(54) Title: SYSTEM AND METHOD FOR NOTIFYING DETECTION OF VAPING, SMOKING, OR POTENTIAL BULLYING

(57) Abstract: Systems and methods notify detection of vaping, smoking, or potential bullying. A notification system for notifying detection of vaping, smoking, and potential bullying includes: an air quality sensor configured to detect air quality; a sound detector configured to detect sounds; a processor configured to identify an abnormality matching signature of vaping, smoking, or potential bullying based on at least one of the detected air quality or the detected sounds; an alert device configured to provide at least one of an audio alert or a visual alert based on the identified abnormality matching signature; and a pair of communication interfaces configured to communicatively couple the processor and the alert device.
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SYSTEM AND METHOD FOR NOTIFYING DETECTION OF VAPING, SMOKING, OR POTENTIAL BULLYING

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims the benefit of and priority to U.S. Provisional Application No. 62/986,970, filed on March 9, 2020. The present application is related to International Application No. PCT/US19/18532, filed on February 19, 2019, which claims the benefit of, and priority to, U.S. Provisional Patent Application No. 62/803,837, filed on February 11, 2019. The entire contents of the foregoing applications are hereby incorporated by reference.

BACKGROUND

Technical Field

[0002] The present disclosure relates to a notification system and method for notifying detection of vaping, smoking, or potential bullying at an enclosed site. More particularly, the present disclosure relates to a notification system including a plurality of sensors for detecting vaping, smoking, or potential bullying and a message server for notifying the detection of such.

Background of Related Art

[0003] Vaping, smoking, and bullying have been serious problems in enclosed areas of academic/business environments due to hazardous/harmful impacts on other people. Various methods and systems have been developed to identify or prevent bullying, smoking, and vaping in enclosed areas, such as classrooms, restrooms, bathrooms, storage rooms, hospital rooms, or other kinds of enclosed areas in schools, hospitals, warehouses, cafeterias, offices, financial institutes, government buildings, or any business facilities. For example, bullying, smoking, and vaping can be identified by camera surveillance. However, such camera surveillance systems
have not been used in private areas such as restrooms, bathrooms, shower rooms, or hospital rooms because privacy has higher priority than identification of bullying, smoking, and vaping.

[0004] Vaping, smoking, or bullying have become more prevalent in younger aged people and cause many health, mental, and environmental issues. Generally, vaping and smoking have similar effects on people around or in close proximity of the vapers or smokers. Thus, by identifying vaping or smoking activities in enclosed areas, people can be supervised appropriately so that harmful and hazardous effects can be prevented.

[0005] Further, when bullying, smoking, or vaping is detected, notification systems are needed which do not alert the people related to the bullying, smoking, or vaping of the notification. Thus, there is interest in improving and developing efficient notification of potential bullying, smoking, or vaping.

**SUMMARY**

[0006] The present disclosure provides systems and methods for notifying of detected vaping, smoking, or potential bullying.

[0007] In aspects of the present disclosure, a notification system for notifying detection of vaping, smoking, and potential bullying includes an air quality sensor configured to detect air quality, a sound detector configured to detect sounds, a processor configured to identify an abnormality matching signature of vaping, smoking, or potential bullying based on at least one of the detected air quality or the detected sounds, an alert device configured to provide at least one of an audio alert or a visual alert based on the identified abnormality matching signature, and a pair of communication interfaces configured to communicatively couple the processor and the alert device.
[0008] In various embodiments of the system, the pair of communication interfaces is a pair of wireless communication interfaces. In various embodiments of the system, the pair of wireless communication interfaces includes a pair of Bluetooth transceivers and/or a pair of Zigbee transceivers.

[0009] In various embodiments of the system, the air quality sensor, the sound sensor, and the processor are co-located in a detector device, and the detector device is separate from the alert device.

[0010] In various embodiments of the system, the alert device is in a vicinity of the detector device, and the alert device is configured to provide the visual alert and not provide an audio alert.

[0011] In various embodiments of the system, the alert device is remote from the detector device, and the alert device is configured to provide the visual alert indicating a location of the detector device. In various embodiments of the system, the alert device includes a display screen, and the visual alert displays a name of the location of the detector device on the display screen and displays time duration since the identified abnormality matching signature.

[0012] In various embodiments of the system, the pair of communication interfaces is a pair of network interfaces, and the communicative coupling of the detector device and the alert device includes network packets.

[0013] In various embodiments of the system, the pair of communication interfaces is a pair of wired communication interfaces configured to communicatively couple the detector device and the alert device by a cable.

[0014] In various embodiments of the system, the air quality sensor and the sound sensor are co-located in a detector device, the processor is located in a server, and the detector device,
the server, and the alert device are separate devices.

[0015] In various embodiments of the system, the server instructs the alert device to generate the visual alert.

[0016] In various embodiments of the system, the detector device is configured to communicate a time of the identified abnormality matching signature and an identifier to the server, the server is configured to match the identifier to a name of a location of the detector device, and the alert device is configured to generate the visual alert including the name of the location and a time duration since the identified abnormality matching signature.

[0017] In aspects of the present disclosure, a notification system for notifying detection of vaping, smoking, or potential bullying, includes a plurality of detector devices configured to detect vaping, smoking, or potential bullying, a server configured to track occurrences of detected vaping, smoking, or potential bullying, a network configured to communicatively couple the plurality of detector devices and the server, and an alert device communicatively coupled to the network and configured to monitor network traffic from the plurality of detector devices, where the alert device provides a visual alert when the network traffic includes an occurrence of detected vaping, smoking, or potential bullying.

[0018] In various embodiments of the system, the alert device is remote from the plurality of detector devices, and the alert device is configured to provide the visual alert indicating a location of the occurrence of detected vaping, smoking, or potential bullying.

[0019] In various embodiments of the system, the alert device includes a display screen, and the visual alert displays a name of the location of the occurrence of detected vaping, smoking, or potential bullying on the display screen.

[0020] In various embodiments of the system, the name of the location is included in the
network traffic.

[0021] In various embodiments of the system, the name of the location is stored in the server, and the alert device is configured to request the name of the location from the server.

[0022] In aspects of the present disclosure, a method for notifying detection of vaping, smoking, or potential bullying includes detecting vaping, smoking, or potential bullying by a plurality of detector devices, tracking by a server occurrences of detected vaping, smoking, or potential bullying, conveying by a network the network traffic between the plurality of detector devices and the server, monitoring the network traffic by an alert device, and providing a visual alert by the alert device when the network traffic includes an occurrence of detected vaping, smoking, or potential bullying.

[0023] In various embodiments of the method, the alert device is remote from the plurality of detector devices, and the visual alert indicates a location of the occurrence of detected vaping, smoking, or potential bullying.

[0024] In various embodiments of the method, the alert device includes a display screen, and the visual alert displays a name of the location of the occurrence of detected vaping, smoking, or potential bullying on the display screen.

[0025] Further details and aspects of exemplary embodiments of the present disclosure are described in more detail below with reference to the appended figures.

