
signature, performing a monitoring system action that  
includes initiating the capture of image data by a  
camera of one or more cameras located in a vicinity of 15  
the swimming pool.

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