**BRIEF DESCRIPTION OF THE DRAWINGS**

[0026] A better understanding of the features and advantages of the disclosed technology will be obtained by reference to the following detailed description that sets forth illustrative
embodiments, in which the principles of the technology are utilized, and the accompanying drawings of which:

[0027] FIG. 1 is a block diagram of a notification system for notifying detection of vaping, smoking, or potential bullying in accordance with embodiments of the present disclosure;

[0028] FIG. 2 is a functional block diagram of the detection sensor of FIG. 1 in accordance with embodiments of the present disclosure;

[0029] FIG. 3A is a graphical illustration showing detected sound results from the detection sensor of FIG. 1 in accordance with embodiments of the present disclosure;

[0030] FIGS. 3B and 3C are graphical illustration showing history data from the detection sensor of FIG. 1 in accordance with embodiments of the present disclosure;

[0031] FIG. 4 is a flowchart showing a learning mode for the detection sensor in accordance with embodiments of the present disclosure;

[0032] FIG. 5 is a flowchart showing an active mode for the detection sensor in accordance with embodiments of the present disclosure;

[0033] FIG. 6 is a flowchart showing a method for detecting vaping in accordance with embodiments of the present disclosure;

[0034] FIG. 7 is a functional block diagram of a computing device in accordance with embodiments of the present disclosure;

[0035] FIG. 8 is a flowchart showing a method for notifying detection of vaping, smoking, or potential bullying in accordance with embodiments of the present disclosure;

[0036] FIG. 9 is a block diagram of an exemplary system for providing an alert, in accordance with embodiments of the present disclosure;
[0037] FIG. 10 is a diagram of an exemplary operation of the system of FIG. 9, in accordance with embodiments of the present disclosure;

[0038] FIG. 11 is a block diagram of another exemplary system for providing an alert, in accordance with embodiments of the present disclosure;

[0039] FIG. 12 is a diagram of an exemplary operation of the system of FIG. 11, in accordance with embodiments of the present disclosure, and

[0040] FIG. 13 is a flow diagram of an exemplary operation of providing an alert, in accordance with embodiments of the present disclosure.

DETAILED DESCRIPTION

[0041] The present disclosure relates to systems and methods for notifying detection of vaping, smoking, and/or potential bullying. When vaping, smoking, and/or potential bullying are identified, warnings or alerts are transmitted to registered users or clients without providing any indication of warnings to persons who vape, smoke, or bully at the site. In this way, the persons who bully, smoke, or vape can be properly reported and appropriately supervised later. Further, persons near the vaping or bullying can be effectively prevented from further harms.

[0042] FIG. 1 illustrates a block diagram showing a notification system 100 according to embodiments of the present disclosure. The notification system 100 includes a plurality of detection sensors 110, which detect air quality related to vaping and sound related to noise disturbance at enclosed sites. The notification system 100 further includes a control server 120 for identifying whether or not vaping or potential bullying occurs at the enclosed site, and a database 130 storing base data for identifying potential bullying and history data of detected sounds and air quality at each enclosed site.
The detected air quality may be analyzed by the detection sensors 110 or the detected air quality may be transmitted to the control server 120 together with the detected sound. The control server 120 may analyze the detected sound based on base data stored at the database 130 and the detected air quality, and determine whether potential bullying and/or vaping occurs at the enclosed sites. The base data stored at the database 130 may be location-dependent, meaning that the base data for one location is different from that for another site. The location-dependent base data may be sound data related to identifying potential bullying. For example, at a bathroom, there are flushing sounds, conversations, cleaning sounds, etc. Based on the size of the bathroom and the installation location of the detection sensor 110, the detection sensor 110 may detect sounds differently from other detection sensors 110 installed at the bathroom or at a bedroom near the bathroom. Thus, the location-dependent base data may be different based on the installation locations even at the same site.

For these reasons, the location-dependent base data is to be obtained at the site for a period in a learning mode. The period may vary depending on the installation location, the time, the day of the week, and the date. The location-dependent base data may be obtained for a period, which is determined based on the environment of the enclosed site and the installation location of the detection sensor 110.

After obtaining location-dependent base data for a period sufficiently long enough to form profile for the location, the detection sensor 110 may be turned into an active mode to identify noise disturbance.

In an aspect, when the detection sensor 110 transmits detected results to the control server 120, the control server 120 may acquire from the database 130 the profile for the location where the detection sensor 110 is installed and the time when the detected results is
obtained, and analyzes the detected results to identify occurrence of potential bullying based on the base data.

[0047] In an aspect, the detected sounds may be used to identify sleep apnea. Sleep apnea is a serious sleep disorder that occurs when a person’s breathing is interrupted while sleeping. People with untreated sleep apnea stop breathing repeatedly during their sleep. This means the brain and the rest of the body may not get enough oxygen. Sleep apnea can lead to more serious problems such as high blood pressure, stroke, heart failure, and diabetes.

[0048] Similar to bullying, base data for sleep apnea may be obtained during the learning mode prior to identifying sleep apnea. During the learning mode, the detection sensor 110 may record decibel levels of the sleeping sounds of a person over a temporal period, which may be more or less than one week. The base data may contain patterns of the person’s breathing at times when the lulls in breathing and loud spikes occur.

[0049] In another aspect, the detection sensor 110 may save the base data in a memory (which is not shown) of the detection sensor 110. In other words, the detection sensor 110 may determine vaping, potential bullying, or sleep apnea by itself at the site where the detection sensor 110 is installed. In this case, the detection sensor 110 transmits signals indicating abnormality matching signature of vaping, potential bully, or apnea. This ensures data privacy, meaning that the data stay within the detection sensor 110, and further ensures privacy of people at the site.

[0050] During the active mode, the detection sensor 110 may listen to the person’s sleeping sounds and the control server 120 may compare the current levels (e.g. decibels) of the sleeping with the expected level from the base data at the corresponding time. The comparing data may be displayed so that the user can see when sleep apnea occurs. The control server 120
may measure anomalies in sound over a predicted norm. The control server 120 may determine patterns of snoring, breathing, or any sound disruption during the sleep by analyzing the sound amplitude pattern that occurs. By analyzing the amplitude of the sound as well as irregular levels of sound in the sleep pattern, the control server 120 may identify sleep apnea.

[0051] In an aspect, the base data may be location-independent, meaning that the base data is the same for every enclosed location at every time. The location-independent base data may be air quality data related to identifying vaping. Since vaping has a signature in temperature, humidity, hydrogen, total volatile organic compound, particulate concentration, and particulate mass ranges, vaping may be identified based on the signature. In an aspect, features for identifying vaping may be integrated into the detection sensor 110 so that the detection sensor 110 may request an alert or warning message to be sent to the client 170, when the signature is identified in the detected air quality. The signature may include combination of predetermined ranges of temperature, humidity, hydrogen, total volatile organic compound, particulate concentration, and particulate mass.

[0052] Generally, hydrogen sensors require at least 7 volts and about 1,000-ohm resistance. The detection sensor 110, however, may have a modified hydrogen sensor, which requires much lower voltage and a much higher resistance. The voltage and resistance may vary based on temperature of the environment.

[0053] The database 130 may further include history data which is time-series and location-specific data for identifying potential bullying for each location where the detection sensor 110 has been installed. In an aspect, the control server 120 may analyze the history data to predict occurrences of vaping and bullying at the location so that appropriate actions may be proactively taken at the location.
In an aspect, the control server 120 may analyze the history data stored at the database 130 to identify trend of the history data. The trend may be a decrease or increase pattern of occurrences of vaping or bullying. In case a decrease or increase pattern is identified, the control server 120 may adjust the base data for identifying potential bullying to make the detection sensor 110 more or less sensitive to the identification. In this way, the base data may be adjusted based on the trend of the history data.

For example, FIGS. 3B and 3C show history data of detected sound level and detected air quality, respectively. The horizontal axes for both graphs of the history data represent time, the vertical axis of FIG. 3B represents decibel or voltage amplitude, and the vertical axis of FIG. 3C represents air quality index. The history data of the detected sounds obtained during the learning mode is used to generate base data for identifying potential bullying or sleep apnea at the installation location in the active mode. As the detected sound fluctuates, the threshold value for identification may vary according to the times. For example, the threshold value for detecting potential bullying at dawn may be lower than the threshold value for detecting potential bullying at noon. It may also vary based on the day of week and location. The threshold value on Wednesday may be higher than on Sunday at a school. On the other hand, the threshold value on Wednesday may be lower than on Sunday at a commercial establishment such as a department store.

In an aspect, the detection sensors 110 may repeat the learning mode and active mode consecutively. As shown in FIG. 3C, the first period (e.g., about ten seconds from the start to 09:31:38) may be used in the learning mode to collect data regarding the environment. Then, the detection sensor 110 determines whether an adjustment or calibration needs to be made to the modified hydrogen sensor so as to properly detect vaping. For example, the voltage or resistance
in the modified hydrogen sensor varies depending on temperature of the environment. Thus, the modified hydrogen sensor can be adjusted or calibrated based on the environment.

[0057] After the first period for collecting environment-calibrated data, the threshold value for vaping is determined in the active mode for a second period and the detection sensor 110 detects vaping based on the threshold value.

[0058] In another aspect, the detection sensors 110 may iterate the learning mode and the active mode after the first and second periods, meaning that the detection sensors 110 may calibrate the modified hydrogen sensor repeatedly so that the detection sensor 110 may accurately detect vaping.

[0059] FIG. 3C shows two curves. The upper curve represents threshold index value for identifying vaping. The lower curve represents the history data of detection results from the air quality sensor of the detection sensor 110. The upper curve is stabilized in a period of time after the power-up.

[0060] In an aspect, the detection sensors 110 may repeat the learning mode and active mode consecutively. As shown in FIG. 3C, the first period (e.g., about ten seconds from the start to 09:31:38) may be used in the learning mode to collect data regarding the environment. Then, the detection sensor 110 determines whether an adjustment or calibration needs to be made to the modified hydrogen sensor so as to properly detect vaping. For example, the voltage or resistance in the modified hydrogen sensor varies depending on temperature of the environment. Thus, the modified hydrogen sensor can be adjusted or calibrated based on the environment.

[0061] After the first period for collecting environment-calibrated data, the threshold value for vaping is determined in the active mode for a second period and the detection sensor 110 detects vaping based on the threshold value.
In another aspect, the detection sensors 110 may iterate the learning mode and the active mode after the first and second periods, meaning that the detection sensors 110 may calibrate the modified hydrogen sensor repeatedly so that the detection sensor 110 may accurately detect vaping based on the index value.

The index value is calculated based on the temperature, moisture, and the detection results of the modified hydrogen sensor. For example, the temperature falls in a range between 60 degrees and 80 degrees Fahrenheit, the moisture is increased by at least 10 percent, and the hydrogen increases from the base level (e.g., environment level) by approximately 10 percent, the detection sensor 110 may determine that vaping has occurred. This determination is provided as an example and is not provided to limit the scope of this application.

In an aspect, the control server 120 may send a command to the detection sensor 110 to adjust internal parameters for detecting potential bullying and vaping based on the trend identified from the history data. Further, the control server 120 may communicate with the detection sensors 110 by calling functions of application programming interface (“API”) between the detection sensor 110 and the control server 120. In this regard, the detection sensor 110 can push detection results to the control server 120 and respond to the control server 120’s request.

In an aspect, the control server 120 may not store detected results from the detection sensors 110 because of privacy issues. Nevertheless, the control server 120 may provide signals back to the detection sensors 110 to indicate tuning parameters and false positives.

Internal parameters of the detection sensor 110 may include LED functionality, sound threshold, networking server IP address, alert timeout, serial number, reboot for device
required or not, latest binary code, vape identification algorithm parameters. This list of parameters should not be understood as exhaustive but provided only for example purposes. The internal parameters of the detection sensor 110 may further include bullying identification algorithm parameters. Bullying or vaping identification algorithm parameters may include a window size or threshold values or ranges.

[0067] In an aspect, the control server 120 may update internal parameters via text or binary files. Internal parameters for each the detection sensor 110 may be saved in the database 130.

[0068] In another aspect, the control server 120 may control the detection sensors 110 collectively, individually, or group by group. For example, several detection sensors 110 may be installed at the same site. When they need to update internal parameters or settings, the control server 120 may control the detection sensors 110 collectively at the site. However, such control may not affect the detection sensor 110 installed in the other sites. The control server 120 may use a query language to request data from the database 130. The query language may be SQL, MySQL, SSP, C, C++, C#, PHP, SAP, Sybase, Java, JavaScript, or any language, which can be used to request data from a database.

[0069] In yet another aspect, even when several detection sensors 110 are installed at the same site, the control server 120 may control them differently because one detection sensor 110 may have different parameters for identifying potential bullying and vaping from those of another detection sensor 110 due to different installation locations at the site. For example, the detection sensor 110 installed at a bedroom has parameters different from those of the detection sensor 110 installed at a bathroom.

[0070] Client 170 may log in to the control server 120 to see graphical representations of
the detection results from the detection sensor 110 via Internet. Communication between the client 170 and the control server 120 may utilize http, https, ftp, SMTP, or related Internet protocols. The client 170 may be able to adjust settings for each detection sensor 110. For example, the settings may include a mode of warnings (e.g., an email, text message, telephone call, instant message, audible warning, etc.), an address, to which such warnings are to be sent in case of identification of potential bullying or vaping, and the like. The client 170 are the ones who are responsible for the sites where the detection sensors 110 are installed for identifying potential bullying and vaping. For example, the client 170 may be a principal, vice president, or person in charge at a school, a president at a company, a manager at a hospital or any commercial establishment, or security personnel. This list, however, is not meant to be exhaustive but is provided only for showing examples. Other peoples in different rankings, at different locations can be included in this list.

[0071] When the detection sensor 110 identifies potential bullying or vaping, the detection sensor 110 may send an alert to the client 170 via a client server 160 using protocols of Internet. The client server 160 may be used for sending a simple message or email to the client 170 supervising the site, where the potential bullying or vaping is detected. The client server 160 may manage the client 170 registered on the client server 160 and show alert history and other notification upon requests from the client 170. Further, the client server 160 may handle customizing or fine tuning the detection sensors 110, which lead to an alert when the detection sensors 110 need to reboot, update, or receive configuration. In an aspect, as dotted lines are shown in FIG. 1, the communication between the client server 160 and the client 170 may not be regularly performed but can be made only when potential bullying or vaping is identified. The client 170 may receive the alert on a computer, smart device, or mobile phone. In this way, the
client 170 are not inundated by overwhelming number of messages because they receive the alert only when potential bullying or vaping is identified. Further, the client 170 may be able to timely, properly supervise at the site whenever an alert is received.

[0072] When the client server 160 receives an alert from the detection sensor 110, the client server 160 may communicate with the message server 140, which manages pushing alerts to the notification subscribers 150. The client 170 may be the person in charge as the first contact person who has a direct access to the control server 120 for the site, and the notification subscribers 150 may be any related personnel as the second contact persons who do not have a direct access to the control server 120. Similar to the ways the client server 160 sends alerts to the client 170, the message server 140 sends alerts to the notification subscribers 150 via a text message, email, instant message, telephone call, audible warning, any communication means readily available to a person having skill in the art. The notification subscribers 150 may receive alerts via a computer, smart device, mobile phone, personal digital assistant, tablet, or any available means for receiving such alerts.

[0073] As described above, vaping can be identified when the signature is detected, meaning that vaping can be identified independent of locations and times. Thus, features related to identification of vaping may be integrated into the detection sensor 110. In this case, when vaping is identified, the detection sensor 110 may bypass the control server 120 and directly communicate with the message server 140 and the client server 160 to transmit alerts to ones in charge or responsible for the sites where the detection sensor 110 are installed. On the other hand, identification of potential bullying is different from site to site due to different environments. In other words, when sounds are detected by the detection sensor 110, the control server 120 receives and analyzes the detected sounds, and determines whether potential bullying has
occurred. As a result, vaping may be identified earlier than potential bullying, and alerts for vaping may be sent to the notification subscribers 150 and the client 170 faster than alerts for potential bullying.

[0074] In an aspect, features for identifying potential bullying may be also integrated into the detection sensor 110. This can be done by the control server 120 controlling the detection sensor 110 to update internal parameters for identifying potential bullying at the corresponding site. In this case, the control server 120 regularly checks the history data stored at the database 130 and regularly update the internal parameters of the detection sensor 110 for identifying potential bullying. After updating the internal parameters of the detection sensor 110, alerts for identifying potential bullying may be sent to the notification subscribers 150 and the client 170 in the same way as alerts for identifying vaping are sent.

[0075] The detection sensors 110 may be grouped into zones when the installation site is large or can be divided into several zones based on sound specifics or air quality specifics. For example, men’s bathrooms may be one zone separate from a zone for woman’s bathrooms. Further, if a bathroom is large, it can have several zones, one being close to toilets and another being close to faucets. Further, storage rooms may be a zone separate from one for classrooms. Furthermore, when the installation site is a medical/business/education/government building, the installation site may have several zones based on managerial responsibilities. For example, storage rooms may be assigned to one zone and offices may be assigned to another zone.

[0076] From the managerial point of view, managers and employees who are responsible for the installation site may be assigned to zones corresponding to their schedules. Thus, every zone or detection sensor is assigned to at least one responsible person at every hour seven days a week. For this purpose, a subscriber list including schedules of the responsible people should be
entered before the active mode is initiated. The subscriber list may include names, contact information, working hours, working days, and assigned zones of the detection sensors 110. The contact information may include at least mobile/work/home phone numbers, an email address, and SMS address. Thus, when potential bullying or vaping is detected, the control server 120 may check who is responsible for the zone where the detection is identified and the detection time, and transmit the contact information of the responsible person to the message server 140. Upon reception, the message server 140 then transmits an alert/warning to the responsible person.

[0077] In an aspect, the control server 120 may include a responsible hierarchy stored in the database 130 and transmit at least two persons responsible for the zone where the detection is identified and the detection time. The client 170 may be near or at the top of the hierarchy. Then, the message server 140 can send the alert/warning to at least two responsible persons so that prompt responsiveness and certainty, that vaping, smoking, or potential bullying is appropriately taken care of in due course, are increased.

[0078] In another aspect, when the database 130 further includes schedules of the responsible persons, the message server 140 may repeatedly resend the alert/warning to the responsible personnel at every predetermined period for a period sufficiently long enough to take care of the detection.

[0079] In still another aspect, the message server 140 may be capable of receiving emails or text messages. After sending the alert/warning to at least one responsible person, the message server 140 may resend the alert/warning every time after a predetermined period has passed without receiving a response text message, email, or any communication from the responsible person. After receiving the response, the message server 140 may stop resending the alert/warning.
[0080] Now referring back to FIG. 2, a functional block diagram of the detection sensor 110 of FIG. 1 is shown in accordance with embodiments of the present disclosure. The detection sensor 110 may include a sound sensor 210, an air quality sensor 220, a network interface 230, a power unit 240, and a controller/processor 250. The terms controller and processor will be used interchangeably herein. The sound sensor 210 may be used for detecting sound and the air quality sensor 220 may be used for detecting air quality.

[0081] In particular, the sound sensor 210 detects sound levels (e.g., decibel (dB)) in the environment. For example, FIG. 3A shows detected sound levels in the form of voltage amplitudes. The horizontal axis represents time and the vertical axis represents voltage amplitude. Curves represent detected sound levels in voltage. The bold lines represent windows for identification. For example, the window of identification may be less than 1 second. Within the window, when the voltage amplitude is greater than a threshold value, potential bullying may be identified. In this example, the threshold value is about 4.9 volts. Thus, between 4 and 5 seconds, potential bullying may be identified.

[0082] As described above, the threshold value for identifying potential bullying depends on the installation location at the site and based on history data obtained during the learning mode. Since the detection sensor 110 may cover a limited area, several satellite detection sensors 110 may be installed at one enclosed space when the area of the enclosed space is greater than the area each satellite detection sensor 110 can cover. For example, the detection sensor 110 may cover an area of 10 by 10 square feet. In this situation, each satellite detection sensor 110 may have different threshold value for identifying potential bullying due to different installation locations at the same enclosed space. The air quality sensor 220 may detect air quality including moisture and hydrogen content in the air and temperature of the air. In other words, the air
quality sensor 220 may include a combination of sensors sensing air quality. In an aspect, the air quality sensor 220 may include other sensors sensing air content of the environment. Vaping may be detected by specific range combination of humidity, hydrogen, and temperature, which is defined as signature in this disclosure. Since the signature does not depend on installation locations and times, internal parameters for identifying vaping may be predetermined. In other words, the air quality sensor 220 does not need training, while the sound sensor 210 needs training. The network interface 230 may be configured to transmit sensed results to the control server 120. In an aspect, the network interface 230 may transmit a request to send an alert, when potential bullying or vaping is identified, to the message server 140 and the client server 160. Further, the network interface 230 may receive a command to update internal settings or parameters from the control server 120.

[0083] In an aspect, the network interface 230 may communicate with others wirelessly or via a wired connection. Wireless connections may be wide area network (WAN), local area network (LAN), personal area network (PAN), ad hoc network, cellular network, etc. Wired network may utilize category 5 cable (CAT5), CAT5E, category 6 cable (CAT6), or similar cables. Updates for the detection sensor 110 may be wirelessly transmitted through the network interface 230 over the air. Further, through the network interface 230, the client 170 or an operator/manager/technician may be able to turn on and off the detection sensors 110 individually.

[0084] The sound sensor 210, the air quality sensor 220, and the network interface 230 may be powered by the power unit 240. Regular batteries may be installed to supply power to the detection sensor 110. For example, AA, AAA, or other suitable batteries may be used. The power unit 240 may utilize batteries and a connection to a power outlet so that the power unit
240 may supply power by using the batteries just in case when the power is out.

[0085] In an aspect, the power unit 240 may receive power supplied from a network cable, such as CAT5 or CAT6, which is called Power-over-Ethernet (PoE) or active Ethernet. PoE+ and 4PPoE may be also used to supply power. The PoE and PoE+ follows standards (e.g., 802.3at and 802.3bt) set by Institute of Electrical and Electronics Engineers (IEEE) providing about 30 watts. As next generation standards for the PoE can provide more power, for example 60 watts, the ethernet cable can provide sufficient power for the power unit 240. Since the network cable supplies power, the detection sensor 110 may be installed everywhere the network cable can be installed without worrying about a distance to a power outlet. Also, since the power unit 240 does not need electric components necessary for connections to a power outlet, manufacturing cost can be lowered and the size of the detection sensor 110 can be reduced.

[0086] The detection sensor 110 further includes the controller 250, which controls functions and settings of the detection sensor 110. When the detection sensor 110 is powered, the controller 250 sets settings of the detection sensor 110 and internal parameters of the sound sensor 210 and the air quality sensor 220. The controller 250 further controls the network interface 230 to transmit detected results or requests for sending alerts when potential bullying, sleep apnea, or vaping is detected, and reset or update settings and internal parameters upon reception of update command from the control server 120.

[0087] The controller 250 may be implemented on Linux, Windows, Android, IOS, or similar software operating system. In an aspect, the controller 250 may be implemented on a hardware system, such as a digital signal processor (DSP), application-specific integrated circuit (ASIC), field-programmable gate array (FPGA), different types of programmable read-only memory (e.g., PROM, EPROM, EEPROM, etc.), microprocessor or microcontroller.
In an aspect, the controller 250 may be implemented on a hardware system by removing unnecessary features from the hardware system to reduce power consumption and integrating necessary features for identification into the hardware system. For example, the controller 250 may be implemented on a Raspberry Pi in a low power mode by removing unnecessary features, which were already equipped in the Raspberry Pi, and by integrating features for identifying vaping, smoking, and potential bullying. In this way, power required for running the sound sensor 210, the air quality sensor 220, the network interface 230, and the controller 250 can be sufficiently supplied via a network cable (e.g., PoE, PoE+ and 4PPoE). This approach for reducing power consumption may be applied to other hardware systems or software operating systems.

For example, a standard processor of Raspberry Pi (e.g., Model 3, 3B, 3B+, etc.) runs at 1.4 GHz. By editing operating system configuration files, the Raspberry Pi processor can run at less than 1.4 GHz, thus the consumption of power being lowered, meaning that the Raspberry Pi processor runs in the low power mode. Further, the Raspberry Pi includes an HDMI port for debugging and diagnostic purposes. When plugging into the HDMI port, a user can change and debug the operating system configuration files. The disclosed embodiments are exemplary, and other implementations are contemplated. For example, the hardware system need not be a Raspberry Pi and can be another hardware/software system that includes a processor, memory, communication interfaces, an operating system, power management, and one or more software applications. The communication interfaces can include, for example, Ethernet, WiFi, USB, and/or HDMI, among others. In various embodiments, the hardware/software system can include a low power mode which permits the system to be powered by Power over Ethernet (PoE). The low power mode can include, for example, setting the processor
to decreased processing capability. Other variations are contemplated.

[0090] In an aspect, the detection sensor 110 may not be equipped with a warning system. Thus, when potential bullying or vaping is detected at the installation site, any person who bullies or vapes cannot recognize that the identification of such is reported to the client 170 and the notification subscribers 150 because the identification is reported silently to the person.

[0091] FIG. 4 shows a flowchart for a method 400 in the learning mode in accordance with embodiments of the present disclosure. As described above, the sound sensor 210 of the detection sensor 110 needs training to generate base data. In the learning mode, the base data is generated. In step 410, the sound sensor detects sounds for a predetermined period. The detected sound is combined with the corresponding timestamp in step 420. The timestamp may include the time, the day of the week, the day, and the month when the sound is detected. The combined data is then saved in a database in step 430.

[0092] In step 440, it is checked whether or not the learning mode is still true. If it is true, the method 400 repeats steps 410–440 until sufficient sound data is saved in the database. In an aspect, the sound data may be saved in a memory in the detection sensor 110 but not in the database, which is distant from the detection sensor 110, for protecting privacy.

[0093] If it is determined that the learning mode is false in step 440, the method 400 proceeds to step 450, in which base data is generated based on the detected sounds saved at the database during the learning mode. The base data may include a series of threshold values for identifying potential bullying or sleep apnea along the time of each day, each week, or each month depending on the total duration of the learning mode. After generation of the base data, the method 400 ends.

[0094] Now turning to FIG. 5, a method 500 is provided in the active mode in
accordance with embodiments of the present disclosure. After the base data is generated in method 400 of FIG. 4, the method 500 starts with steps 510 and 560. In step 510, the sound sensor detects sound in the environment and in step 560, the air quality sensor detects air quality. In the method 500, detections of sound and air quality are shown parallelly. In an aspect, such detections may be serially performed.

[0095] In step 520, timestamp is provided to the detected sounds. Based on the timestamp, a control system makes a request for history data from the database in step 530. The control system then determines based on the history data whether or not noise disturbance is detected in step 540. The noise disturbance may be related to potential bullying or sleep apnea. In an aspect, the noise disturbance may be related to sound related phenomena or situations, such as fights, hurricane, voice recognition, etc.

[0096] If it is determined that the noise disturbance is identified in step 540, the control system silently sends an alert to one or more users who are in charge of the installation site in step 550. After sending the alert, the method 500 restarts the process.

[0097] If it is determined that the noise disturbance is not identified in step 540, steps 510–550 are repeated.

[0098] Now returning back to the air quality detection, after the air quality is detected in step 560, the control system determines whether or not the signature is identified in step 570. In case when it is determined that the signature is not identified in step 570, the method 500 repeats steps 560 and 570. In this way, sleep apnea, potential bullying, or vaping can be detected and informed to the users. People at the site, however, may not acknowledge the transmission of the alert because the alert is transmitted silently to the people responsible for the site.

[0099] If it is determined that the signature is identified in step 570, the method 500 may
further check the sound sensor to determine whether the signature is identified because air fresheners at the detection site automatically spray into the air, or heating, ventilation, and air conditioning (HVAC) equipment blows air through vents. In other words, the sound sensor is used to determine whether there is a person at the detection site in step 580. In case when the signature is identified by something other than people in step 580, the control method 500 goes back to step 560 without sending an alert. However, when presence of a person is identified by the sound sensor in step 580, the control system silently sends an alert to the one or more users via a text message, email, instant message, optical warning, or oral warning in step 550.

[0100] Turning now to FIG. 6, a flowchart is provided for a method 600 for detecting vape. The method starts from sensing temperature and humidity in step 610. As described above, the modified hydrogen sensor of the detection sensor may vary because the voltage or resistance in the modified hydrogen sensor varies depending on temperature of the environment. Thus, in step 620, it is determined whether an adjustment to the modified hydrogen sensor is needed.

[0101] When it is determined that the adjustment is needed in step 620, the voltage or resistance of the modified hydrogen sensor is adjusted to appropriately sense gas (e.g., hydrogen) in step 630 and then the method 600 moves to step 640.

[0102] When it is determined that the adjustment is not needed in step 620, the modified gas sensor reads gas in step 640.

[0103] In step 650, it is determined whether the sensed temperature, humidity, and gas match an abnormality matching signature, meaning that the sensed results are within the corresponding ranges. When they match the abnormality matching signature, an alert is sent in step 660. Otherwise, the method 600 goes back to step 610 and repeats steps 610–660.

[0104] Turning now to FIG. 7, a simplified block diagram is provided for a computing
device 700, which can be implemented as the control server 120, the database 130, the message server 140, and the client server 160 of FIG. 1. The computing device 700 may include a memory 702, a processor 704, a display 706, a network interface 708, an input device 710, and/or an output module 712. The memory 702 includes any non-transitory computer-readable storage media for storing data and/or software that is executable by the processor 704 and which controls the operation of the computing device 700.

[0105] In an aspect, the memory 702 may include one or more solid-state storage devices such as flash memory chips. Alternatively, or in addition to the one or more solid-state storage devices, the memory 702 may include one or more mass storage devices connected to the processor 704 through a mass storage controller (not shown) and a communications bus (not shown). Although the description of computer-readable media contained herein refers to a solid-state storage, it should be appreciated by those skilled in the art that computer-readable storage media can be any available media that can be accessed by the processor 704. That is, computer readable storage media may include non-transitory, volatile and non-volatile, removable and non-removable media implemented in any method or technology for storage of information such as computer-readable instructions, data structures, program modules or other data. For example, computer-readable storage media includes RAM, ROM, EPROM, EEPROM, flash memory or other solid state memory technology, CD-ROM, DVD, Blu-Ray or other optical storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to store the desired information and which can be accessed by the computing device 700.

[0106] The memory 702 may store application 716 and/or data 714 (e.g., base data and history data from the sound sensor 210 and the air quality sensor 220 of FIG. 2). The application
716 may, when executed by processor 704, cause the display 706 to present the user interface 718 including FIGS. 3A–3C. The processor 704 may be a general-purpose processor, a specialized graphics processing unit (GPU) configured to perform specific graphics processing tasks while freeing up the general-purpose processor to perform other tasks, and/or any number or combination of such processors. The display 706 may be touch-sensitive and/or voice-activated, enabling the display 706 to serve as both an input and output device. Alternatively, a keyboard (not shown), mouse (not shown), or other data input devices may be employed. The network interface 708 may be configured to connect to a network such as a local area network (LAN) consisting of a wired network and/or a wireless network, a wide area network (WAN), a wireless mobile network, a Bluetooth network, a Zigbee network, and/or the internet.

[0107] For example, the computing device 700 may receive, through the network interface 708, detection results for the detection sensor 110 of FIG. 1, for example, detected sound in the learning mode and the active mode, and history data, which is time-series data including detected sounds and detected air quality from the detection sensor 110 for the whole running times or a predetermined period. The computing device 700 may receive updates to its software, for example, the application 716, via the network interface 708. The computing device 700 may also display notifications on the display 706 that a software update is available.

[0108] The input device 710 may be any device by means of which a user may interact with the computing device 700, such as, for example, a mouse, keyboard, foot pedal, touch screen, and/or voice interface. The output module 712 may include any connectivity port or bus, such as, for example, parallel ports, serial ports, universal serial busses (USB), or any other similar connectivity port known to those skilled in the art. The application 716 may be one or more software programs stored in the memory 702 and executed by the processor 704 of the
computing device 700. The application 716 may be installed directly on the computing device 700 or via the network interface 708. The application 716 may run natively on the computing device 700, as a web-based application, or any other format known to those skilled in the art.

[0109] In an aspect, the application 716 will be a single software program having all of the features and functionality described in the present disclosure. In other aspect, the application 716 may be two or more distinct software programs providing various parts of these features and functionality. Various software programs forming part of the application 716 may be enabled to communicate with each other and/or import and export various settings and parameters relating to the identification of potential bullying, sleep apnea, and vaping. The application 716 communicates with a user interface 718 which generates a user interface for presenting visual interactive features to the notification subscribers 150 or the client 170 of FIG. 1 on the display 706. For example, the user interface 718 may generate a graphical user interface (GUI) and output the GUI to the display 706 to present graphical illustrations such as FIGS. 3A–3C.

[0110] Now turning to FIG. 8, a method 800 is provided for notifying detection of vaping, smoking, or potential bullying in accordance with embodiments of the present disclosure. The notification method 800 starts with the notification system receiving a responsibility schedule from the client 170 in step 810. The responsibility schedule may include working hours, working days, assigned zones, names, and contact information of persons responsible for a premise, where a plurality of detection sensors is to be installed. The list of responsibility schedule is not meant to be exhaustive but is provided for explanatory purposes only, and may contain further information as readily appreciated by a person having ordinary skill in the art. The contact information may include a working phone number, a mobile phone number, a home phone number, a working email, a social media address, or any other address that the message server
can send an alert/warning.

[0111] After the plurality of detection sensors are installed at the premise, the plurality of detection sensors has to go through the learning mode to obtain base data. During the learning mode, each detection sensor collects sensed results to form the base data, which is to be used for detecting vaping, smoking, and potential bullying. The base date may be collected in a similar way as steps 410–450 of FIG. 4.

[0112] The learning mode may be complete in one or more weeks to collect base data to accommodate weekday specifics, hours specifics, etc. Thus, the base data is not a constant reference data but includes a time series data, which fluctuates during 24 hours or weekdays. In order to accommodate holidays or weekends, the base data may include a constant reference data. In an aspect, the learning mode may take less than one or two weeks or more based on the characteristics of the premise.

[0113] After obtaining the base data sufficiently, the active mode is activated and the plurality of sensors starts to sense air quality, sound, and temperature in step 830. The sensed results are then compared with the base data in consideration of the sensing time and the sensing location in step 840. When it is determined that there is no activity of vaping, smoking, and potential bullying, the method 800 keeps going back to step 830 so that the plurality of detection sensors continuously senses air quality, sound, and temperature.

[0114] When it is determined that vaping, smoking, or potential bullying is detected in step 840, the notification system sends an alert to a person responsible for the premise based on the responsibility schedule in step 850. The notification system selects the responsible person who is in charge of the location where and the time when vaping, smoking, or potential bullying is detected. The detection location may not be a specific location of the detection sensor which
detects vaping, smoking, or potential bullying but a location of the zone, to which the detection sensor belongs.

[0115] The alert may not be sent to the location of the detection, meaning that persons in the detection location are unable to know that the alert is sent to the responsible person. In this way, vaping, smoking, or potential bullying can be appropriately addressed before the persons doing such activity are aware of transmission of the alert.

[0116] Step 860 assures that the responsible person receives the alert by re-sending the alert until the notification system receives a response from the responsible person. For this cause, the notification system is capable of receiving emails, text messages, or audio/video data via several communication methods.

[0117] Accordingly, described above are systems and methods for detecting vaping, smoking, or potential bullying, and systems and methods for notifying persons of a detected occurrence based on an assignment schedule. The disclosure below will describe systems and methods for an alert device to provide an audio alert and/or a visual alert of a detected occurrence of vaping, smoking, or potential bullying.

[0118] FIG. 9 is a diagram of a system having a detector device 910 that is communicatively coupled to a separate alert device 920, and both devices are in the same vicinity. In various embodiments, the detector 910 device can be the detection sensor 110 of FIG. 1. In the illustrated embodiment, the detector device 910 includes an air quality sensor 912, a sound detector 914, a communication interface 916, and a processor 918. In various embodiments, the detection device 910 can include other sensors not explicitly shown in FIG. 9, including other sensors described above herein, or can include sensors different from those shown in FIG. 9. The processor 918 can operate to identify vaping, smoking, and/or potential
bullying based on air quality detected by the air quality sensor 912 and/or sounds detected by the sound sensor 914, such as in the manner described above herein. The detector device 910 can include other components not explicitly shown in FIG. 9, such as memory, or other components described above herein, or other components that persons skilled in the art will recognize.

The alert device 920 includes a visual device 922, an audio device 924, and a communication interface 926. In various embodiments, the alert device 920 can include a visual device 922 and no audio device 924. In various embodiments, the alert device 920 can include an audio device 924 and no visual device 922. In various embodiments, the visual device 922 can be a flashing light, a siren light, or another type of warning or alert light. In various embodiments, the visual device 922 can be a display screen that can display a warning or alert message. The message, for example, can indicate the location where the detection occurred, such a message showing the name or label of the location. In various embodiments, the visual device 922 can display a time duration since the alert incident occurred, such as number of seconds since the identified abnormality matching signature. This allows monitoring personnel to decide whether or not it may be too late to investigate the incident. Time duration can be displayed as text. In various embodiments, the alert message can be shown with varying brightness. For example, the name of the location can be initially displayed at full brightness and can be dimmed over time. In various embodiments, the visual device 922 can include a display screen and one or more warning or alert lights. In various embodiments, the audio device 924 can be a mechanical device such as a mechanical bell. In various embodiments, the audio device 924 can be an audio speaker that plays an audio warning or alert tone or clip. The embodiments described above are exemplary, and variations are contemplated to be within the scope of the present disclosure.
The pair of communication interfaces 916, 926 allows the detector device 910 and the alert device 920 to communicate. In various embodiments, when the detector device 910 detects vaping, smoking, or potential bullying, the detector device 910 can instruct the alert device 920 to provide an alert. The communication interfaces 916, 926 can be wired communication interfaces that are coupled to each other by a cable 930. For example, in various embodiments, the communication interfaces 916, 926 can be USB ports, lightning ports, HDMI ports, coaxial ports, or Ethernet ports, and the cable 930 can be a USB cable, a lightning cable, a HDMI cable, a coaxial cable, or an Ethernet cable, respectively. Other types of wired interfaces and cables are contemplated to be within the scope of the present disclosure. In various embodiments, the communication interface 916 may be a different wired interface than the communication interface 926, and the cable 930 can include an adaptor that allows the two interfaces 916, 926 to communicate.

In various embodiments, the communication interfaces 916, 926 can be wireless communication interfaces, such as Bluetooth transceivers, Zigbee transceivers, or custom radio transceivers which communicate using wireless signals 942, 944. Other types of wireless transceivers will be recognized by persons skilled in the art and are contemplated to be within the scope of the present disclosure. In various embodiments, one or both of the communication interfaces 916, 926 can include a wired interface and no wireless interface, or a wireless interface and no wired interface, or both a wired interface and a wireless interface. The detector device 910 can communicate information and/or instructions to the alert device 920, such as a name or label for the location where vaping, smoking, or potential bullying is detected.

FIG. 10 shows an example of an implementation of the system of FIG. 9 for a bathroom, such as a school bathroom. The detector device 910 is installed inside the bathroom
to detect vaping, smoking, and/or potential bullying. The alert device 920 is separate from
the detector device 910 and is installed in the vicinity of the detector device 910. In the illustrated
embodiment, the alert device 920 is installed right outside the bathroom and is communicatively
coupled with the detector device 910 by a cable 930. When the detector device 910 detects
vaping, smoking, and/or potential bullying, the detector device communicates an instruction via
the cable 930 to the alert device 920, which provides a visual alert but not an audio alert. In this
manner, persons outside the bathroom are alerted to a detected occurrence inside the bathroom,
without the occupants of the bathroom being alerted. Appropriate personnel outside the
bathroom, such as school faculty or security, can perceive the visual alert and respond
accordingly, while bystanders, such as students, can avoid the bathroom of the detected
occurrence. The illustration of FIG. 10 is exemplary, and the disclosed systems and methods are
applicable to other settings, locations, room, buildings, and/or facilities.

[0123] Referring now to FIG. 11, there is shown a system in which an alert device 1120
is remote from one or more detector devices 1110a to 1110n, where 1110n indicates an n-th
detector device where n ≥ 2. The detector devices 1110a to 1110n include network interfaces
1112a to 1112n, respectively, which can be wired network interfaces such as Ethernet and/or
wireless network interfaces such as Wi-Fi. The alert device 1120 also includes a network
interface 1122, which can be a wired network interface such as Ethernet and/or a wireless
network interface such as Wi-Fi. The detector devices 1110a to 1110n and the alert device 1120
are in communication with a network 1140 and communicate using network data packets. The
detector devices 1110a to 1110n can communicate with a server 1130, which can be a control
server 120, a message server 140, and/or a client server 160 as shown in FIG. 1.

[0124] In an aspect of the present disclosure, the detector devices 1110a to 1110n can
detect vaping, smoking, and/or potential bullying and can communicate detected occurrences to the server 1130 by network data packets. The server 1130 can track detected occurrences. The alert device 1120 can be configured to monitor network data packets for detected occurrences of vaping, smoking, and/or potential bullying. In various embodiments, the alert device 1120 can be a network repeater or another type of network device that can intercept the network data packets and then forward them to the server 1130. The alert device 1120 can analyze the intercepted network data packets to identify occurrences of detected vaping, smoking, and/or potential bullying. The network data packets can include an indication of the location of the detected occurrence, such as a name or a label for the location, and the alert device 1120 can display the name or label of the location of the detected occurrence. In various embodiments, the network data packets can include a time of the detected occurrence, and the alert device 1120 can display the time duration since the occurrence was detected. An example of such a configuration is shown in FIG. 12, in which the alert device is remote from detector devices and is located in, for example, a school faculty lounge. FIG. 12 is exemplary, and other locations for the alert device are contemplated to be within the scope of the present disclosure.

[0125] Referring again to FIG. 11, and in another aspect of the present disclosure, the detector devices 1110a to 1110n can detect air quality, sound levels, and/or other sensed information, but the detector devices 1110a to 1110n may not by themselves detect vaping, smoking, and/or potential bullying. Rather, the detector devices 1110a to 1110n communicate the sensed information to the server 1130, and a processor of the server 1130 identifies vaping, smoking, and/or potential bullying based on the received information, in the manner described earlier in the present disclosure. In such a configuration, the alert device 1120 may not intercept network data packets between the detector devices 1110a to 1110n and the server 1130. Rather,
when the server 1130 identifies vaping, smoking, and/or potential bullying, the server 1130 instructs the alert device 1120 to provide an alert. In such a configuration, the detector devices 1110a to 1110n can communicate their identifiers to the server 1130. In various embodiments, the identifiers can be network identifiers, such as IP addresses or MAC addresses. In various embodiments, the identifiers can be another type of identifier, such as a unique identifier that is assigned to the detector devices 1110a to 1110n. The server 1130 can maintain a database that matches detector device identifiers to names or labels of the locations of the detector devices 1110a to 1110n. The server 1130 can match a detector device identifier of a name or label of the location of the detector device using such a database. When the server 1130 identifies vaping, smoking, and/or potential bullying, the server 1130 can communicate the name or label of the location of the occurrence, and the alert device 1120 can display the name or label, such as the display shown in FIG. 12. The server 1130 can also communicate a time of the identified vaping, smoking, and/or potential bullying, to the alert device 1120, and the alert device 1120 can display a time duration since the occurrence was identified.

[0126] The embodiment of FIG. 11 is exemplary, and variations are contemplated to be within the scope of the present disclosure. For example, in various embodiments, there may be multiple alert devices and/or multiple servers and/or multiple networks. In various embodiments, the network may be configured in different ways, which persons skilled in the art will recognize. Such and other variations are contemplated to be within the scope of the present disclosure.

[0127] FIG. 13 is a flow diagram of an exemplary operation for providing an alert of detected vaping, smoking, and/or bullying. At block 1310, the operation detects vaping, smoking, or potential bullying by a plurality of detector devices. At block 1320, the operation tracks, by a server, occurrences of detected vaping, smoking, or potential bullying. At block
1330, the operation conveys, by a network, network traffic between the plurality of detector
device and the server. At block 1340, the operation monitors the network traffic by an alert
device. And at block 1350, the operation provides a visual alert by the alert device when the
network traffic includes an occurrence of detected vaping, smoking, or potential bullying. The
operation of FIG. 13 is exemplary and does not limit the scope of the present disclosure.

[0128] Since other modifications and changes may be made to fit particular operating
requirements and environments, it is to be understood by one skilled in the art that the present
disclosure is not limited to the examples described in the present disclosure and may cover
various other changes and modifications which do not depart from the spirit or scope of this
disclosure.

[0129] The embodiments disclosed herein are examples of the disclosure and may be
embodied in various forms. For instance, although certain embodiments herein are described as
separate embodiments, each of the embodiments herein may be combined with one or more of
the other embodiments herein. Specific structural and functional details disclosed herein are not
to be interpreted as limiting, but as a basis for the claims and as a representative basis for
teaching one skilled in the art to variously employ the present disclosure in virtually any
appropriately detailed structure. Like reference numerals may refer to similar or identical
elements throughout the description of the figures.

[0130] The phrases “in an embodiment,” “in embodiments,” “in various embodiments,” “in
some embodiments,” or “in other embodiments” may each refer to one or more of the same or
different embodiments in accordance with the present disclosure. A phrase in the form “A or B”
means “(A), (B), or (A and B).” A phrase in the form “at least one of A, B, or C” means “(A);
(B); (C); (A and B); (A and C); (B and C); or (A, B, and C).”
The systems described herein may also utilize one or more controllers/processors to receive various information and transform the received information to generate an output. The controller/processor may include any type of computing device, computational circuit, or any type of processor or processing circuit capable of executing a series of instructions that are stored in a memory. The controller/processor may include multiple processors and/or multicore central processing units (CPUs) and may include any type of processor, such as a microprocessor, digital signal processor, microcontroller, programmable logic device (PLD), field programmable gate array (FPGA), or the like. The controller/processor may also include a memory to store data and/or instructions that, when executed by the one or more processors, causes the one or more processors to perform one or more methods and/or algorithms.

Any of the herein described methods, programs, algorithms or codes may be converted to, or expressed in, a programming language or computer program. The terms “programming language” and “computer program,” as used herein, each include any language used to specify instructions to a computer, and include (but is not limited to) the following languages and their derivatives: Assembler, BASIC, Batch files, BCPL, C, C++, Delphi, Fortran, Java, JavaScript, machine code, operating system command languages, Pascal, Perl, PL1, scripting languages, Visual Basic, metalanguages which themselves specify programs, and all first, second, third, fourth, fifth, or further generation computer languages. Also included are database and other data schemas, and any other meta-languages. No distinction is made between languages which are interpreted, compiled, or use both compiled and interpreted approaches. No distinction is made between compiled and source versions of a program. Thus, reference to a program, where the programming language could exist in more than one state (such as source,
compiled, object, or linked) is a reference to any and all such states. Reference to a program may encompass the actual instructions and/or the intent of those instructions.

[0133] It should be understood that the foregoing description is only illustrative of the present disclosure. Various alternatives and modifications can be devised by those skilled in the art without departing from the disclosure. Accordingly, the present disclosure is intended to embrace all such alternatives, modifications and variances. The embodiments described with reference to the attached drawing figures are presented only to demonstrate certain examples of the disclosure. Other elements, steps, methods, and techniques that are insubstantially different from those described above and/or in the appended claims are also intended to be within the scope of the disclosure.
CLAIMS

What is claimed is:

1. A notification system for notifying detection of vaping, smoking, and potential bullying, the notification system comprising:
   - an air quality sensor configured to detect air quality;
   - a sound detector configured to detect sounds;
   - a processor configured to identify an abnormality matching signature of vaping, smoking, or potential bullying based on at least one of the detected air quality or the detected sounds;
   - an alert device configured to provide at least one of an audio alert or a visual alert based on the identified abnormality matching signature; and
   - a pair of communication interfaces configured to communicatively couple the processor and the alert device.

2. The notification system of claim 1, wherein the pair of communication interfaces is a pair of wireless communication interfaces.

3. The notification system of claim 2, wherein the pair of wireless communication interfaces includes at least one of a pair of Bluetooth transceivers or a pair of Zigbee transceivers.

4. The notification system of claim 1, wherein the air quality sensor, the sound sensor, and the processor are co-located in a detector device, wherein the detector device is separate from the alert device.
5. The notification system of claim 4, wherein the alert device is in a vicinity of the detector device, wherein the alert device is configured to provide the visual alert and not provide an audio alert.

6. The notification system of claim 4, wherein the alert device is remote from the detector device, wherein the alert device is configured to provide the visual alert indicating a location of the detector device.

7. The notification system of claim 6, wherein the alert device includes a display screen, and wherein the visual alert displays a name of the location of the detector device on the display screen and displays time duration since the identified abnormality matching signature.

8. The notification system of claim 4, wherein the pair of communication interfaces is a pair of network interfaces, wherein the communicative coupling of the detector device and the alert device includes network packets.

9. The notification system of claim 4, wherein the pair of communication interfaces is a pair of wired communication interfaces configured to communicatively couple the detector device and the alert device by a cable.

10. The notification system of claim 1, wherein:
    
    the air quality sensor and the sound sensor are co-located in a detector device,
the processor is located in a server, and

the detector device, the server, and the alert device are separate devices.

11. The notification system of claim 10, wherein the server instructs the alert device to generate the visual alert.

12. The notification system of claim 11, wherein:

   the detector device is configured to communicate a time of the identified abnormality matching signature and an identifier to the server;

   the server is configured to match the identifier to a name of a location of the detector device, and

   the alert device is configured to generate the visual alert including the name of the location and a time duration since the identified abnormality matching signature.

13. A notification system for notifying detection of vaping, smoking, or potential bullying, the notification system comprising:

   a plurality of detector devices configured to detect vaping, smoking, or potential bullying;

   a server configured to track occurrences of detected vaping, smoking, or potential bullying;

   a network configured to communicatively couple the plurality of detector devices and the server; and

   an alert device communicatively coupled to the network and configured to monitor network traffic from the plurality of detector devices, wherein the alert device provides a visual
alert when the network traffic includes an occurrence of detected vaping, smoking, or potential bullying.

14. The notification system of claim 13, wherein the alert device is remote from the plurality of detector devices, wherein the alert device is configured to provide the visual alert indicating a location of the occurrence of detected vaping, smoking, or potential bullying.

15. The notification system of claim 14, wherein the alert device includes a display screen, and wherein the visual alert displays a name of the location of the occurrence of detected vaping, smoking, or potential bullying on the display screen.

16. The notification system of claim 15, wherein the name of the location is included in the network traffic.

17. The notification system of claim 15, wherein the name of the location is stored in the server, wherein the alert device is configured to request the name of the location from the server.

18. A method for notifying detection of vaping, smoking, or potential bullying, the method comprising:
   - detecting vaping, smoking, or potential bullying by a plurality of detector devices;
   - tracking, by a server, occurrences of detected vaping, smoking, or potential bullying;
   - conveying, by a network, network traffic between the plurality of detector devices and the server;
monitoring the network traffic by an alert device; and

providing a visual alert by the alert device when the network traffic includes an occurrence of detected vaping, smoking, or potential bullying.

19. The method of claim 18, wherein the alert device is remote from the plurality of detector devices, wherein the visual alert indicates a location of the occurrence of detected vaping, smoking, or potential bullying.

20. The method of claim 19, wherein the alert device includes a display screen, and wherein the visual alert displays a name of the location of the occurrence of detected vaping, smoking, or potential bullying on the display screen.
FIG. 1

Detection Sensors

Client Server 160

Control Server 120

Database 130

Message Server 140

Client 170

Notification Subscribers 150

100
START

Detect sounds

Provide timestamp

Save the detected sounds with the timestamp at database

Is learning mode true?

YES

NO

Generate base data for detection of sound disturbance

END

FIG. 4
START

510 Detect sounds

520 Provide timestamp

530 Request history based on the timestamp

540 Is noise identified? NO

550 Send an alert to a user

560 Detect air quality

570 Is signature identified? NO

FIG. 5
START

Sense temperature and humidity

Need adjustment?

Adjust voltage of gas sensor

Read gas sensor

Is vape base data matched?

Send alert

FIG. 6
FIG. 7

COMPUTING DEVICE

700

PROCESSOR

704

DISPLAY

706

NETWORK

INTERFACE

708

MEMORY

702

DATA

714

APPLICATION

716

USER

INTERFACE

718

INPUT

DEVICE

710

OUTPUT

MODULE

712
START

Receive a responsibility schedule from a user

Collect base data for a predetermined period during a learning mode

Sense air quality, sound, and temperature during an active mode

Is vaping, bullying, or smoking detected based on the base data?

Send an alert to a person based on the responsibility schedule and a location and a time of the detection

Does the person respond to the alert?

END

FIG. 8
FIG. 9

Detector device 910

Air quality sensor 912

Sound detector 914

Comm. interface 916

Processor 918

Alert device 920

Visual device 922

Audio device 924

Comm. interface 926

942 944 930
Detect vaping, smoking, or potential bullying by a plurality of detector devices.

Track, by a server, occurrences of detected vaping, smoking, or potential bullying.

Convey, by a network, network traffic between the detector devices and the server.

Monitor the network traffic by an alert device.

Provide a visual alert by the alert device when the network traffic includes an occurrence of detected vaping, smoking, or potential bullying.

END
**INTERNATIONAL SEARCH REPORT**

**Box No. II  Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. □ Claims Nos.: because they relate to subject matter not required to be searched by this Authority, namely:

2. □ Claims Nos.: because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. □ Claims Nos.: because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box No. III  Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

- see additional sheet

1. □ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. X As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of additional fees.

3. □ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. □ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

**Remark on Protest**

- □ The additional search fees were accompanied by the applicant’s protest and, where applicable, the payment of a protest fee.

- □ The additional search fees were accompanied by the applicant’s protest but the applicable protest fee was not paid within the time limit specified in the invitation.

- □ No protest accompanied the payment of additional search fees.
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**
- INV. G08B21/12 G08B13/16
- ADD. G08B25/08 G08B25/10

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**
- Minimum documentation searched: [classification system followed by classification symbols]
  - G08B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where patentable, search terms used)
- EPO-Internal, WPI Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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<th>Relevant to claim No.</th>
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* Special categories of cited documents:
  - "A" document defining the general state of the art which is not considered to be of particular relevance
  - "E" earlier application or patent but published on or after the international filing date
  - "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
  - "O" document referring to an oral disclosure, use, exhibition or other means
  - "P" document published prior to the international filing date but later than the priority date claimed
  - "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
  - "X" document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
  - "Y" document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
  - "A" document member of the same patent family

**Date of the actual completion of the international search**
- 18 May 2021

**Date of mailing of the international search report**
- 27/05/2021

**Name and mailing address of the ISA/ European Patent Office, P.B. 5618 Patentiaan 2
NL - 2230 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016**

**Authorized officer**
- Königser, Axel
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FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-20

   Subject: System for detecting vaping, smoking or bullying
   Problem: How to securely detect events such as vaping, smoking or bullying.
   Solution: Use of an air quality sensor and a sound detector and an processor which analyses data from both sensors in order to generate alert.

1.1. claims: 13-20

   Subject: Managing surveillance of a large area with respect to vaping, smoking or bullying.
   Problem: Provide surveillance over a large area, such as a building, with respect to events related to vaping, smoking or bullying.
   Solution: Provision of a plurality of detector devices which are networked with a server and an alert device which receives notifications related to detected vaping, smoking or bullying events.

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